A Surface Made of Plates

Define It!

fault: a break in Earth's crust where blocks of rock are moving in different directions

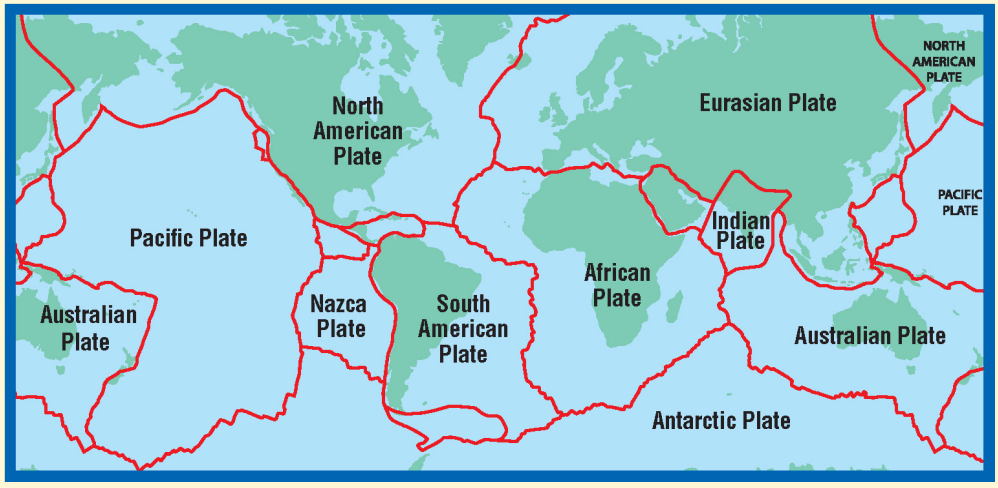
gradual: taking place slowly

mantle: a layer of molten rock beneath Earth's crust

plates: large sections of Earth's crust

The outer layer of Earth is called the crust. The crust is made of different kinds of rock. Earth's crust is broken into many large pieces called **plates**. All the land and oceans on Earth lie on top of these plates. Beneath the plates is the hot, soft **mantle**. The mantle moves and carries the plates along with it.

The movement of plates can be **gradual** or sudden. When plates move suddenly, an earthquake happens. Part of the ground may lift up several feet, or cracks in the earth may appear. The place where Earth's crust breaks is called a **fault**.



Use the map to find where you live. Write the name of the plate you are on.

_____

Concepts:

Earth's crust is made up of plates.

When the plates move suddenly, an earthquake happens.

Earthquakes

Concepts:

Earthquakes happen along the boundaries of plates.

Plates interact along their boundaries in different ways.

Earthquakes

Moving Plates

Define It!

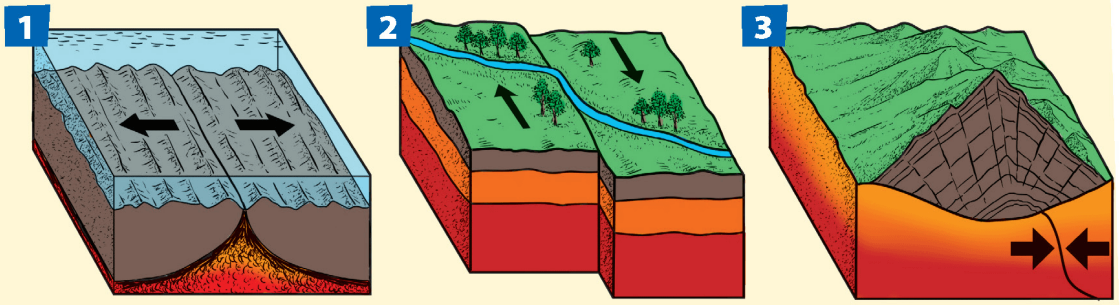
boundary: a border or an edge

collide: to crash into; to come together

interact: to act on one another

Earthquakes happen along the **boundaries** of plates, or where the edge of one plate meets another. Plates **interact** along their boundaries as they move in different directions.

Some plates slide past each other. The famous San Andreas Fault in California is an example of plates sliding in opposite directions. Other plates **collide**, or run into each other. When plates collide, they cause powerful earthquakes and can even build mountains. The Himalaya Mountains in Asia are the result of two plates colliding. In other places, plates move apart from each other. This does not cause very strong earthquakes, but ocean basins are often created when two plates pull apart.



Write whether the diagrams above show plates *sliding past* each other, *colliding*, or *moving apart*.

1. _____

2. _____

3. _____

Concept:
Scientists use different tools to measure and classify earthquakes.

Measuring Earthquakes

Define It!

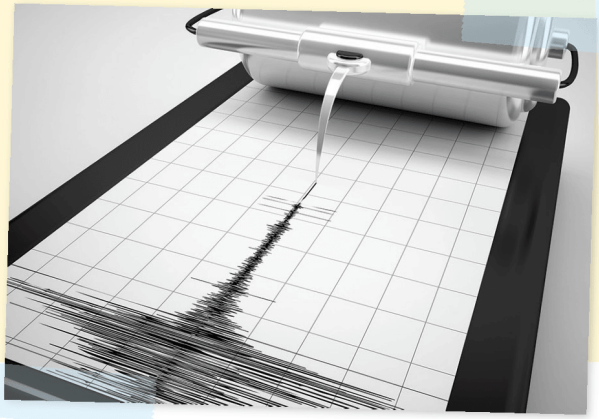
duration: the length of time that something lasts

magnitude: a measure of the amount of energy released by an earthquake

seismometer: a tool that records movements in Earth's crust

Scientists study earthquakes with a tool called a **seismometer**, which detects and records movement in the ground. When an earthquake happens, a seismometer will display a series of zigzag lines that allow scientists to figure out the **duration** and strength of the quake.

In 1935, a scientist named Charles Richter invented a system of measuring earthquakes. This is called the Richter scale. An earthquake is given a number from 1 to 10 to describe its **magnitude**. A magnitude 1 earthquake is so weak that you can't feel it. An 8.0 earthquake would knock you off your feet! Since scientists began using the Richter scale, the strongest earthquake ever recorded was a 9.5 in Chile in 1960.



Write *true* or *false*.

1. A seismometer measures the magnitude of an earthquake. _____

2. A magnitude 10 earthquake is the strongest. _____

Skill:
Interpret information in graphic representations.

Richter Scale

This chart shows the effects of earthquakes of different magnitudes around the world, as well as how many of them are recorded per year. Use the information in the chart to complete the sentences below.

Richter Scale Magnitude	Average Number of Earthquakes (per year)	Earthquake Effects
2.0–2.9	1,300,000	Not felt but are recorded on seismometers
3.0–3.9	130,000	Barely noticeable; hanging objects may swing
4.0–4.9	13,000	Most people notice them; buildings shake
5.0–5.9	1,300	Everyone notices them; windows may break
6.0–6.9	134	Walls may crack; chimneys may fall
7.0–7.9	18	Ground cracks; weak buildings fall down
8.0–8.9	1	Many buildings fall; bridges collapse
9.0–9.9	1 per 20 years	Complete devastation over a wide area
10.0+	Extremely rare	Never recorded

1. Earthquakes of a magnitude of 9.0 happen at a rate of about _____ every _____ years.

2. Usually, an earthquake must be at least a magnitude of _____ to cause any buildings to fall down.

3. Most people notice earthquakes that are a magnitude of _____ or greater.

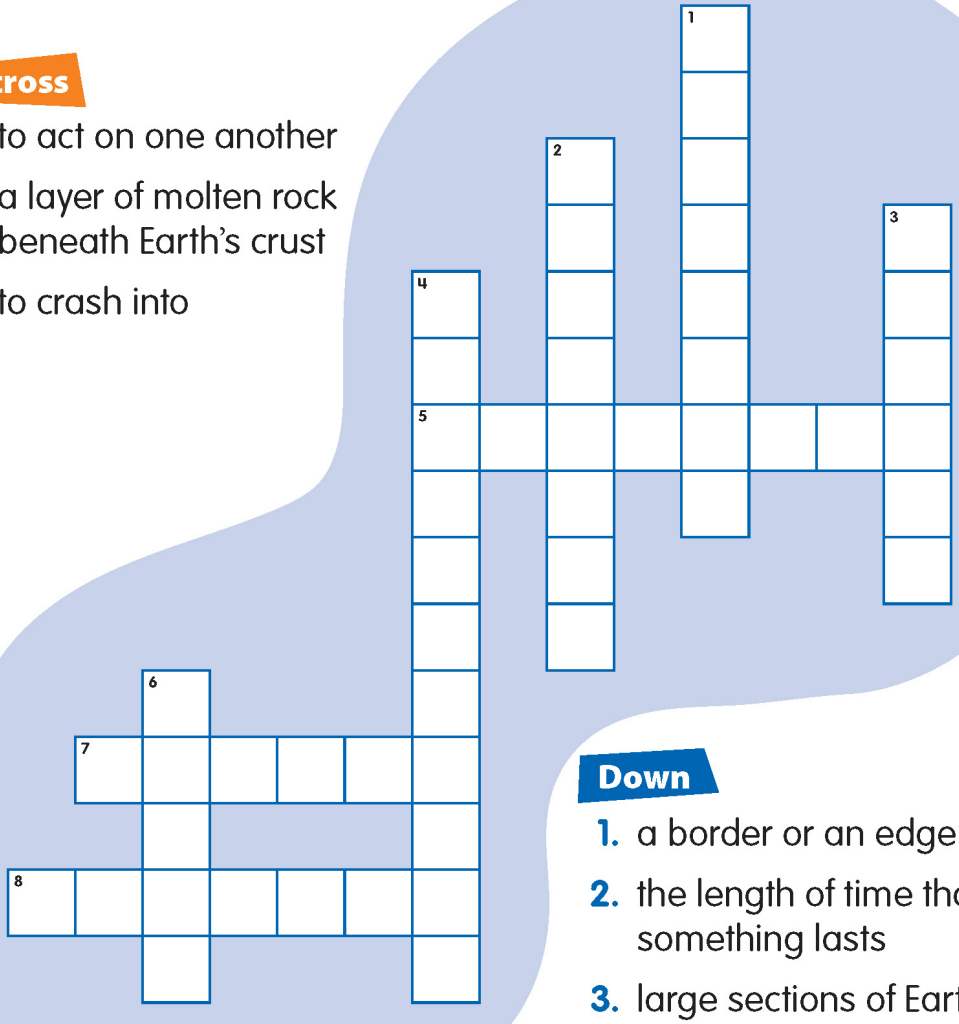
4. The number of earthquakes between magnitudes of 3.0 and 6.9 that happen every year is about _____.

Earthquakes

Earthquakes Crossword Puzzle

Use the vocabulary words to complete the crossword puzzle.

seismometer	duration	mantle	collide
boundary	interact	plates	fault



Across

5. to act on one another
7. a layer of molten rock beneath Earth's crust
8. to crash into

Down

1. a border or an edge
2. the length of time that something lasts
3. large sections of Earth's crust
4. a tool that records movements in Earth's crust
6. a break in Earth's crust where blocks of rock are moving in different directions

Skill:
Apply content vocabulary.

Earthquakes

Skills:

Conduct experiments and draw conclusions about the results.

Earthquake-Proof

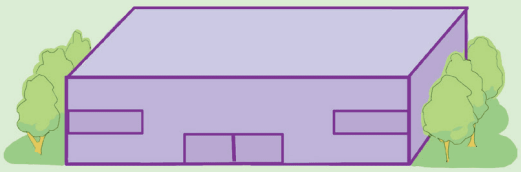
Engineers in areas where earthquakes happen must think about how to make buildings that can stand up to damage from a powerful quake. In this experiment, you will use the information on earthquake-proof designs to make two different buildings. You will then test how these buildings stand up against an earthquake.

What You Need

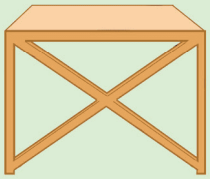
- toothpicks (at least 30)
- miniature marshmallows (at least 30)
- large baking dish
- 1 or 2 boxes of flavored gelatin (and help from an adult to make it)
- plastic wrap

Earthquake-Proof Design Tips

- Buildings with large, wide bases are stronger than those with small, narrow bases.
- Shorter buildings are more earthquake-proof than taller ones.
- Earthquake-proof buildings usually have cross-bracing, or triangle-shaped designs.



▲ large, wide base



◀ cross-bracing

Earthquakes

Directions

1. Prepare the gelatin with an adult the night before the experiment, following the instructions. Pour the gelatin mixture into the baking dish so that it completely covers the bottom of the dish and is at least 1" thick.
2. Put plastic wrap on the baking dish and place it in the refrigerator.
3. The next day, use the marshmallows and toothpicks to create two different buildings: one that you think will stand up to an earthquake, and one that you think will fall down. Place them on top of the gelatin in the baking dish.
4. First, shake the baking dish back and forth slowly and softly. Next, shake it quickly and forcefully. Then answer the questions.

What Did You Discover?

1. What happened when you shook the dish softly? Did either of your buildings fall over? Which one seemed stronger?

_____

_____

2. What happened when you shook the dish harder? Did either of your buildings fall over? Which one seemed stronger?

_____

_____

3. What might you do to make your buildings stronger?

_____

_____

Skills:
Collect, record, and analyze information.

Famous Earthquakes

There are many places on Earth where earthquakes happen often. Sometimes these earthquakes are so strong that they cause a lot of damage. People remember these earthquakes for years and years. Choose one of the areas below and research to find out about a famous earthquake that happened in that area. Then use the research to answer the questions.

Japan Alaska California Indonesia Chile

1. Where did the earthquake take place? _____

2. When did the earthquake take place? _____

3. What was the magnitude of the earthquake? _____

4. What effect did the earthquake have on the surrounding area? What type of damage did it do? Did it cause any other types of natural disasters (tsunamis, landslides, etc.)?

_____

_____

_____

_____

_____

_____

_____

Earthquakes

Page 42

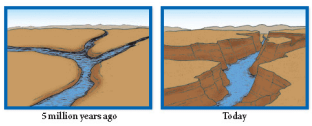
Application

Skills:
Write an opinion piece supporting a point of view with reasons.
Draw illustrations that show scientific concepts.

Weathering & Erosion

How the Canyon Became Grand

Think about how the land in the area of the Grand Canyon probably looked five million years ago. Think about how it looks now. In what ways has it changed? Explain what forces helped to make those changes.



5 million years ago | Today

Answers will vary but must show an understanding of how erosion and weathering brought on the change from a mountainous area to a deep, wide canyon with a river running through it.

What do you think the Grand Canyon will look like five million years in the future? Draw it.

Draw It!

Page 43

Reading

Concept:
Glaciers are large sheets of ice that are found in places that are cold year-round.

Glaciers

What Are Glaciers?

Define It!

glacier: a slow-moving mass of ice

pressure: the weight or force produced when something presses against something else

Have you ever seen a snow-topped mountain? If so, you may have been looking at a **glacier**. Glaciers are large sheets of ice that form in places where more snow falls than melts. As layers of snow build upon one another, the weight from the top layers presses down on the layers underneath. This **pressure** turns the snow to ice, like when you squeeze fluffy snow into a hard snowball.

Because glaciers form slowly, most are found in places that are cold year-round. These places include Greenland, Antarctica, Alaska, and the tops of mountains.

This glacier sits on top of a mountain in Chile.

Complete the sentences.

1. Glaciers can only be found in places that are cold throughout the entire year.
2. Glaciers form in places where more snow falls than melts.

Page 44

Concepts:
Glaciers are moving objects that can advance and retreat.
Movement of glaciers has helped to shape the land.

Glaciers

Moving Ice

Define It!

advance: to move forward

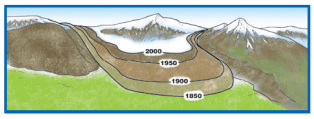
massive: very large

retreat: to move backward

Glaciers might appear to stay in one place, but they are actually "rivers" of ice that flow downhill. Glaciers can **advance** and **retreat** great distances, depending on the amount of snow that has fallen or ice that has melted. When a glacier advances, it flows farther downhill or spreads out. When a glacier retreats, it moves backward. This is because the ice is melting faster than the glacier is growing.

Glaciers are the largest moving objects on Earth, scraping rocks and soil from their paths like giant bulldozers. Movement of these **massive** sheets of ice can reshape the land over thousands of years.

Look at the diagram of a glacier. The lines show how far the ice retreated between the years 1850 and 2000.



During which period of time did the glacier retreat the most? 1900 to 1950

Page 45

Concepts:
Glaciers shape the land by erosion.
Glaciers can leave behind moraines and basins.

Glaciers

Glaciers Shape the Land

Define It!

basin: a large hole in the ground that can contain water

debris: small pieces of rock

moraine: a ridge of loose rock and soil created by a glacier and left behind when the glacier melts

ridge: a long and narrow raised area

One way that glaciers shape the surface of our planet is by erosion. The ice carries broken rocks and soil over long distances and deposits the **debris** far from its original location. One of the best examples of this kind of erosion is California's Yosemite Valley. Huge glaciers carved a giant U-shaped valley in the rock and left behind **ridges** of dirt and gravel called **moraines**.

In other places, erosion by glaciers created lakes. The Great Lakes were formed from **basins** scooped out by moving glaciers. When the ice melted, these basins filled with water.

Yosemite Valley

Name two famous places created by glaciers.

1. Yosemite Valley
2. The Great Lakes

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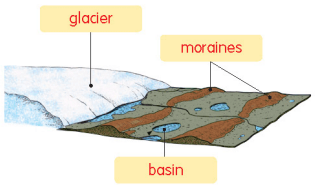
Visual Literacy

Skill:
Label images that have self-scientific concepts.

Glaciers

Moraines and Basins

Look at the diagram. Label the *glacier*, *moraines*, and *basin*.



Write *true* or *false*.

1. Moraines create ridges of loose rock and soil. false
2. Moving glaciers can scoop out basins in the land. true
3. When glaciers melt, they can leave behind moraines. true
4. Both basins and moraines are created by erosion from glaciers. true
5. The Great Lakes were formed from moraines created by glaciers. false

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Vocabulary Practice

Skill:
Apply content vocabulary.

Glaciers

Either/Or Questions

Write each answer.

1. Is something that is massive very large **or** very small? very large
2. When a glacier moves backward, is it advancing **or** retreating? retreating
3. Were the Great Lakes formed from basins **or** moraines? basins
4. Does pressure from the weight of the snow **or** erosion of the land help to form glaciers? pressure
5. Is debris deposited by mountains **or** by glaciers? glaciers
6. When a glacier flows farther downhill, is it retreating **or** advancing? advancing
7. Are moraines large holes in the ground **or** ridges of dirt and gravel? ridges of dirt and gravel

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Glaciers

	Observations
Ice cube on foil	foil scratched and tore
Ice cubes in tub	ice melted and left sand behind

What Did You Discover?

1. What happened when you rubbed the ice cube across the foil? It scratched or tore the foil.
2. What was left in the plastic tub after the ice cubes melted? What would this be called when a real glacier melts? water and sand; a moraine
3. What did the experiment show you about the ways that glaciers change Earth's surface? Glaciers can move rock, and these rocks can scratch and reshape Earth's surface.

Page 50

Application

Skill:
Write an opinion piece supporting a point of view with reasons.

Glaciers

Melting Ice

Today we live in a very warm period, and glaciers are on the move—backward! Most glaciers are melting faster than they are growing, and this has scientists worried about the future of our planet.

This sign reads "The glacier was here in 1908."

Pretend that you are a scientist studying the impact of the changing glaciers on the world today. What are five questions you would ask?

Example
What might happen if all the glaciers in Antarctica were to completely melt?

Examples:

1. How cold is the air around the glaciers?
2. Is the glacier advancing or retreating?
3. How fast is the glacier moving?
4. Where does the water from melting ice go?
5. How old is the glacier?

Page 51

Reading

Concepts:
Earth's crust is made up of plates.
When the plates move suddenly, an earthquake happens.

Earthquakes

A Surface Made of Plates

Define It!

fault: a break in Earth's crust where blocks of rock are moving in different directions

gradual: taking place slowly

mantle: a layer of molten rock beneath Earth's crust

plates: large sections of Earth's crust

The outer layer of Earth is called the crust. The crust is made of different kinds of rock. Earth's crust is broken into many large pieces called **plates**. All the land and oceans on Earth lie on top of these plates. Beneath the plates is the hot, soft **mantle**. The mantle moves and carries the plates along with it.

The movement of plates can be **gradual** or sudden. When plates move suddenly, an earthquake happens. Part of the ground may lift up several feet, or cracks in the earth may appear. The place where Earth's crust breaks is called a **fault**.

Use the map to find where you live. Write the name of the plate you are on.

Answers will vary.

Page 52

Concepts:
Earthquakes happen along the boundaries of plates.
Plates interact along their boundaries in different ways.

Earthquakes

Moving Plates

Define It!
boundary: a border or an edge
collide: to crash into; to come together
interact: to act on one another

Earthquakes happen along the **boundaries** of plates, or where the edge of one plate meets another. Plates **interact** along their boundaries as they move in different directions.

Some plates slide past each other. The famous San Andreas Fault in California is an example of plates sliding in opposite directions. Other plates **collide**, or run into each other. When plates collide, they cause powerful earthquakes and can even build mountains. The Himalaya Mountains in Asia are the result of two plates colliding. In other places, plates move apart from each other. This does not cause very strong earthquakes, but ocean basins are often created when two plates pull apart.

1 2 3

Write whether the diagrams above show plates *sliding past* each other, *colliding*, or *moving apart*.

1. moving apart
2. sliding past
3. colliding

Shaping the Earth

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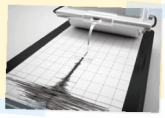
Page 53



Concept:
Scientists use different tools to measure and classify earthquakes.

Earthquakes

Measuring Earthquakes

Define It!
duration: the length of time that something lasts
magnitude: a measure of the amount of energy released by an earthquake
seismometer: a tool that records movements in earth's crust

Scientists study earthquakes with a tool called a **seismometer**, which detects and records movement in the ground. When an earthquake happens, a seismometer will display a series of zigzag lines that allow scientists to figure out the **duration** and strength of the quake.

In 1935, a scientist named Charles Richter invented a system of measuring earthquakes. This is called the Richter scale. An earthquake is given a number from 1 to 10 to describe its **magnitude**. A magnitude 1 earthquake is so weak that you can't feel it. An 8.0 earthquake would knock you off your feet! Since scientists began using the Richter scale, the strongest earthquake ever recorded was a 9.5 in Chile in 1960.

Write *true* or *false*.

1. A seismometer measures the magnitude of an earthquake. false
2. A magnitude 10 earthquake is the strongest. true

Shaping the Earth

53

Page 54

Visual Literacy

Skill:
Interpret information in graphic representations.

Earthquakes

Richter Scale

This chart shows the effects of earthquakes of different magnitudes around the world, as well as how many of them are recorded per year. Use the information in the chart to complete the sentences below.

Richter Scale Magnitude	Average Number of Earthquakes (per year)	Earthquake Effects
2.0–2.9	1,300,000	Not felt but are recorded on seismometers
3.0–3.9	130,000	Barely noticeable; hanging objects may swing
4.0–4.9	13,000	Most people notice them; buildings shake
5.0–5.9	1,300	Everyone notices them; windows may break
6.0–6.9	134	Walls may crack; chimneys may fall
7.0–7.9	18	Ground cracks; weak buildings fall down
8.0–8.9	1	Many buildings fall; bridges collapse
9.0–9.9	1 per 20 years	Complete devastation over a wide area
10.0+	Extremely rare	Never recorded

1. Earthquakes of a magnitude of 9.0 happen at a rate of about 1 every 20 years.
2. Usually, an earthquake must be at least a magnitude of 7.0 to cause any buildings to fall down.
3. Most people notice earthquakes that are a magnitude of 4.0 or greater.
4. The number of earthquakes between magnitudes of 3.0 and 6.9 that happen every year is about 144,434.

Shaping the Earth

54

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Vocabulary Practice

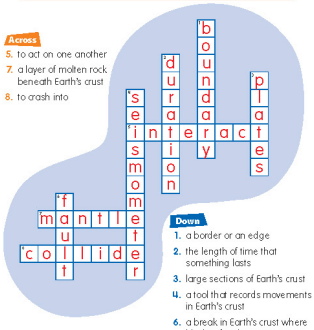
Skill:
Apply content vocabulary.

Earthquakes

Earthquakes Crossword Puzzle

Use the vocabulary words to complete the crossword puzzle.

seismometer duration mantle collide
boundary interact plates fault



Across
5. to act on one another
7. a layer of molten rock beneath Earth's crust
8. to crash into

Down
1. a border or an edge
2. the length of time that something lasts
3. large sections of Earth's crust
4. a tool that records movements in Earth's crust
6. a break in Earth's crust where blocks of rock are moving in different directions

Shaping the Earth

55

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Earthquake-Proof, continued

Earthquakes

Directions

1. Prepare the gelatin with an adult the night before the experiment, following the instructions. Pour the gelatin mixture into the baking dish so that it completely covers the bottom of the dish and is at least 1" thick.
2. Put plastic wrap on the baking dish and place it in the refrigerator.
3. The next day, use the marshmallows and toothpicks to create two different buildings: one that you think will stand up to an earthquake, and one that you think will fall down. Place them on top of the gelatin in the baking dish.
4. First, shake the baking dish back and forth slowly and softly. Next, shake it quickly and forcefully. Then answer the questions.

What Did You Discover?

1. What happened when you shook the dish softly? Did either of your buildings fall over? Which one seemed stronger?
   Answers will vary.
2. What happened when you shook the dish harder? Did either of your buildings fall over? Which one seemed stronger?
   Answers will vary.
3. What might you do to make your buildings stronger?
   Answers will vary.

Shaping the Earth

57

Page 58

Application

Skills:
Collect, record, and analyze information.

Earthquakes

Famous Earthquakes

There are many places on Earth where earthquakes happen often. Sometimes these earthquakes are so strong that they cause a lot of damage. People remember these earthquakes for years and years. Choose one of the areas below and research to find out about a famous earthquake that happened in that area. Then use the research to answer the questions.

Japan Alaska California Indonesia Chile

1. Where did the earthquake take place? Answers will vary.
2. When did the earthquake take place?
3. What was the magnitude of the earthquake?
4. What effect did the earthquake have on the surrounding area? What type of damage did it do? Did it cause any other types of natural disasters (tsunamis, landslides, etc.)?

Shaping the Earth

58

Page 59

Reading

Concepts:
There are three types of volcanoes: active, dormant, and extinct.
Most of the world's volcanoes are located along the edge of the Pacific Ocean.

Volcanoes

Where Are Volcanoes?

Define It!
active: a volcano that is currently erupting, showing signs of erupting, or has erupted recently
dormant: a volcano that hasn't erupted recently, but is expected to erupt again
erupt: to release lava, ash, and gases
extinct: a volcano that will likely not erupt again

There are thousands of volcanoes on our planet. Most of them are **dormant** or **extinct**. This means that they haven't **erupted** for a long time, or they will not erupt again. However, about 1,500 volcanoes on Earth are still **active**. This means that they have erupted recently and could erupt again in the future.

Most of the world's active volcanoes are in an area called the Ring of Fire. The Ring of Fire is a band of volcanoes that circles the Pacific Ocean. These volcanoes are mostly located along the boundary of the Pacific Plate.

Answer the questions.

1. Where are most of the world's active volcanoes located?
   Ring of Fire
2. About how many volcanoes on Earth are still active? 1,500

Shaping the Earth

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Page 60

Concepts:
Hot molten rock beneath Earth's crust is called magma.
Hot molten rock often erupts from a volcano is called lava.

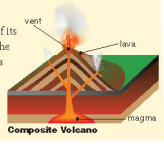
Volcanoes

From Magma to Lava

Define It!
lava: hot melted rock that flows from a volcano
magma: hot melted rock that comes from Earth's mantle
vent: an opening in a volcano through which lava can flow

We may see volcanoes rise high above Earth's surface, but they also reach down into the middle layer of Earth, the mantle. Volcanoes form when hot rock rises from the mantle through cracks in the crust. The hot, soft rock of the mantle is always moving. As the rock gets closer to the crust, there is less pressure pushing against it. The rock begins to expand and turns from a solid into liquid **magma**.

When a volcano erupts, magma pushes up through a tube in the volcano and out of its **vent**. When magma reaches the surface, we call it **lava**. As lava cools, it turns from a liquid back into a solid. Now it is a hard rock, not soft the way it was in the mantle.



Composite Volcano

Write *true* or *false*.

1. Magma comes from the mantle. true
2. As magma cools on Earth's surface, it becomes hard rock. false

Shaping the Earth

60

Page 61

Concept:
Volcanoes can erupt violently or slowly and steadily.

Volcanoes

Ways Volcanoes Erupt

Define It!
chamber: a space inside something
debris: small pieces of broken rock, lava, and other materials blown out during an eruption
violent: very strong or powerful

When volcanoes erupt, they can be either **violent** or quiet and steady. Quiet, steady eruptions are known as lava flows. Lava pours through a vent in the crust onto Earth's surface in a slow, constant stream. The Hawaiian Islands were created by this kind of eruption.


Mt. Etna in Indonesia erupted violently in 2011.


Lava flows slowly and steadily from Mt. Kilauea in Hawaii.

Violent eruptions mostly happen in volcanoes that have a deep **chamber** that fills with magma. As magma fills the chamber, it releases gases. These gases build up under the layers of rock at the top of the volcano. Eventually, the pressure is so great that the volcano explodes, sending ash, gases, and other volcanic **debris** into the air. The eruption that destroyed the ancient city of Pompeii in Italy is an example of a violent eruption.

Write whether the sentence describes a *violent eruption* or a *quiet, steady* one.

1. Ash, gases, and debris explode into the air. violent
2. Lava oozes from the vent in a slow stream. quiet, steady

Shaping the Earth

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