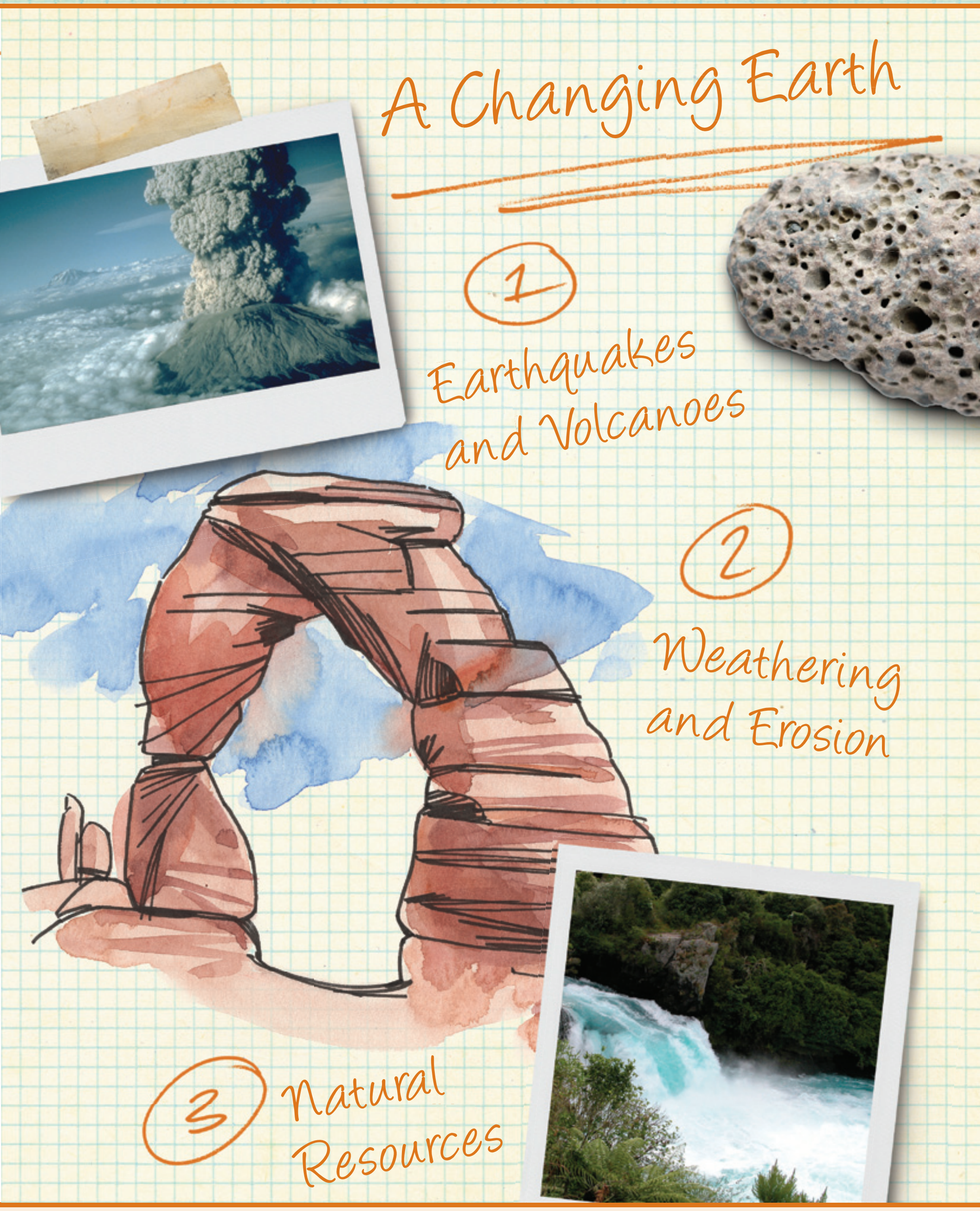
Unit 1 Overview

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 1 Earthquakes and Volcanoes					
1	3–5	1–3	1		• Introduction to book • Chapter opener • Preview the unit and chapter content
2	6–9	4–7	2–3		• Plate tectonics • Causes of earthquakes, faults • Seismic waves • Detecting earthquakes
3	10–13	8–11	3–6	Quiz 1–A	• Measuring earthquakes • Building for earthquakes • Related disasters
4	14–15		7–8		**Activity: Practice using a scientific method** • Formulating hypothesis • Recording data
5–6	16–17	12–13	9–10	Rubric	**Activity: Construction Site** • Experimenting to discover structures that can withstand earthquakes • Identifying and controlling variables
7	18–21	14–17	11–12		• Causes of volcanoes • Locations of volcanoes • Classifying volcanoes
8–9	22–23	18–19	13–14	Rubric	**Activity: Create an Eruption** • Make a model of a volcano
10	24–26	20–22	15–16	Quiz 1–B	• Effects of volcanoes • Dangers of volcanoes • Products of volcanoes • Other thermal eruptions
11–12	27	23	17–18	Rubric	**Exploration: I.N.V.E.N.T.** • Design equipment to help scientists study volcanoes
13	28–29				• Using graphic organizers to identify related concepts
14	30	24	19–20		**Chapter Review** • Apply knowledge to everyday situations
15	30			Chapter 1 Test	**Chapter 1 Test**
Chapter 2: Weathering and Erosion					
16	31	25	21		• Preview chapter content
17	32–35	26–29	22		• Rock Cycle • Mechanical Weathering
18	36–39	30–33	22–24	Quiz 2-A	• Chemical Weathering • Caves
19	40–41		25–26		**Activity: Measuring** • Measure length and width • Measure mass and volume
20	42–44	34–36	27–28	Quiz 2-B	• Soil particles and texture • Soil horizons
21	45	37	29–30	Rubric	**Exploration: Soil Detective** • Determining the texture of soil • Using a flow chart
22–23	46–47	38–39	31–32	Rubric	**Activity: Retaining the Right Amount** • Experimenting with soil samples • Predicting the amoung of particles needed for a soil sample • Measuring accurately
24	48–51	40–43			• Agents of erosion • Mass movements • Steam erosion
25	52–53	44–45	33–34	Rubric	**Activity: Stream Erosion** • Measuring accurately • Modeling erosion • Experimenting with ways to lessen erosion
26	54–57	46–49	35–36	Quiz 2-C	• Wave erosion • Wind erosion • Ice erosion
27	58–59		37–38		• Using the PQ3R method to read informational text
28	60	50	39–40		**Chapter Review** • Apply knowledge to everyday situations
29	60			Chapter 2 Test	**Chapter 2 Test**

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 3: Natural Resources					
30	61	51	41		• Preview chapter content
31	62–65	52–55	42		• Fossil fuels (petroleum, coal, natural gas) • Nuclear energy
32	66–67	56–57	43–44	Rubric	**Activty: Clean Up the Spill** • Modeling an oil spill cleanup • Predicting success of cleanup methods • Inferring how cleanup methods work for actual oil spills
33	68–71	58–61	45–46	Quiz 3-A	• Hydroelectric energy • Geothermal energy • Wind energy • Solar energy
34	72–75	62–65	47–48	Quiz 3-B	• Minerals • Metals • Soil conservation
35	76–77	66–67	49–50	Rubric	**Activity: Erosion Prevention** • Forming a hypothesis about limiting erosion • Inferring methods of soil conservation
36–37	78–83	68–73	51–52	Quiz 3-C	• Water cycle • Oceans • Fresh water • Frozen water • Reduce, reuse, recycle
38	84–85		53–54		**Exploration: Water Conservation** • Water usage in Bible times
39	86–87	74–75	55		**Technology: Autonomous Underwater Vehicles** • Identifying examples of technology • Explaining uses for AUVs
40	88	76	56		**Chapter Review** • Apply knowledge to everyday situations
41	88			Chapter 3 Test	**Chapter 3 Test**



Objectives

- Recognize the interrelationship of science concepts
- Explain that ideas about science change, but that God never changes
- Preview the unit and chapter content

Unit Introduction

Science 6 is divided into six units. Grouping chapters together in units helps the student understand relationships between the science concepts.

In Unit 1 the student will see how the volcanoes and earthquakes discussed in Chapter 1 move the earth's surface and expose more surface area to the processes of weathering and erosion discussed in Chapter 2.

Many minerals and ores discussed in Chapter 3 are found in volcanic areas.

Good soil management, as discussed in Chapter 3, helps prevent the wind and water erosion discussed in Chapter 2.

Use every opportunity that arises to help the student connect new information with material that he has already learned.

Look through Unit 1. What are the topics of the chapters we will study in this unit? Possible answers: earthquakes and volcanoes, weathering and erosion, natural resources

Why do you think these chapters are organized into the same unit? Answers will vary. Elicit that all of the chapters are about physical attributes of the earth.

One way to see the greatness of God is to look at the way all creation fits together. Although the earth is under the curse of sin, God uses all things for His glory. Whether it is a thorn bush that provides shelter for an animal or a volcano that enriches the soil, God controls all of creation.

TEACHER HELPS

Science notebook
You may choose for the student to keep a science notebook. The notebook provides a place to keep Activity Manual pages as well as other papers used in Activities, Explorations, and other science-related projects.

Pages can be organized by chapter or grouped by type, such as Reinforcement, Review, Activity, etc.

Keeping a notebook will help the student develop organizational skills. The notebook can also be used in the student's portfolio to demonstrate his progress and ability to think scientifically.

Plan to check the content, organization, and neatness of the notebook at least once per chapter.

Design theme
Each unit and chapter opens with what could be pages from a journal kept by a scientist. The pages include sketches, photographs, and items that reflect the unit and chapter content.

Unit photos
The photos on page 1 are of Mt. St. Helens erupting on July 22, 1980, with Mt. Adams in the background and the Waikato river in New Zealand.

Weblinks
The BJU Press website offers additional information and links you may find helpful throughout the unit.

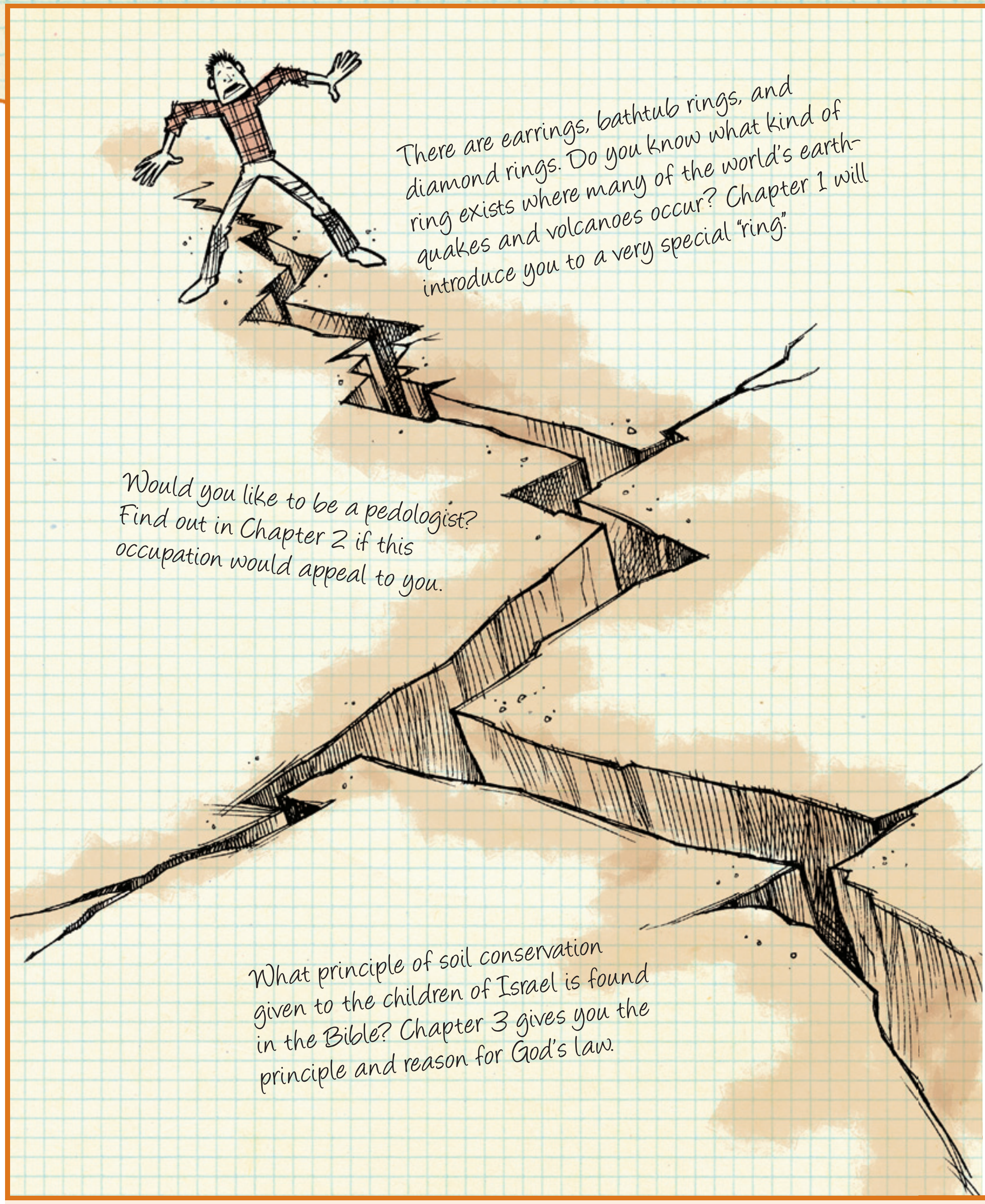
www.bjupress.com/resources

Project Idea

The project idea presented at the beginning of each unit is designed to incorporate concepts of each chapter as well as information gathered from other resources. You may choose to use the project as a culminating activity at the end of the unit or as an ongoing activity while the chapters are taught.

Unit 1: A New Town

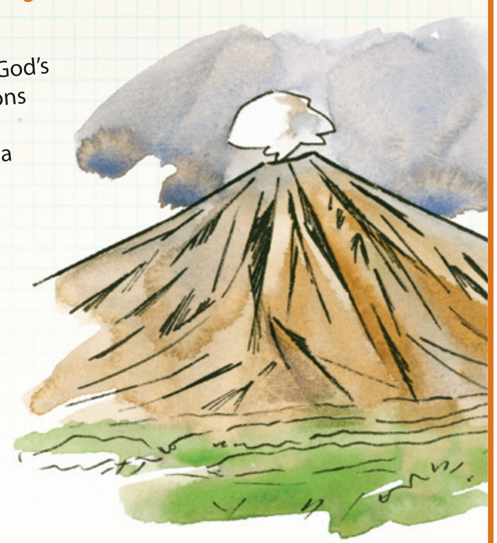
Design a map of a region that incorporates land features from the unit. Plan a new town that makes use of the land features and natural resources available. The town should include some of the following: industry, residential areas, transportation, agriculture, businesses, communication, parks, and recreation.



1

Earthquakes and Volcanoes

Throughout history man has tried to explain God's wonderful creation. Many of these explanations seem laughable to us today. Some people thought that earthquakes occurred because a huge turtle moved. Others believed that volcanoes erupted because a Hawaiian goddess was angry. Many beliefs in false gods came from attempts to explain natural events. Today man often uses theories or laws to explain the world around him. But only God knows all things. Man continually has to revise his ideas as God reveals more and more about His creation. There are many aspects of creation that man will never fully understand until he meets his Creator face to face.



3

Introduction

God's Word tells of many great and mighty things that man cannot understand without God's revelation. As Christians grow in Christ, God reveals more of Himself to them through His Word.

God's creation also contains things that are beyond man's understanding. Through the ages man has tried to explain the world around him. But all knowledge and understanding comes from God. As God allows man to learn more and more about His creation, man must constantly reevaluate his ideas. It is important for students to understand that all truth, whether scriptural or scientific, comes from God.

Teach for Understanding

Provide time for the student to complete Looking Ahead, Activity Manual page 1. For part B, encourage the student to think of things he would like to learn about earthquakes and volcanoes. He should write his answers in question form, such as, "Why do some earthquakes cause more damage than others?"

Provide the answers for part A and allow the student to check his work. After the chapter is finished, you may choose to have him look back at this page and check his understanding of the ones he had missed. As time allows, discuss his questions about earthquakes and volcanoes. You may choose to provide trade books or other resources to help answer questions that are beyond the scope of this chapter.

Activity Manual

Preview, page 1

The Looking Ahead page is intended to assess the student's prior knowledge before beginning the chapter.

HISTORY

Turtles and earthquakes

Many stories about what causes earthquakes exist. One tale tells of the earth held on the backs of four elephants. These elephants stand on the back of a turtle that stands on a cobra. If any of the animals moves, an earthquake occurs. Another legend places the earth on the backs of seven turtles. As the turtles move away from each other, earthquakes occur.

Hawaiian goddess and volcanoes

Religions of the islands in the Pacific Ocean have many goddesses. Pele, the goddess of fire, is specific to Hawaii. People there believe Pele lives in a crater on one of the islands and whenever she becomes angry, a volcano erupts.

TEACHER HELPS

Chapter preview

Other preview and prereading activities may include using a K-W-L chart, a probe, or an anticipation guide.

Diagrams

Diagrams from the Student Text are included on the Teacher's Toolkit CD.

Chapter photo

The photo on page 3 is of a collapsed overpass on Highway 10 in Northridge /Reseda (California) area at the epicenter of an earthquake in 1994.

Objectives

- Identify some of the results of the constant changes on the earth's surface
- Explain the theory of plate tectonics
- Infer that plate boundaries are unstable areas of the earth's surface
- Interpret diagrams of the parts of the earth and the different kinds of faults
- Relate the movement of plates to faults and earthquakes

Materials

- several dry sticks, each about 1 cm in diameter
- eye protection (glasses or safety goggles)
- world map

Vocabulary

lithosphere	plate boundary
plate	earthquake
theory of plate tectonics	fault

Introduction

Give one student eye protection and a stick. Instruct the student to try to break the stick slowly. After the stick breaks, ask the following questions.

Did the stick break easily? It probably did not.

How did the stick feel as it bent? There was tension.

Did the stick break quickly or slowly? It probably bent for a while and then broke quickly.

Allow several other students to try breaking sticks.

Conclude that tension built in each stick before the stick broke suddenly.

This lesson presents another situation in which tension builds and is released suddenly.

Teach for Understanding

Purpose for reading questions help prepare the student for reading the lesson pages.

Purpose for reading

What beliefs do some scientists have about the surface of the earth and the formation of land masses?

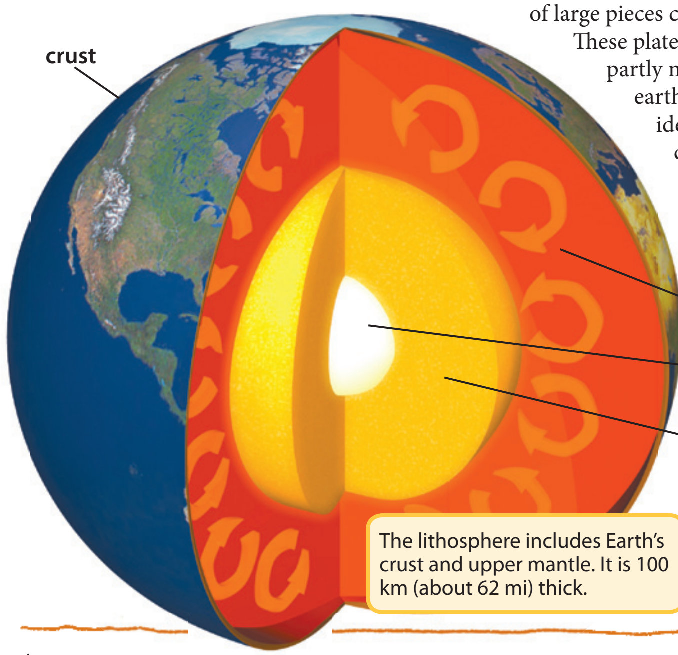
What causes earthquakes?

In 1811–12 a series of earthquakes hit New Madrid (MA drid), Missouri. One of these earthquakes was so strong that it rang bells in Boston's church steeples over 1,100 miles away and toppled chimneys in Virginia. It even caused the Mississippi River to run backwards for a while! A letter written at that time compares the movement of the earth to waves in a gentle sea. Few of us experience the ground moving like the sea. However, the ground that we think of as solid and steady is actually in continuous motion. Sometimes this movement causes large shifts in the earth's surface, resulting in earthquakes. At other times, the earth's surface splits and allows the molten rock beneath to escape as a volcano. The earth's surface is constantly changing.

Earthquakes

Plate Tectonics

The earth is made up of the inner and outer core, the mantle, and the crust. The earth's crust is quite thin compared to the other parts of the earth. The portion of the crust that forms the continents is approximately 45 km (25 mi) thick. The crust under the ocean is even thinner—only about 5 to 8 km (2 to 4 mi) thick. Some scientists believe that the earth's **lithosphere** (LITH uh sfeer), the crust and upper area of the mantle, consists of large pieces called **plates**. These plates float on the partly melted rock in the earth's mantle. The idea that the earth's crust is made up of moving plates is called the **theory of plate tectonics**.



The lithosphere includes Earth's crust and upper mantle. It is 100 km (about 62 mi) thick.

4

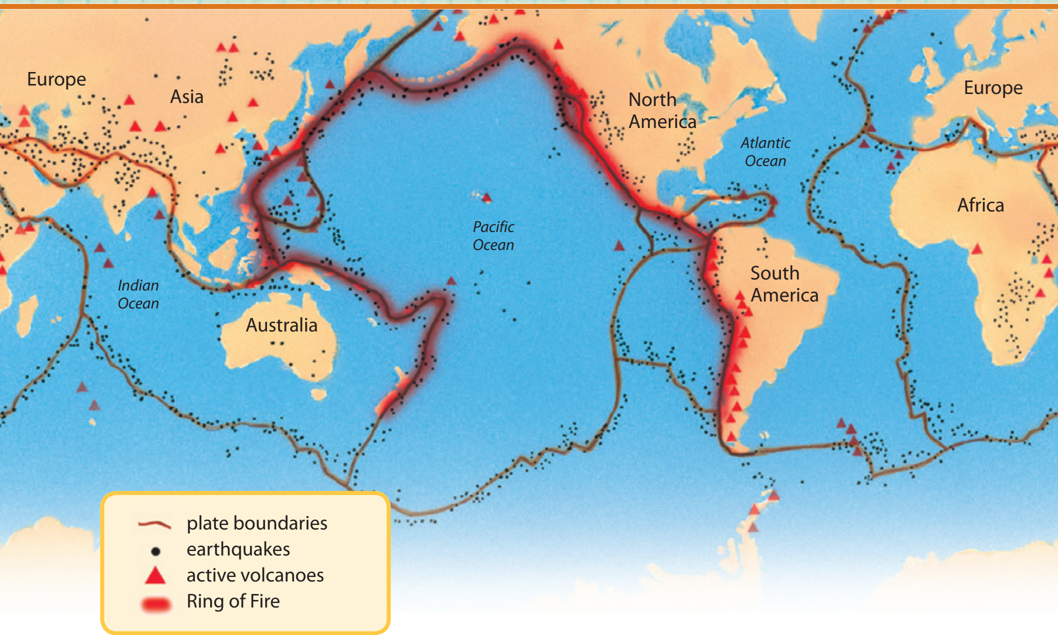
SCIENCE BACKGROUND

Scientific theories
As a scientist works, he may develop and test many hypotheses. A hypothesis is a reasonable, testable statement based on available information that tries to predict the results of an experiment. If a scientist has discovered and tested an idea which consistently explains a certain phenomenon, it may be referred to as a theory by the scientific community. The theory of plate tectonics is one such theory.

Tectonics
Tectonics is the study of the earth's structural features.

Creationists and the Noahic Flood
Creationists have differing views about how mountains and oceans formed after the Noahic Flood.

Convection currents
Scientists think that the hot matter in the earth's mantle moves in convection currents. Hot matter rises, spreads out sidewise, and then cools and falls. This circular motion is similar to the way water boils. As the hot matter spreads out, it moves the plates.



Places where the plates meet are called **plate boundaries**. Scientists think that currents in the molten rock of the earth's mantle may move the plates a few centimeters each year. This movement may cause the plates to separate, to collide, or to slide along their plate boundaries.

Some scientists believe that at one time the earth could have been a single large landmass that they call *Pangaea* (pan JEE uh). Because there was no recorded observation, we cannot be sure that such a landmass existed. We also cannot know how the landmass may have broken into pieces. However, the Bible tells us in the book of Genesis that God sent a great flood to destroy the wickedness on the earth. Genesis 7:11 states that "the fountains of the great deep [were] broken up, and the windows of heaven were opened." Many Creation scientists think that the earth's surface went through catastrophic changes during the Noahic Flood. These changes could have caused the great landmass to break and separate. The plates may have moved with such tremendous force that landforms such as mountains could have been formed as plates collided. Although many scientists believe that landforms took millions of years to form, the Bible teaches that most of them formed rapidly during and after the Flood.

5

SCIENCE MISCONCEPTIONS

Scientists are not sure how certain landforms were formed. We cannot base how the earth may have changed in the past on how it changes now.

New Madrid earthquakes

A series of large earthquakes shook the New Madrid area of Missouri from December 1811 to February 1812. The quakes during this period were estimated to have been between 7.5 and 8.3 on the Richter scale. People felt aftershocks for months afterward. The quakes caused immense damage. They pushed up some large areas of land and made others sink down, creating lakes where lakes had not been before. Movement under the Mississippi River's surface created large waves, and the river looked like it was flowing upstream. For more information on this subject, research Lorenzo Dow's journal, which contains a firsthand account.

Pangaea

Genesis 1:9–10 tells us that God gathered together the waters to let the dry land appear. The word "earth" describing the dry land is singular, but the word "seas" used for the water is plural. In 1858 the Creation scientist Antonio Snider-Pellegrini used these verses to develop the idea of a single landmass existing at one time.

Discussion

What are some results of the earth's continuous motion? Possible answers: earthquakes, volcanoes, changes in the earth's surface

Why is it difficult to be certain about the earth's interior and its movements? Possible answer: Man has limited ability to observe the earth's interior and its movements.

What are the main parts of the earth? crust, mantle, outer core, inner core

Which is thicker, the crust under the continents or the crust under the oceans? the crust under the continents

What is the lithosphere? the crust and upper part of the earth's mantle

What are the large pieces of the lithosphere called? plates

What is the theory of plate tectonics? the idea that the earth's crust is made of moving plates

What do scientists call the places where plates meet? plate boundaries

In what three ways can plates move against each other? collide, separate, and slide

What is Pangaea? a large landmass that some scientists think may have existed at one time

Can we know for sure that Pangaea existed? Why? No; there is no recorded observation of this landmass.

Discuss the map on Student Text page 5.

What do you notice about the locations of volcanoes and earthquakes? They tend to be near plate boundaries. They also tend to be near each other.

Locate the area of the New Madrid earthquakes. Did these earthquakes occur near a plate boundary? no

Where are the nearest plate boundaries to the New Madrid earthquakes? the Pacific coast and the middle of the Atlantic Ocean

From the New Madrid earthquakes, what can you conclude about the relationship of plate boundaries and earthquakes? Possible answer: Not all earthquakes occur along plate boundaries.

What do Creation scientists think caused great changes on Earth? Noah's Flood

Discuss the catastrophic effects that the Noahic Flood had on Earth as time permits.

Discussion

What usually causes an earthquake? the sudden shifting of rocks along plate boundaries

Not all earthquakes occur along plate boundaries. Name an earthquake that was not near a plate boundary. the New Madrid earthquake

What is a fault? a break in the earth's surface along which rock can move

What is an earthquake? the released energy that causes vibrations in the earth's surface

A plate boundary is also a fault because it is a break in the surface of the earth.

Use the world map to locate the places mentioned as faults are discussed.

What are the three kinds of faults? reverse, normal, strike-slip

What determines the kind of fault? how the rocks move against each other

What causes a reverse fault? rocks pushing together until a section of rock moves upward

What sometimes form where continental plates collide with oceanic plates? ocean trenches

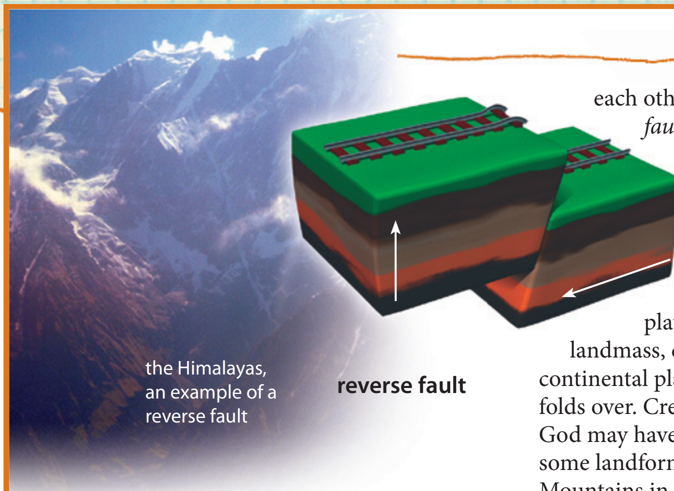
What are some examples of reverse faults? the Himalaya Mountains, Mariana Trench

What causes a normal fault? rocks moving apart

What sometimes fills the gap created by a normal fault at a plate boundary? molten rock from under the crust

What kind of fault is the Great Rift Valley in Africa? a normal fault

What do scientists call a normal fault that occurs under the ocean? sea-floor spreading



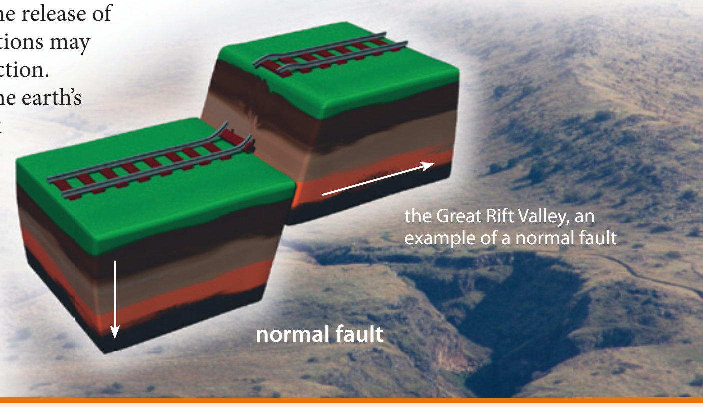
the Himalayas, an example of a reverse fault

Causes of Earthquakes

When two surface plates push and scrape against each other, energy builds up in the moving plates. This energy may build up for many years. But just as a stick only bends so far before it breaks, eventually the rocks along the plate boundaries shift suddenly and release their stored energy, resulting in an **earthquake**. The stored energy causes vibrations that shake and rattle the earth's surface. Sometimes the release of energy is small. These little tremors are so small that no one even feels them. However, if the release of energy is great, the vibrations may cause widespread destruction.

Faults are breaks in the earth's surface along which rock can move. There are three kinds of faults, depending on how the rocks move against each other. A *thrust*, or *reverse*, *fault* occurs where rocks push together until they force a section of rock upward. Colliding plate boundaries are reverse faults. When a continental plate, a plate consisting mainly of landmass, collides with another continental plate, one plate buckles or folds over. Creation scientists think that God may have used this process to form some landforms, such as the Himalaya Mountains in Asia. Where a continental plate collides with an oceanic plate, one plate often slides under the other plate, creating deep ocean trenches, such as the Mariana Trench in the western Pacific.

The second type of fault is a *normal fault*. As rocks move apart, a section of rock may fall between the separating rocks. Where normal faults occur at plate boundaries, the fault sometimes allows molten rock from under the crust to fill in the gap and form new land. The Great Rift Valley in Africa is an example of a separating plate



the Great Rift Valley, an example of a normal fault

6

SCIENCE MISCONCEPTIONS

Plate boundaries are faults, but not all faults occur at plate boundaries.

HISTORY

San Francisco earthquake
During the early 1900s San Francisco was the largest city on the West Coast. Many people lived in closely built wooden structures. An earthquake that struck in 1906 devastated the city. Buildings and roads collapsed. Trees were uprooted. Telephone lines fell down, and water pipes broke. Fires started and burned for three days because water was not available for fighting them. It is said that more buildings were lost to the fires than to the actual earthquake.

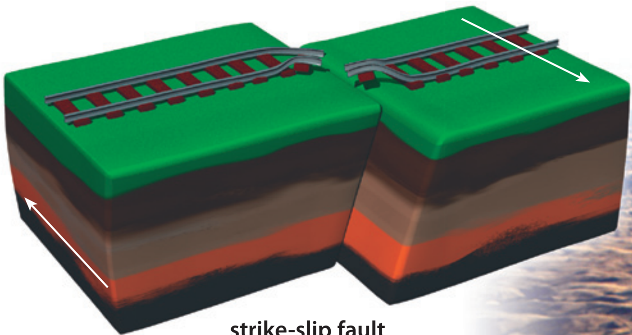
boundary. New land is also forming along the Mid-Atlantic Ridge in the Atlantic Ocean. As molten rock pushes up between plates, it causes them to spread apart. The magma then cools, forming new land. This is called *sea-floor spreading*.

A *strike-slip fault* occurs as rocks move horizontally past each other. One of the most famous strike-slip faults is the San Andreas Fault in California. It is the site of many earthquakes.

There are other reasons an earthquake might happen. Adding or removing large amounts of earth may cause the earth to shift or move, resulting in an earthquake. This can occur during the construction of large buildings or dams. Sometimes the movement of molten rock under a volcano can also be a cause. All of these causes, however, usually create only small earthquakes.

Imagine what happens to pipes, gas lines, and power and telephone lines when an earthquake shakes an urban area. Even if buildings have been constructed to withstand earthquakes, many things still cannot bend and move with the shaking of the earth.

It is God who allows all things to happen in His creation, including earthquakes. Psalm 104:32 reminds us of God's mighty power. Just a look from God, the Creator and Sustainer of all things, can make the earth tremble. When earthquakes occur, it is not by chance.



strike-slip fault

the San Andreas Fault, an example of a strike-slip fault

QUICK CHECK

1. What are the main parts of the earth?
2. Give two or three reasons an earthquake may occur.
3. Name and describe the three kinds of faults.

7

DIRECT A DEMONSTRATION

Demonstrate how rocks move along faults

Materials: two damp sponges, table or other smooth surface

Demonstrate a reverse fault by pushing the sponges against each other along the table. Repeat the demonstration several times.

Did the sponges always move the same way when pushed together? no **Describe how they moved.** Possible answers: Both pushed up together. One pushed under the other. One folded under the other.

Rock in a reverse fault can respond in similar ways.

Demonstrate the two other kinds of faults.

What happened to the sponges as they rubbed against each other? They pulled out of shape.

As rocks move along faults, they can be pulled or pushed out of shape, causing stress. The release of that stress can cause earthquakes.

Discussion

What causes a strike-slip fault? rocks moving horizontally past each other

Along which famous fault in California do many earthquakes occur? San Andreas Fault

What human activity can cause earthquakes? moving large quantities of earth

What size earthquake does this activity cause? a very small earthquake

Use Activity Manual page 2 to reinforce what happens with each type of fault.

Discuss the map on Activity Manual page 3.

The San Andreas Fault is located along the coast of California. How is the fault marked on the map? with a purple line

What major US cities are close to the San Andreas Fault? Possible answers: Sacramento, San Francisco, San Jose, Los Angeles, and San Diego

Imagine that an earthquake has just occurred in San Francisco. What kinds of problems would emergency personnel have to deal with? Possible answers: Fires may occur because of broken gas lines. Water supplies may be disturbed because of pipe breaks. Communication may be difficult. Roads may be impassable. Buildings and bridges may be collapsed. Electrical lines may be down.

Could God have used earthquakes to shape the earth we see today? yes

What are some characteristics of God demonstrated through disasters such as earthquakes? Possible answers: providence, omnipotence, omniscience

Answers

1. crust, mantle, inner core, and outer core
2. Possible answers: sudden shifting of the earth's crust; addition or removal of large amounts of earth; movement of molten rock under a volcano.
3. reverse fault—rock is pushed up
   normal fault—rock drops down between separating rocks
   strike-slip fault—rock moves horizontally along other rock

Activity Manual

Reinforcement, page 2

Expansion, page 3

You will use this page again in the next lesson.

Objectives

- Compare and contrast body waves and surface waves
- Explain differences between the Mercalli scale and the Richter scale
- Describe disasters related to earthquakes

Materials

- water
- pie plate
- medicine dropper

Vocabulary

focus
seismic wave
epicenter
seismologist
seismograph
magnitude
tsunami

Introduction

What things do you enjoy doing at a lake or pond?

Have you ever thrown or skipped rocks on a lake or pond?

What happened to the water when the rock hit it? Ripples spread out from the place where the rock touched the water.

Demonstrate how ripples move out from a source by filling a pie plate with water and using the medicine dropper to drop water into it one drop at a time.

Teach for Understanding

Purpose for reading

How do earthquakes travel?

What are some effects of earthquakes?

Discussion

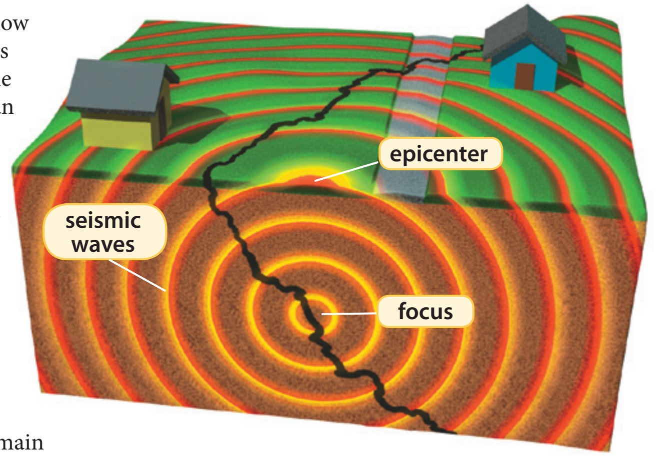
What do we call the beginning point of an earthquake? focus

What are seismic waves? the vibrations of an earthquake

Energy is defined as the ability to move something through a distance. Why would seismic waves be called energy waves? They cause vibrations, or movements, of the earth.

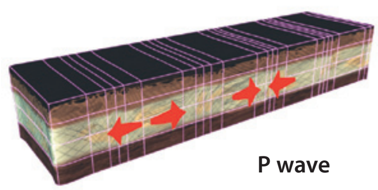
Earthquake Waves

Earthquakes take place below the surface of the earth. Waves of energy are sent out from the **focus**, or beginning point of an earthquake. These vibrations, or **seismic** (SIZE mik) **waves**, flow out from the focus in all directions, similar to the ripples caused when a pebble is tossed into a pond. The point on the surface of the earth directly above the focus is called the **epicenter**.

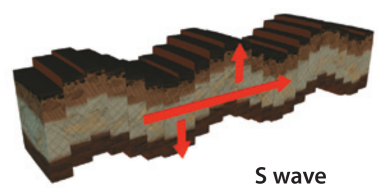


Body waves are seismic waves that occur beneath the surface of the earth. The two main kinds of body waves are P waves and S waves. The P waves, or primary waves, move quickly through both the solid and liquid material in the earth's interior. These waves can actually be felt on the side of the earth opposite from the focus of an earthquake.

S waves, or secondary waves, move more slowly. They cannot move through the liquid material in the earth. **Seismologists**, scientists who study the movement of the earth, use the difference in the speed of P and S waves to help calculate the location of the focus of an earthquake.



The P wave is the fastest moving body wave. It travels in a straight path by a push-and-pull motion.



The S wave moves more slowly than the P wave. It moves in an up-and-down zigzag pattern.

8

TEACHER ✶HELPS✶

Showing ripples
To allow students to see the ripples in the water easily, place a shallow clear plastic or glass pan on an overhead projector.

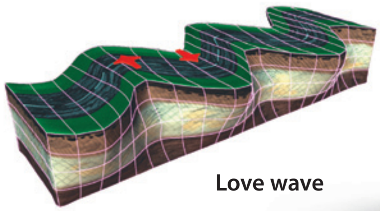
SCIENCE BACKGROUND

Alternate names for waves
S waves are also called shear waves or transverse waves. P waves are also called compressional waves. In *Science 5*, transverse waves were discussed in the light chapter and compression waves were discussed in the sound chapter.

HISTORY

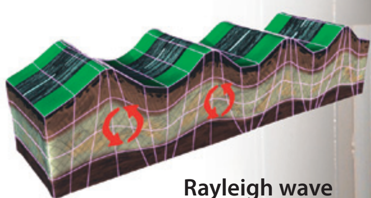
Chinese seismoscope
The earliest seismoscope, or instrument to detect an earthquake, was called an earthquake weathercock. Chang Heng, a Chinese geographer, invented it in AD 132. The "dragon jar" was eight feet tall and was made of bronze. When an earthquake occurred, a metal rod inside the jar fell, causing one of the dragons on the side of the jar to drop a ball from its mouth to the frog's mouth below. This indicated that an earthquake had occurred, as well as the direction the earthquake had come from. For 1,600 years this was the only method available for detecting earthquakes. The pendulum seismograph used today was invented in 1897.

When P and S waves reach the surface of the earth, they produce *surface waves*. Surface waves are the slowest moving and most destructive waves. Love waves and Rayleigh (RAY lee) waves are two types of surface waves.



Love wave

Love waves, the fastest moving surface waves, move back and forth in a zigzag pattern.

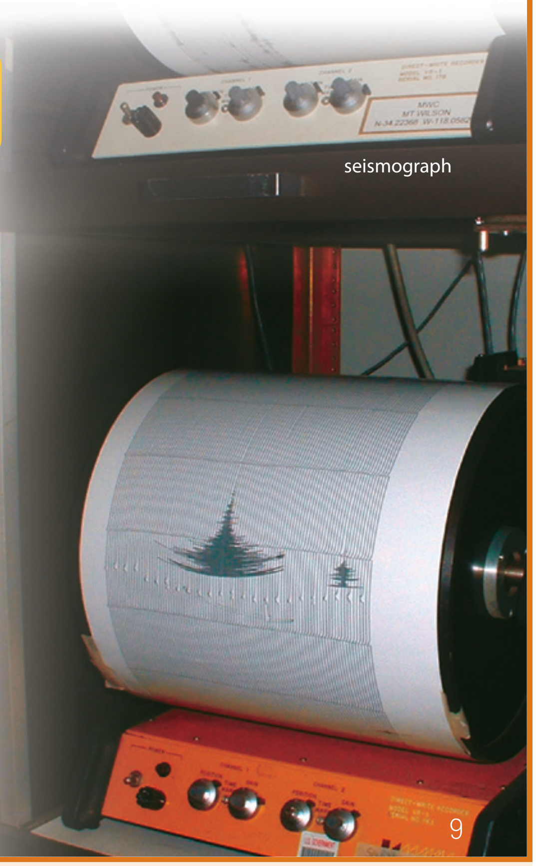


Rayleigh wave

Rayleigh waves move along the ground in a rolling motion, similar to the way ocean waves roll.

Detecting Earthquakes

Seismologists use a machine called a **seismograph** to detect, time, and measure the movements of the earth. As the earth moves, seismographs produce seismograms, or records of the movements. Early seismographs used rotating drums and pens that touched the paper on the drums to form seismograms. Today, most seismographs are part of an advanced computer system. These instruments measure and record up-down, east-west, and north-south movements, giving scientists an accurate record of earthquake activity.



seismograph

9

Discussion

What is the point on the surface of the earth directly above the focus called? epicenter

What are body waves? seismic waves that occur beneath the surface of the earth

What are two types of body waves? primary (P) waves and secondary (S) waves

Describe the movements of P and S waves. The P waves move quickly in a straight line by a push-and-pull motion. The S waves are slower and travel up-and-down in a zigzag pattern.

Which waves arrive at the surface of the earth first? primary

Which kind of waves can only move through solids? S waves, secondary waves

Why do scientists determine the difference in speed of P and S waves? to calculate the location of the focus of an earthquake

What is a seismologist? a scientist who studies movements of the earth

What are surface waves? waves produced by P and S waves when they reach the surface of the earth

Which waves are more destructive, body waves or surface waves? Why? surface waves; they move on the surface of the earth.

What are two types of surface waves? Love waves and Rayleigh waves

Describe the movements of Love waves and Rayleigh waves. Love waves move in a side-to-side zigzag pattern. Rayleigh waves move in a rolling motion like ocean waves.

What machine do scientists use to detect, time, and measure the movement of the earth? a seismograph

How have seismographs changed since their invention? Today most seismographs are part of a computer system.

People have described earthquakes as sounding like trains. Why would the seismic waves from an earthquake create sound? Possible answer: Vibrations create sound. Seismic waves are huge vibrations in the earth's crust.

DIRECT A DEMONSTRATION

Demonstrate different types of waves

Materials: a plastic spring toy

Instruct two students to hold the spring toy, one at each end. Tell them to stand about five to six feet apart and lay the spring toy on the floor.

- To demonstrate the movement of the P wave, ask one student to push in his end of the spring toy. The "P wave" will travel down to the end of the toy and back.
- To demonstrate the S wave, tell the students to stand, each still holding one end of the toy. One student should move the spring toy in an up-and-down motion.
- To demonstrate the Love wave, tell the students to move the spring toy in a side-to-side motion.

Ask the students if they can think of a way to demonstrate the Rayleigh wave using the spring toy.

Discussion

What two scales measure earthquakes? Mercalli scale and Richter scale

Which scale depends on man's observations of an earthquake's destruction? the Mercalli scale

Using the Mercalli scale, would it be difficult to determine the strength of an earthquake in a largely unpopulated area? Why or why not? Yes, because the scale measures observable destruction. Without buildings to observe, determining the strength of an earthquake would be difficult.

Charles Richter developed the Richter scale. How is it different from the Mercalli scale? The Richter scale measures the strength of the seismic waves rather than just the observable damage.

What is the magnitude of an earthquake? its strength

Why is the Richter scale more accurate than the Mercalli scale? The Richter scale is not dependent on man's observations or the population of an area.

In what ways can architects improve a building's stability? Possible answers: by laying the foundation in rock, using good design, and using strong building materials

On what foundation are Christians to build their lives? Jesus Christ

Jesus Christ is a solid foundation in an unstable world.

Which of the earthquake scales is influenced by the way buildings are constructed? the Mercalli scale Why? It is based on the amount of destruction that occurs.

How does the way buildings are constructed influence Mercalli scale measurements? Mercalli scale measurements for the same waves may be smaller than Richter scale measurements in areas with reinforced structures but greater in areas with weaker structures.

Discuss *Science and the Bible.*

Where does the Bible describe the earth opening up and swallowing people? Numbers 16

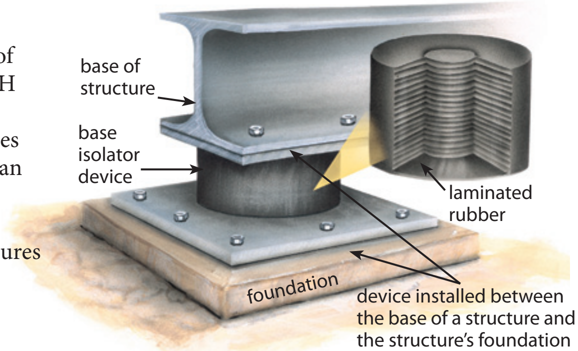
Why were Korah and his followers judged this way? Guide to the conclusion that Moses asked God to do a "new thing" so that all the people would know God's specific judgment on those who opposed His chosen leaders.

Measuring Earthquakes

Scientists use two scales to measure and compare the strength of earthquakes. The Mercalli (mur KAH lee) scale is based on the amount of destruction that an earthquake causes to manmade structures. This scale can be used to gain a general idea of the strength of earthquakes in the past.

The Richter (RIK tur) scale measures the **magnitude**, or strength, of the seismic waves of an earthquake. An earthquake is assigned a decimal number based on the strength of its seismic waves. Each whole number is ten times greater than the previous one. For example, an earthquake with a magnitude of 6 has seismic waves ten times greater than an earthquake with a magnitude of 5. But an earthquake with a magnitude of 7 has seismic waves one hundred (10 × 10) times greater than an earthquake with a magnitude of 5.

Earthquake Isolation Device



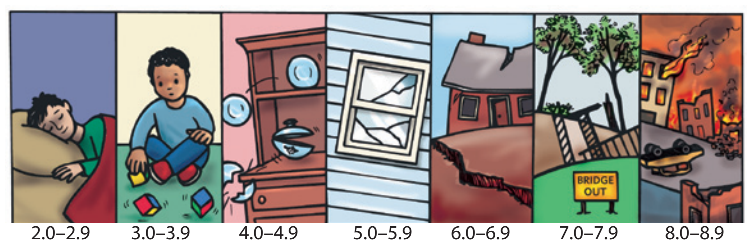
Building for Earthquakes

Man cannot predict or control earthquakes, but he can try to minimize the damage they cause. Most destruction from an earthquake occurs because structures such as buildings and roads collapse. Therefore, engineers and architects work to develop structures that will sustain only minor damage in an earthquake and will remain standing.

The Bible describes a man who hears and obeys God as having his foundation on a rock (Matt. 7:24–27). Likewise, the best foundation for a building is solid rock. A building with a foundation on sand or fill material has little stability.

In addition, building materials and design are key factors to a structure's stability. Concrete reinforced with steel rods is a common building material. A building constructed using a steel

Richter scale effects



10

SCIENCE BACKGROUND

Richter scale
Each number on the Richter scale represents seismic waves that are ten times greater than the previous number. However, the increase in energy released by the earthquake is actually about thirty times greater for each successive number.

Other effects of earthquakes
Some other effects earthquakes have on the earth's features include cave-ins, wells drying up as water tables shift, and seiches (the sloshing of water in lakes).

BIBLE

Strong foundation
Luke 6:46–49 compares a Christian's obedience to God's Word with the construction of a house. A believer who has taken the time to study and obey God's Word establishes a foundation on which to base his life's decisions. That foundation prepares him to face storms of difficulty that may enter his life. [Bible Promise: D. Identified in Christ]

DIRECT AN ACTIVITY

Looking at both sides of an issue
Provide *Discussion Organizer* for each student (IA page). Present the issue of whether Christian adults should have jobs such as architects or engineers or should work in jobs where their main emphasis is telling others about Christ. Group the students and assign each group one side of the organizer. Guide their completion of it. Provide time for the students to present their side of the issue and write their own conclusion.

SCIENCE & THE BIBLE

Some scientists who question the accuracy of the Bible doubt that the earth could actually open up and swallow something. But in Numbers 16, the Bible records just such an occurrence. When Korah rallied others against God's chosen leaders, Moses asked God to do "a new thing." That new thing was the earth opening up and swallowing Korah, his followers, and all their goods. They "went down alive into the pit, and the earth closed upon them: and they perished from among the congregation" (Num. 16:33).

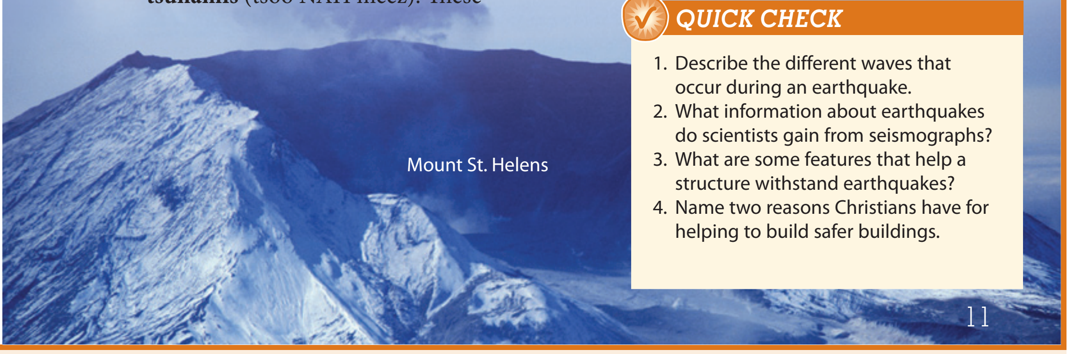
frame also tends to be stable. The frame connects all parts of the structure and allows it to move as one piece instead of pulling apart.

Areas of the world that frequently have earthquakes benefit from the work of good engineers and architects. The Bible teaches that God gave humans the responsibility to study the earth and to make wise use of it (Gen. 1:28). The Bible also teaches that humans are to love others (Mark 12:31). Planning and building for earthquakes is one way that a Christian can show love for others.

Related Disasters

Earthquakes cause, or sometimes result from, other catastrophic events. An earthquake, volcano, or landslide occurring under or near the ocean can cause a series of giant waves called **tsunamis** (tsoo NAH meez). These waves can move over 700 km (435 mi) per hour at sea with a height of only about 1 m. As the waves reach the shallow water near the shore, they can grow to a height of over 30 m (98 ft). These waves cause much damage when they reach land.

Another event associated with an earthquake is a volcanic eruption. Seismic waves from beneath a volcano alert scientists to the immense pressure building up below the surface. For example, Mount St. Helens, in the state of Washington, began shooting up steam and ash in March 1980. In May, an earthquake caused a landslide that allowed the pressure to release. The northern side of the mountain exploded, and lava and gases poured from the mountain.


Mount St. Helens

QUICK CHECK

1. Describe the different waves that occur during an earthquake.
2. What information about earthquakes do scientists gain from seismographs?
3. What are some features that help a structure withstand earthquakes?
4. Name two reasons Christians have for helping to build safer buildings.

MATH **Comparing magnitudes**
The Richter scale is based on powers of ten. Each increase of one number on the scale represents an earthquake magnitude ten times greater than the magnitude of the previous number.

How much greater is a magnitude 4 earthquake than a magnitude 3 earthquake? 10 times

How much greater is a magnitude 4 earthquake than a magnitude 2 earthquake? 100 times

How much greater is a magnitude 8 earthquake than a magnitude 3 earthquake? 100,000 times

TECHNOLOGY **Triangulation**
Scientists use a method called triangulation to locate the epicenter of an earthquake. Seismograph readings of the same earthquake are taken from three earthquake stations. Scientists use these measurements to determine the distance of the earthquake from each station. The point at which all three measurements meet is the epicenter of the earthquake. Methods of triangulation are also used by rescuers to find the locations of lost aircraft, boats, and even cellular phones.

Discussion

What is a tsunami? a huge wave resulting from an earthquake, landslide, or volcano that occurs under or near the ocean

Why is a tsunami so dangerous? Possible answers: The waves are large and strong. It is a series of waves. Since a tsunami is the result of sudden movement, there are no definite warning signs that a tsunami will occur.

Tsunamis were once called "tidal waves," but the moon does not affect these waves as it does true tidal waves.

***Tsunami* is a Japanese word meaning "harbor wave." Why would a tsunami be called a harbor wave?** Possible answer: The greatest destruction occurs when the wave is confined to an area such as a shallow beach or harbor.

What other catastrophic events are associated with earthquakes? Possible answers: volcanic eruptions, landslides

How did a landslide caused by an earthquake effect the eruption of Mount St. Helens? The landslide released some pressure, and one side of the mountain exploded.

Answers

1. P wave—fast-moving body wave; travels in a straight line by a push-and-pull motion; can travel through solids and liquids
   S wave—body wave that is slower than P waves; moves in an up-and-down zigzag pattern; cannot travel through liquid
   Surface wave—the slowest moving and most destructive; examples are Love and Rayleigh waves
2. Seismographs detect, time, and measure movements of the earth.
3. concrete reinforced with steel rods; foundation laid in rock; steel framing
4. God gave humans the responsibility to study the earth and make wise use of it (Gen. 1:28) and humans are to show love to others (Mark 12:31).

Activity Manual

Expansion, pages 3–4

Guide the students as they complete these pages. These pages may also be used as independent work for advanced students.

Review, pages 5–6

These pages review Lessons 2 and 3.

Assessment

Quiz 1-A

The quiz may be given any time after completing this lesson.

Objectives

- Practice a scientific method

Materials

- one fettuccine noodle
- paper or foam cup
- 30 cm piece of string
- roll of pennies
- 2 stacks of books 30 cm high

Vocabulary

scientific method	procedure
hypothesis	material
problem	conclusion

Introduction

The following experiment is intended as a teacher demonstration. The emphasis is to explain each step of a scientific method and practice the process skills that will be used in the other activities. Guide the student through the completion of the pages as the parts of a science experiment are discussed.

The scientific method is a systematic approach to problem solving. Used consistently, it makes science a subject of discovery through observation. Although the specific steps of the scientific method may vary, they should include using a hypothesis to identify a problem, experimenting to test the hypothesis, and drawing conclusions to test the accuracy of the hypothesis.

Teach for Understanding

Discussion

What is the problem of an experiment? the question that the experiment will answer

The problem is worded as a question and is specific rather than general. Write the problem for display. The problem for this experiment is "How many pennies can one strand of suspended fettuccine hold before breaking?"

Write the problem on Activity Manual page 7.

Display the materials. The student will often be able to choose the materials he will use for his experiments. For this experiment, the materials are a cup, a piece of string, a fettuccine noodle, pennies, and stacks of books.

List the materials you will use.

A Science Experiment

Name ______________________

ACTIVITY

Scientists follow a procedure when conducting experiments. The procedure we will practice includes identifying the problem, listing materials, forming a hypothesis, establishing and following a procedure, and drawing conclusions.

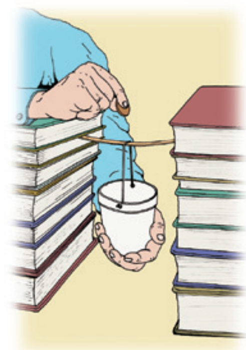
Problem

Each experiment begins with a **problem**, or question that needs answering. This experiment's problem asks about the strength of uncooked fettuccine.

A. Write the problem.

How many pennies can one strand of fettuccine hold before breaking?

Materials



In the list of **materials**, include all the materials and equipment you will use to conduct the experiment. In some experiments all of the materials will be listed for you. In others, you will choose some or all of the materials.

B. List the materials you will use.

1 fettuccine noodle (uncooked)	*1 paper or foam cup*
30 cm piece of string	*1 roll of pennies*
2 stacks of books 30 cm high	

Hypothesis

A **hypothesis** is a scientist's idea of the answer to a problem. As you conduct an experiment, the hypothesis is a *statement* of your idea or a diagram of how the problem will be answered through that experiment. A hypothesis often includes *specific criteria* about the conditions of the experiment.

C. Four choices for a hypothesis are given. Read each and decide if it is a good hypothesis. If you answer *No*, explain what is wrong with that hypothesis.

1. Will ten pennies break one suspended piece of fettuccine? ☐ Yes ■ No
   A hypothesis is written as a statement, not as a question.
2. Twelve pennies will break the suspended fettuccine. ☐ Yes ■ No
   This hypothesis does not tell how many pieces of fettuccine are being used. (specific criteria)
3. I think six pennies will break one suspended piece of fettuccine. ■ Yes ☐ No
4. One piece of fettuccine will hold no more than ten pennies without breaking. ☐ Yes ■ No
   This hypothesis does not tell that the fettuccine is suspended. (the condition of the fettuccine)

D. Write a hypothesis in your own words.

Answers will vary.

TEACHER ✱HELPS✱

Relate the scientific method to playing a game

Problem: Who will win the game?

Hypothesis: I think that X will win the game because X.

Materials: List items needed to play the specified game.

Procedure: List order of play.

Control/Variables: Identify rules of play and variations to rules. Some variables result in different methods of play and/or type of winner.

Conclusion: The winner is X, because X.

Follow-up: Next time I will X to try to win or to win again.

Procedure

The **procedure** is the steps of an experiment. The steps must be followed exactly to ensure the accuracy of the results. Scientists **record** their observations and results throughout an experiment.

E. Follow the procedure.

1. Prepare the cup by making a string handle for it.
2. Hang the empty cup on the piece of fettuccine.
3. Suspend the fettuccine between the stacks of books. Place a book on each end of the fettuccine to hold it in place.
4. Support the cup with your hand and place one penny inside it. Gently lower the cup until it hangs from the fettuccine.
5. Repeat step 4 until the number of pennies reaches the number in your hypothesis or until the fettuccine breaks.
6. Record your observations and results.

Number of pennies	Did the fettuccine break?

Conclusions

The **conclusions** evaluate the accuracy of a hypothesis. They relate and apply the information to other areas.

F. Answer the questions.

1. Do your results support your hypothesis? If not, was your prediction too low or too high? *Answers will vary.*
2. Would each piece of fettuccine hold the same number of pennies? Explain. *Answers will vary.*

Follow-up

The **follow-up** usually considers variations to an experiment. Sometimes specific details or suggestions to change the variables are given.

Example: Try dropping the cup instead of lowering it gently after adding pennies.

A hypothesis is a scientist's testable idea of the answer to the problem. The hypothesis is written as a statement rather than as a question. The conditions for the hypothesis should be very specific. Discuss the wording of the sample hypotheses.

What are some other possible hypotheses about this problem?

Record the student's responses. Allow the student to evaluate each idea to see if it meets the conditions for a hypothesis.

Write your chosen hypothesis.

The procedure is the steps of an experiment that must be followed exactly.

Why is it important to follow the steps exactly? to ensure the accuracy of results

Record your observations on the chart in the Activity Manual.

What are you using as a unit of measurement in this experiment? pennies

If the fettuccine does not break by the time you reach the number of pennies given in the hypothesis have you answered the problem? No, because we still don't know if the fettuccine will break when we add another penny.

If the fettuccine breaks before the student's prediction, help him see that the hypothesis was wrong. Allow the student to predict another number and form a new hypothesis to test.

Help the student draw conclusions based on the experiment. Generally, conclusions are inferences based on what the student has seen.

Do your results support your hypothesis? If not, was your prediction too low or too high?

The follow-up usually involves changing one variable or condition of the experiment.

What details or conditions about this experiment could we vary or change? Possible answers: the kind of pasta, the number of pieces of pasta, the length of the piece of pasta

Would the experiment have produced the same results if the cup had been dropped suddenly instead of being lowered gently? Why? no; Possible answer: Dropping the cup suddenly may cause the fettuccine to break sooner.

Activity Manual

Activity, pages 7–8

Lessons
5–6

Student Text pages 12–13
Activity Manual pages 9–10

Objectives
- Model the effects of an earthquake on a building
- Design and construct a structure that can withstand a simulated earthquake
- Record and analyze information to form conclusions
- Identify variables

Materials
- See Student Text page

Introduction

Two lesson days are allotted for this activity. You may choose to make the first structure on the first day and the second structure on the second day.

What are some things you would associate with a construction site? Possible answers: workers, hard hats, huge machines and bulldozers, metal beams, noise

In what ways is teamwork important to the construction of a building? Possible answers: to meet the goals and plans of the project; to make the best use of the knowledge and skills of each person; to save time; to use resources and materials wisely; for safety

This activity will require you to work as a team as you construct a model structure.

God wants us to be dependable workers so that others can count on us to complete the job. [BATs: 2c Faithfulness; 2e Work]

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

Procedure
Display the materials the students will use.

How do you think these materials can be used to find out what kinds of buildings will withstand an earthquake? Answers will vary.

ACTIVITY

Construction Site

You are the engineer. You have been assigned the task of building in an earthquake-prone area. The task of your construction team is to design a structure that will withstand the forces of an "earthquake."

Process Skills
- Predicting
- Experimenting
- Making and using models
- Observing
- Identifying and controlling variables
- Recording data

Problem
How would you design a building that can withstand an "earthquake"?

Before the activity
1. Decide on the details about your earthquake: the number of shakes it will have, its magnitude, the direction that it will shake, and the kind of seismic waves the shake will represent. Record those decisions in your Activity Manual.
2. Discuss possible designs for your structure. The building must be at least two stories high. Think about the shape, materials, foundation, height, weight, and any other factors that may influence the stability of your structure.

Materials
foam base, approximately 20 cm × 25 cm (8 in. × 10 in.)
package of large marshmallows
box of fettuccine noodles
Activity Manual

Procedure
1. Write your hypothesis about how your building will withstand the stress of your earthquake.
2. Draw your design in your Activity Manual.
3. Construct your building on the foam base.
4. Following the limits set, replicate an earthquake by shaking the foam base appropriately.
5. Record the number of shakes your building withstood and the amount of damage that occurred.
6. Think how you might improve your building. List your ideas for improvements.

12

TEACHER ✱HELPS✱

Organizing groups
Divide the class into science teams or groups of three or four. Place high, average, and low achievers in each group. Depending on the abilities and personalities of the students, you may need to assign tasks to ensure that each team member participates.

Marshmallows
Keep the marshmallows cool to prevent them from getting sticky too quickly. Encourage the students to use whole marshmallows rather than tear them apart.

SCIENCE BACKGROUND

Earthquake engineering
The goal of early engineers and architects of earthquake-resistant construction was to avoid or slow the collapse of buildings to provide time for occupants to escape. However, as technology improves, engineers and architects are better able to design structures that will not only remain standing, but will also sustain only minimal damage during an earthquake.

7. Rebuild your structure, adding your improvements.
8. Predict how your improved building will withstand another earthquake. Simulate another earthquake under the original guidelines and record your observations.

Conclusions

- Did your rebuilt structure perform better than your original? Why or why not?

Follow-up

- Try making another building with different materials. Test and compare its stability with those you already tested.

13

SCIENCE PROCESS SKILLS

Identifying and controlling variables
Variables are the changeable parts of an experiment. An effective experiment begins with the variables set to specific criteria, such as choosing the details of the earthquake. The scientist then changes only one variable at a time and compares the results.

What are some variables that could change in this activity? Possible answers: the details of the "earthquake"; the kinds of building materials used; the type of foundation; the design of the structure

Discuss what information could be gained from changing one of these variables. For example, change the foundation to a tray of sand.

What information would be gained by changing the foundation variable? The results would show which foundation is more stable.

In order to gain information about the foundation, what changes, if any, would need to be made to the other variables? Guide students to conclude that for the data to be accurate, all of the other variables would have to remain the same.

Discuss which variable or variables were changed when the structure was rebuilt.

Before beginning, decide as a class on the details of the "earthquake."

- How many shakes will the earthquake have?
- How far will each shake be?
- What direction will it shake?
- What kind of seismic waves will the shaking demonstrate?

To make things more challenging for the teams, you may set a time limit.

Allow each group to plan and build its structure.

Test the stability of the structure with an "earthquake" as decided on by the class.

What are some qualities that made the structure stable? Possible answers: reinforcements; firm foundation in the foam

What are some ways to improve your structure? Answers will vary.

Direct each team to rebuild its structure, implementing the improvements discussed.

Guide the students as they make predictions, retest, and record their observations of the second structure.

Did your results support your new hypothesis? Answers will vary.

Compare the stability of your second structure to that of the first. Was the second more stable? Answers will vary.

Does this activity illustrate the stability of a building in a real earthquake? Why or why not? Answers will vary.

Conclusions

Provide time for the student to evaluate his hypothesis and answer the questions.

Use the questions in the Science Process Skills to discuss identifying and controlling variables.

Activity Manual

Activity, pages 9–10

Guide the students as they use these pages to write a hypothesis, plan their structures, record their observations, and draw conclusions.

Assessment

Rubrics

The rubric is a suggested tool for grading an activity. Guidelines for using a rubric are included on the Teachers Toolkit CD. Select the prepared rubric, or design a rubric to include your chosen criteria.

Student Text pages 14–17
Activity Manual pages 11–12

Objectives

- Explain the causes of a volcanic eruption
- Identify the parts of a volcano
- Describe three ways volcanoes are classified

Materials

- world map or globe
- aerosol can with a warning label that says not to puncture or heat the can

Vocabulary

magma
volcano
volcanologist
magma chamber
lava
Ring of Fire
hot spot
tephra
pyroclastic flow

Introduction

What are some household things that are pressurized? Possible answers: spray paint, can of whipped cream, shaving cream

Show the aerosol can and read the warning on the label.

Why do you think it is dangerous to puncture a pressurized can? The contents would expand too quickly and erupt or explode.

Why do you think it is dangerous to heat a pressurized can? Since heating causes most things to expand, heating a pressurized can causes the contents to expand, which further increases the pressure. The increased pressure may cause the can to explode suddenly.

Teach for Understanding

Purpose for reading

How are volcanoes like a pressurized can?

Are all volcanoes the same?

Discussion

What do we call the molten rock under the earth's crust? magma

What do we call a person who studies volcanoes? a volcanologist

How is a volcano formed? A crack in the earth's crust allows magma and gases to come to the surface.

What are magma chambers? pockets of molten rock in the earth's lithosphere

What name is given to magma once it comes through the earth's surface? lava

How do magma and gases get from a magma chamber to the earth's surface? through vents

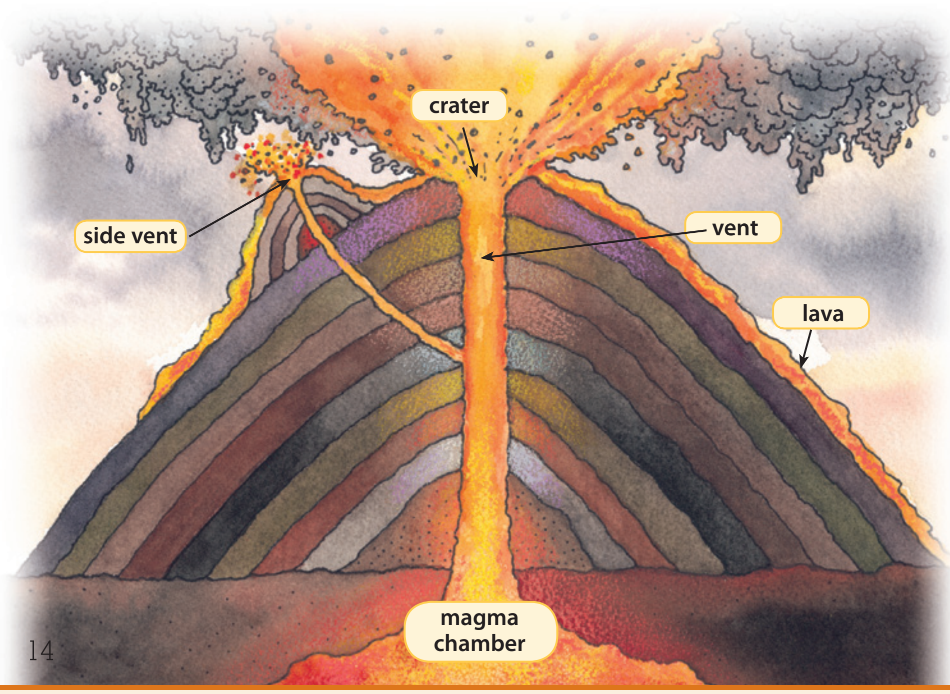
Volcanoes

According to the theory of plate tectonics, the plates of the earth's crust float on a layer of semiliquid rock. Because we do not usually see it, we rarely think about this melted rock. But sometimes it gets our attention in dramatic ways. When a volcano erupts, molten rock, or **magma**, may suddenly explode through the earth's surface, scorching and destroying everything in its path.

Causes of Volcanoes

A **volcano** forms where a crack in the earth's crust allows magma and gases to come to the surface. **Volcanologists** (vol kuh NOL uh jists), scientists who study volcanoes, think that deep in the earth's lithosphere there are pockets of molten rock called **magma chambers**. Just as a hot air balloon rises through cooler air, the hot magma from these chambers rises and pushes its way through the denser rock of the earth's crust. When the magma breaks the surface, it is called **lava**.

Lava flows out of the earth through an opening in the surface called a *vent*. The bowl shape at the top of a main vent is called a *crater*. However, a volcano may have more than one vent. Vents sometimes develop on the sides of the volcano as well as at the top. An eruption that flows through the side vents is called a *flank eruption*.



14

SCIENCE BACKGROUND

The Ring of Fire
The Ring of Fire is a zone where earthquakes and volcanoes occur often. It is located around the edges of the Pacific Ocean.

Volcano classifications
Scientists sometimes classify volcanoes into more categories than are presented in this lesson. This text presents the broadest and most common classifications.

Volcanic ash
Volcanic ash is not like the ash from burned wood or paper. It is small pieces (less than 2 mm) of crushed rock and natural glass. Exposure to a cloud of volcanic ash can cause eye, lung, and skin injuries.

Bowl-shaped craters
Scientists believe that most craters are sunken and bowl shaped as a result of hot magma lowering as it cools.

SCIENCE MISCONCEPTIONS

Evolutionists use hot spots as proof of the great age of the earth. They claim that in order for chains of islands to have formed, the plates must have been moving for millions of years. We do not know exactly how the volcanic islands formed. Perhaps the hot spot moves instead of the plate. Whatever the case, God did not need millions of years to form any of the earth's land features. He is all-powerful and able to control the surface of our Earth as well as all other aspects of our lives.

The mineral and gas content of the magma determine the explosiveness of a volcano. A hotter, thinner lava tends to flow as a liquid. However, thick lava often traps gases. As the hot gases expand, they explode violently, sending globs of hot lava and rocks flying into the air. Many erupting volcanoes produce clouds filled with jagged bits of crushed rock called *volcanic ash*. A volcanic cone, or funnel-shaped mound, can form from layers of ash or hardened lava. The Mexican volcano Paricutín (pah REE koo TEEN) produced a cone of ash several hundred feet high in just a few weeks.

Locations of Volcanoes

Volcanoes may occur anywhere. But two-thirds of active volcanoes are found in an area around the edges of the Pacific Ocean. These volcanoes form a ring that volcanologists call the **Ring of Fire**.

The Mediterranean Sea is another common place for volcanoes. Mount Etna is a well-known volcano in this area. It rumbles to life regularly, but it is a popular place for sight-seers who enjoy the adventure of climbing the mountain.

Volcanoes also exist under the water. Underwater eruptions called submarine eruptions are twenty times more frequent than eruptions on land. Many of these underwater volcanoes occur in the middle of a crustal plate rather than along a plate boundary. Scientists believe that these volcanoes are formed from **hot spots**, places where a pool of intensely hot magma rises toward the surface. Since oceanic crustal plates are usually thinner than continental crustal plates, the magma melts the rock above it and breaks through the crust. As the volcano erupts, new land forms. Some geologists believe that chains of islands, such as the Hawaiian Islands, were formed as crustal plates moved across hot spots.

SCIENCE & HISTORY

Mount Vesuvius (vuh SOO vee us) in Italy had a major eruption in AD 79. A heated cloud of gas, ash, and rock was forced into the air. The volcano buried the nearby city of Herculaneum. A little farther away, a poisonous gas cloud enveloped Pompeii and killed the inhabitants. Over fifteen feet of fine ash then covered the city. Archaeologists excavated this area and discovered that the ash preserved moldings of the people and places. By pouring plaster into the ash molds, archaeologists revealed details of the people who died in the eruption. These details include folds in their clothing and even the expressions on their faces.

Pronunciations
In *Science and History*, the pronunciation of Herculaneum is (her kyuh LAY nee um) and of Pompeii is (pahm PAY).

Locating volcanic islands
Use the world map to point out other volcanic islands, such as the Philippines, Iceland, the Azores, and the Galapagos Islands. Observe whether these islands occur along plate boundaries or are formed by hot spots in the earth's crust.

What shape are most craters? bowl shaped

What do we call an eruption that flows through a side vent rather than the main vent? flank eruption

What determines the explosiveness of a volcano? the mineral and gas content of the lava

How is volcanic ash different from the ash you might find in a fireplace? Possible answer: Volcanic ash is small bits of rock, not soft bits of burned wood.

Refer back to Student Text page 5. Point out the Ring of Fire on the map.

What relationship can you see between plate boundaries and volcanoes? Volcanoes tend to occur along plate boundaries.

Explain what scientists think causes a volcano to erupt. Rock below the earth is under pressure. It becomes hot and melts. Magma rises and pushes its way through the earth's crust, causing an eruption.

Why does hot magma rise? because heat rises

Where would you find most of the earth's volcanoes? under the ocean

What are underwater eruptions called? submarine eruptions

What makes hot spots different from where most volcanoes occur? Hot spots are not necessarily along plate boundaries.

Think about the difference in thickness between the ocean crust and the continental crust. Why would hot spots be more frequent under the ocean crust? Answers will vary, but suggest that the ocean crust is thinner and the magma can push through more easily.

Discuss *Science & History.*

Which volcanic eruption caused the destruction at Pompeii? Mount Vesuvius, AD 79

How is it possible for archaeologists to find out details about the people who died in the eruption? The volcanic ash preserved moldings of the people and places. Pouring plaster in the molds allows archaeologists to see the details.

Discussion

What are three ways to classify volcanoes? by shape, by how often they erupt, and by type of eruption

Which of these ways do you think is the most reliable way to classify a volcano? Accept any answer, but elicit that shape is probably the most reliable classification.

Which kind of volcano is not cone shaped? shield volcano

How are shield volcanoes formed? by a continual flow of lava

Which kind of volcano usually has the least explosive eruption? shield volcano

What is an example of a shield volcano? Mauna Loa

What are some characteristics of a cinder cone volcano? Possible answers: resembles a hill; has a bowl-like crater; usually has more than one vent; made of cinders

What are cinders? bits of ash and lava showered into the air by a volcano

Describe a composite cone volcano. A composite cone volcano has steep sides and layers of lava and tephra.

What is tephra? a mixture of cinders, ash, and rock

Why might a composite cone volcano be taller and steeper than a cinder cone volcano? Possible answer: As the lava layers cool, they form hard rock that other layers can build upon. A cinder cone has loose rock that moves when another eruption occurs.

Define active, dormant, and extinct volcanoes. active—erupted in recorded time and expected to erupt again; dormant—erupted in the past but currently inactive and not expected to erupt again; extinct—no recorded eruption and not expected to erupt in the future

Is classifying volcanoes by how often they erupt accurate? Give an example of your answer. no; Possible answer: Mount Vesuvius, Mount Tambora, and Mount Katmai were all considered extinct when they erupted.

How does knowing the type of volcanic eruption help scientists? The type of eruption gives scientists a clue about what happens inside the volcano.

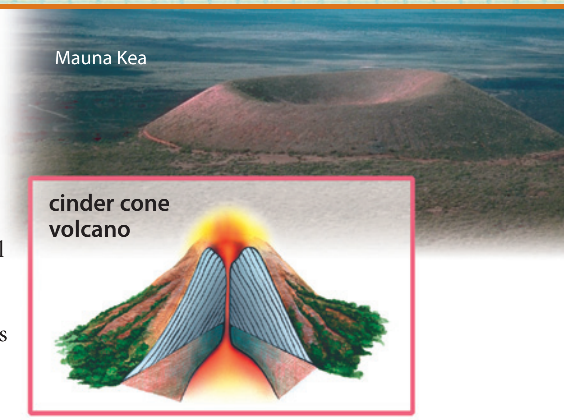
Classifying Volcanoes

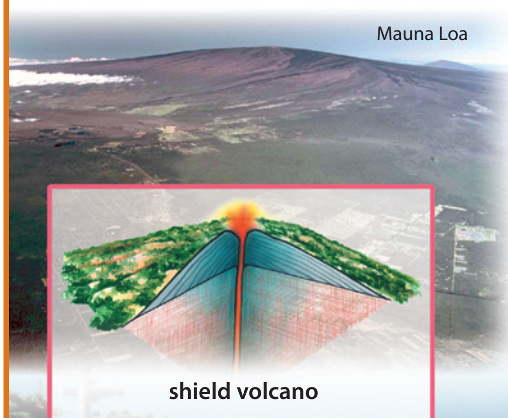
By shape

Not all volcanoes are cone shaped. *Shield volcanoes* have gradually sloping sides and look like upside-down saucers. They are formed by a continual flow of lava. The shield volcanoes formed from hot spots are some of the largest in the world, but these volcanoes are generally not explosive.

There are two kinds of cone-shaped volcanoes. A *cinder cone volcano* is usually a volcano that resembles a hill more than a mountain. It most often has a bowl-like crater at the top and usually contains one main vent. Its eruption tends to be explosive, and it often showers bits of ash and lava, called cinder, into the air.

The *composite cone volcano* is the large, symmetrical, cone-shaped volcano that is commonly pictured. This volcano has steep sides that can measure several thousands of meters high. It is made of layers of hardened lava and **tephra** (TEF ruh), a mixture of cinders, ash, and rock. These volcanoes often have explosive eruptions.





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SCIENCE BACKGROUND

Mauna Loa
Mauna Loa, a Hawaiian volcano, is the largest known shield volcano on Earth. Its name means "long mountain." It is 4168 m (13,677 ft) above sea level. If all of the mountain were showing, it would be the world's tallest mountain, at about 17,069 m (56,000 ft) high. This large volcano makes up over half of the landmass of the Hawaiian Islands. Thirty-three eruptions have been recorded.

MATH

Calculating height
Mauna Loa, a Hawaiian volcano, is 17,069 m (56,000 ft) high.

If about 4168 m (13,677 ft) of Mauna Loa is above sea level, how much of this volcano is below sea level? 12,901 m (42,323 ft)

Write a fraction that shows the approximate portion of Mauna Loa's height that is above sea level. ¼

By how often they erupt

Volcanoes are also classified by how often they erupt. An *active* volcano is one that has erupted at some point during a recorded time period and is expected to erupt again. Some volcanoes are considered *dormant* because they have erupted in the distant past but are currently inactive and not expected to erupt again. A volcano that does not have a recorded eruption and is not expected to erupt in the future is called *extinct*. Although a volcano may be considered extinct, there is no guarantee that it actually is. Mount Vesuvius, Mount Tambora (tam BOR uh), and Mount Katmai (KAT my) were all considered extinct volcanoes before they erupted suddenly, killing many people.

By the type of eruption

Not all volcanoes erupt in the same way. The type of eruption gives scientists clues to what is happening inside the volcano. A volcano with runny lava and little or no cinder, ash, and steam is called a *Hawaiian eruption*. It is a quiet eruption that may continue for a long period of time. If the volcano produces a fountain of lava that runs down the sides, volcanologists call it a *Strombolian eruption*. Neither the Hawaiian nor the Strombolian eruption is considered violent or very dangerous.

A *Vulcanian eruption*, however, is violent. It usually causes a loud explosion that sends lava, ash, cinders, and gas into the air. Similar but even more violent is a *Pelean* (puh LAY un) *eruption*, named after Mount Pelée on the Caribbean island of Martinique. This eruption also produces an avalanche of red-hot dust and gases called a **pyroclastic** (PIE roh KLAS tic) **flow**, which races down the side of the volcano. When Mount Pelée exploded in 1902, it destroyed a city of 30,000 people in less than two minutes.

The most powerful eruption is the *Plinian* (plin EE un) *eruption.* In addition to spewing out lava, this eruption blows gases, ash, and debris very high into the atmosphere. The ash can get caught in the winds of the upper atmosphere and travel for miles.

Volcanoes do not always erupt the same way every time. In fact, sometimes one eruption will change the conditions inside the volcano so that it erupts differently soon afterwards. In 1980 Mount St. Helens erupted as a Pelean eruption with a huge pyroclastic flow that leveled the side of the mountain. The eruption opened a new vent that later exploded in a Plinian eruption, showering ash for miles around the mountain.

QUICK CHECK

1. Draw and label a diagram of a volcano.
2. What is a hot spot?
3. What are three ways to classify a volcano?

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Plinian eruptions

HISTORY

Plinian eruptions are named for Pliny the Younger, a Roman statesman who observed the eruption of Mount Vesuvius in AD 79 from several miles away. His observations were recorded in two letters sent to a historian. The eruption of Mount Vesuvius was a Plinian eruption. Pliny the Younger's uncle, Pliny the Elder, died in the eruption.

Locating volcanoes

GEOGRAPHY

Find the location of each volcano on the world map as it is discussed in the Student Text.

Discussion

What are characteristics of a Hawaiian eruption? little or no lava, runny lava, ash, steam

Which kinds of eruptions are considered the least dangerous? Hawaiian, Strombolian

What are three kinds of eruptions that are considered violent and dangerous? Vulcanian, Pelean, and Plinian eruptions

What is a pyroclastic flow? an avalanche of very hot gases and dust

Does a pyroclastic flow move quickly or slowly? quickly

Which kind of eruption produces a pyroclastic flow? Pelean

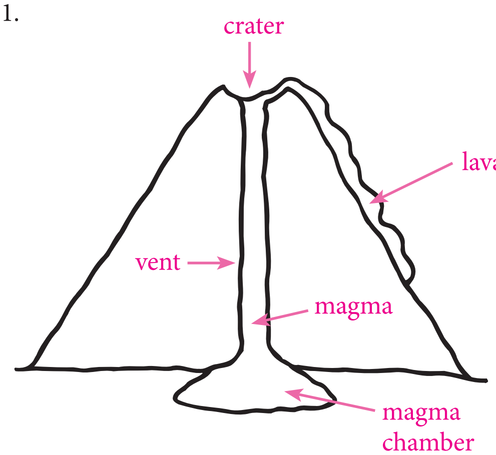
How did the Pelean type of eruption get its name? It is named after Mt. Pelée on the island of Martinique.

Why is a Plinian eruption considered the most powerful? It sends gases, ash, and debris so high that they spread over a large area.

Why might a volcano erupt in more than one way? An initial eruption may create conditions that produce a different kind of eruption.

Answers

1.



2. Scientists believe that hot spots occur at places on a crustal plate (other than the rim) where a pool of intensely hot magma breaks through and forms new land.
3. by shape, by how often they erupt, and by the kind of eruption

Activity Manual

Expansion, page 11

This page identifies continents and the Ring of Fire on a map.

Reinforcement, page 12

A web is a graphic way to organize material. This web groups the different classifications of volcanoes by name and characteristics.

Student Text pages 18–19
Activity Manual pages 13–14

Objectives
- Design a model volcano based on one of the three kinds of volcanoes
- Construct a model of a volcano
- Communicate the type of volcano made and the process used to make the volcano
- Compare the model volcano to an actual volcano

Materials
- See Student Text page

Introduction

Two lesson days are allotted for this activity. On the first day, introduce the activity, set guidelines and a due date for the volcanoes, and begin planning. The second lesson day may occur at a later time, when you are ready to erupt the volcanoes.

Review the three shapes of volcanoes.

What are the three shapes of volcanoes? shield, cinder cone, composite cone

What are the types of eruptions? Hawaiian, Strombolian, Vulcanian, Pelean, and Plinian

Discuss characteristics of each volcano shape and each type of eruption.

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

You will build a volcano. What do you think would be the best way to start?

What type of volcano do you want to model? What materials will you use?

ACTIVITY

Create an Eruption

Design a volcano model that is based on one of the three shapes of volcanoes: shield, cinder cone, or composite cone. Try to make your volcano as realistic as possible.

Process Skills
- Predicting
- Measuring
- Making and using models
- Observing
- Communicating

Purpose
Make a model of a volcano.

Procedure
1. Decide on the shape and design of your volcano. Draw your design in your Activity Manual.
2. Form your volcano according to your design. You may choose to use clay, papier-mâché, or other materials of your own. Insert a small bottle into the top of your volcano. This is where you will put your eruption materials later.
3. Record the materials you used to make your volcano.
4. If necessary, allow your volcano to harden. Decorate the volcano as desired. For example, you may choose to paint it and add other details such as dirt, rocks, and trees to make it look more realistic.
5. The eruption for your volcano results from combining baking soda and vinegar. Experiment with different amounts of each ingredient to make the kind of eruption you want. Record the ingredients and measurements of your trial solutions.
6. Try adding things to your lava ingredients as desired. Red food coloring added to the vinegar will produce a red lava flow. You could also add gelatin, warm water, Alka-Seltzer, or powdered laundry detergent to the baking soda and vinegar solution. Be creative.
7. Record your chosen eruption materials on the materials list.

Materials
- large piece of cardboard or wood
- clay or papier-mâché
- small bottle or container
- decorating materials (optional)
- baking soda
- vinegar
- additional lava materials (optional)
- funnel (optional)
- safety goggles (optional)
- Activity Manual

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TEACHER ✱HELPS✱

Time management
Constructing a volcano can be done at home before the lesson or in groups in class. If you construct the volcano in class, clay models may take less time. You will also need to allow at least one additional day for the activity.

Managing eruptions
You may want to do the eruptions outside because of the mess the volcanoes will make. Red food coloring may stain table tops and other surfaces.

Suggested materials
Possible materials for the volcano include clay, papier-mâché, and plaster mix.

Design variations
Possible design variations include making flank vents for flank eruptions, gluing real soil and plants to the slopes, and building a village nearby.

8. Use a funnel to add your ingredients to the small bottle, if necessary. It is easier to put the baking soda and any dry ingredients in the bottle first before adding the vinegar.
9. Erupt your volcano using your chosen solution.

Conclusions

- Did your volcano erupt as you expected?
- In what ways was your eruption similar to a real volcanic eruption?
- In what ways was your eruption different from a real volcanic eruption?

Follow-up

- Try varying the quantities or using other materials to make the model volcano look or erupt more like a real volcano.

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Procedure

Before erupting the volcanoes, give each student an opportunity to share the steps and materials of his project. Then have the student share the type of volcano he has modeled.

Remind the student to carefully measure and record the substances he uses to cause the eruption.

After the activity, compare eruption results.

What materials produced a realistic eruption?

What materials did not work as well as expected?

How did the amounts of eruption materials used affect the eruption results?

How did the size of the container used in the vent affect the eruption?

How did the size or shape of the volcano affect the eruption?

Conclusions

Provide time for the student to answer the questions.

Use the questions in the Science Process Skills to discuss modeling.

Activity Manual

Activity, pages 13–14

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

SCIENCE BACKGROUND

Chemical reaction

When baking soda and vinegar are combined, they cause a chemical reaction that results in foaming. A real volcano does not erupt as a result of this type of chemical reaction. The eruptions in this activity do not model the conditions of real volcanic eruptions. This activity focuses on modeling the shapes of volcanoes.

SCIENCE PROCESS SKILLS

Making and using models

Models help us examine and experience things that may otherwise be too small, too large, or too inconvenient to handle.

What parts of a model volcano are representative of a real volcano? Possible answers: the shape and design of the volcanic cone; the way the material flows from the volcano

What parts of the model are not good representations of a volcano? Possible answers: the chemical makeup of the "lava"; the type of eruption; the temperature and dangers associated with the lava.

Student Text pages 20–22
Activity Manual pages 15–16

Objectives
- Identify possible dangers of volcanoes
- List some of the meteorological effects of a volcanic eruption
- Name some of the products of volcanoes
- Describe other kinds of thermal eruptions

Materials
- igneous rocks for display
- pictures of Yellowstone National Park

Vocabulary

vog	hot spring
debris flow	geyser
igneous rock	mud pot

Introduction

Have you ever visited Yellowstone National Park in Wyoming?

What are some things you observed on your visit?
Possible answers: Old Faithful, hot springs, animals

You may want to take time to share pictures from trips to Yellowstone. Research Yellowstone National Park on the Internet to view pictures of the geysers and hot springs.

Teach for Understanding

Purpose for reading

How can a volcano affect your everyday life even if you do not live near one?

What other ways does heat escape from inside the earth?

Effects of Volcanoes

In 1815 Mount Tambora erupted in Indonesia. The Plinian eruption blasted millions of tons of ash, dust, and gases high into the atmosphere. Scientists think the gases may have reflected the sun's rays away from the earth. This caused dramatic cooling worldwide. In fact, 1816 was known as "the year with no summer." In some places snow fell all year long. Crops were damaged and destroyed, causing a food shortage. In 1991 the eruption of Mount Pinatubo (PIN uh TOO bo) also caused a slight cooling of worldwide temperatures. This eruption helped produce brilliant sunsets and sunrises for more than a year.

The gases released from a volcano are similar to smog, the pollution caused by many cars and industry in urban areas. Scientists call volcanic gases **vog**, meaning volcanic fog. Just like city pollution, vog can aggravate respiratory problems. It can also cause acid rain as the sulfur dioxide in the gases mixes with water droplets to form an acid. Acid rain can eat away metals and stone structures and kill plant and animal life.

Dangers of Volcanoes

When you think of a life-threatening eruption, you might picture a crowd of people running from a great lava flow. Lava flows do pose a threat, but they are generally slow moving. The ash and gases released into the atmosphere are actually a greater threat to living things. The pyroclastic flow caused by a Pelean eruption probably causes more destruction than any other feature of a volcano. It was a pyroclastic flow that killed the people of Pompeii.

Another danger is a debris flow. A **debris flow** occurs when part of the mountain collapses and mud and rock fragments surge down the mountain. This debris flow can bury a city and smother the life in its path.

Mount Pinatubo

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SCIENCE BACKGROUND

Volcanic rock
Igneous rock is often divided into *extrusive rock*, lava that cools quickly above ground, and *intrusive rock*, magma that cools more slowly below ground.


pumice

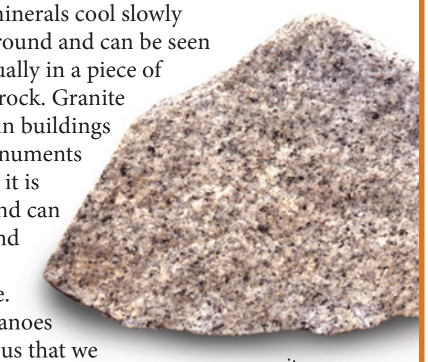
Products of Volcanoes

Not all effects of volcanoes are bad. The soil around volcanoes is rich in minerals. Indonesian farmers working the land around Mount Merapi, an active volcano, can harvest three crops each year instead of one. Valuable gems are also found in and around volcanoes.

Volcanoes produce **igneous** (IG nee us) **rock** as magma and lava cool and harden. The faster the lava cools, the smoother the rock will be. Different kinds of rock can come from the same kind of lava, depending on how the lava cools. Pumice forms when the foam on the top of lava cools swiftly. Because of its many air pockets, pumice is a rock that will actually float on water! Pumice can be ground into powder and used to make abrasive soap and polish.

Obsidian (ahb SID ee un) is another igneous rock. It cools so quickly that it has a glassy, smooth surface. When obsidian breaks, it has sharp edges. It was once formed into weapons such as arrowheads and cutting tools. Because of its beauty, you may see obsidian in jewelry.

Some igneous rock forms when magma cools below the ground. Granite is an example of this kind of rock. Granite is composed of four minerals: quartz, feldspar, mica, and hornblende. These minerals cool slowly underground and can be seen individually in a piece of granite rock. Granite is used in buildings and monuments because it is stable and can withstand a lot of pressure.


granite

Volcanoes remind us that we live in a fallen world. Because of sin, the earth no longer functions as God made it to. But volcanoes also remind us that God has not abandoned His world. He still cares for it and sustains it. He also still loves the people He created. Although volcanoes destroy, they also renew and enrich the earth.

Thy faithfulness is unto all generations: thou hast established the earth, and it abideth. Psalm 119:90

21

Book connection
LANGUAGE
Your students may enjoy reading *The Journeyman* by Elizabeth Yates, published by JourneyForth, a division of BJU Press. It tells the story of a young man during "the year with no summer."

Discussion

What do scientists think caused "the year with no summer"? the Plinian eruption of Mount Tambora

In what ways can a volcano affect the weather? Possible answers: An eruption can cause changes in temperature because of the gases, ash, and dust in the atmosphere. It can cause acid rain. It can cause vog.

What is vog? gases released from a volcano

Why is vog dangerous? Possible answers: Vog can aggravate respiratory problems. It can cause acid rain, which eats away metal and stone and can kill plants and animals.

Why is a lava flow not particularly dangerous? It moves slowly.

What are two other kinds of volcanic dangers that occur quickly? pyroclastic flow, debris flow

What is a debris flow? the surge of mud and rock fragments that occurs when part of a mountain collapses

What are some benefits of volcanoes? Volcanoes enrich the soil around them with minerals. Often valuable gems are found in and around volcanoes.

What kind of rock does a volcano produce? igneous rock

What determines the kind of rock formed by a volcano? Possible answers: how quickly the lava cools; mineral content

How does granite differ from pumice and obsidian? It is formed by magma cooling under the earth's surface rather than by lava cooling above the surface.

In what way does God use volcanoes to renew the earth? Possible answers: Volcanoes produce new land. They bring minerals to the surface.

Discuss how God's using destructive volcanoes to renew the earth is an example of His mercy.

Display the igneous rocks. Allow students to infer how each rock may have cooled to form its structure.

Discussion

What does *thermal* mean? Answers may vary, but elicit that *thermal* refers to heat.

What are some other words that use *therm* as part of the word? Possible answers: thermometer, thermostat

What is a hot spring? a heated pool of ground water

What is a geyser? a hot spring that periodically blows steam and hot water into the air

How are a geyser and a volcano similar? They both erupt as a result of heat and pressure.

What is a mud pot? a hot spring that contains more mud than water

Why do you think these types of eruptions are called thermal eruptions? They are heated by the earth's magma.

Yellowstone National Park is famous for its many kinds of thermal eruptions. It appears to be located on one of the few hot spots in a continental crustal plate.

Answers

1. Its gases, ash, and dust can cause cooling. Vog pollutes the air and can cause acid rain.
2. rock that forms from cooled lava and magma
3. Possible answer: Volcanoes do not just destroy. They renew the earth and add minerals to the soil.
4. hot springs, geysers, mud pots

Activity Manual

Review, pages 15–16

These pages review Lessons 7 and 10.

Assessment

Quiz 1-B

The quiz may be given any time after completing this lesson.

Other Thermal Eruptions

Volcanoes are not the only way that heat escapes the earth. Sometimes a body of water is located near an underground magma pool. Heat from the hot magma warms the water. Once the water is heated, it rises to the earth's surface, creating a **hot spring**. Many

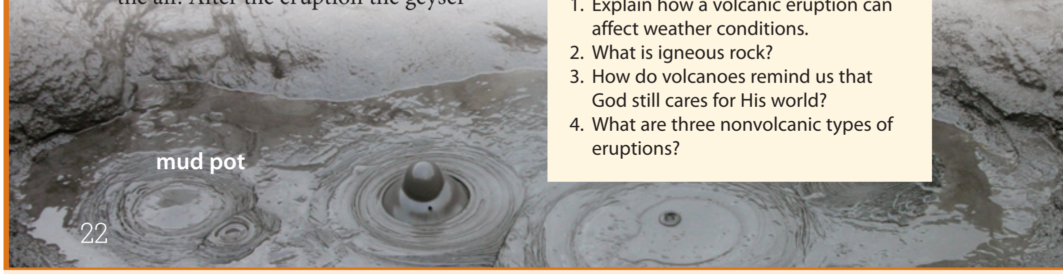
people enjoy these hot springs because the warm water relieves aches and pains and relaxes muscles.

A **geyser** (GY zur) is a hot spring that periodically blows steam and hot water into the air. The water in a geyser is under great pressure and is heated beyond the normal boiling point. As the water heats, it forms steam bubbles, which become trapped in places under the earth. The pressure builds up until the water and steam explode into the air. After the eruption the geyser settles down and begins to build up pressure again. Old Faithful, located in Yellowstone National Park, is a famous geyser. Iceland and Japan also have many active geysers.

A hot spring that contains more mud than water is called a **mud pot**. As the hot water rises, it flows through the mud and warms it. Sometimes these mud pots are close to boiling, causing the mud to bubble and splatter. Mud pots usually smell bad. They give off sulfurous gases that smell like rotten eggs.

QUICK CHECK

1. Explain how a volcanic eruption can affect weather conditions.
2. What is igneous rock?
3. How do volcanoes remind us that God still cares for His world?
4. What are three nonvolcanic types of eruptions?



22

HISTORY

Yellowstone National Park

Yellowstone National Park is the oldest national park in the world. After a geological survey was done of the area in the 1870s, it was decided Yellowstone was a unique place and should not belong to any one person. On March 1, 1872, the US Congress decided to make it the first national park. In addition to Old Faithful, the park has approximately 10,000 other hot springs, mud pots, and geysers.

Old Faithful is not the biggest geyser at the park. It received its name by being consistent. Its eruptions are between 35 minutes and 2 hours apart, and the duration of each eruption predicts the interval to the next eruption.

DIRECT A DEMONSTRATION

Demonstrate how a geyser works

Materials: large metal funnel, pan, water, hot plate (or stove)

Put the wide end of the funnel in the pan. Fill the pan with water until it is level with the stem of the funnel.

Place the pan over the heat until the water boils. When the water boils it will demonstrate a geyser.

How is the funnel like a geyser? The hot plate heats the water like the magma heats the water pool. The hot water begins to rise. It shoots out the top of the funnel just as it shoots out the top of the geyser.

I.N.V.E.N.T.

EXPLORATION

Many inventions have helped scientists discover new information about volcanoes. Some information can be gathered at a distance. NASA flies planes carrying radar equipment that can see through volcanic clouds over active volcanoes. This equipment tells the type and location of lava flow. Other instruments measure temperature and the gases being released. A seismograph is used to record movement in the area of the volcano. Small changes in the slope of the ground can be a warning sign. A tiltmeter registers this motion. A geodometer is a laser beam used to assess the shape and size of a volcano.

Scientists also study volcanoes up close, but this is very dangerous. A volcanologist may wear a suit made partly of aluminum to help fireproof his clothing. Leather gloves and hiking boots are also important for protecting him from extreme heat. Sometimes he needs a gas mask. He may use a stainless steel pipe to gather lava samples. Scientists take many risks to discover information from a volcano.

What to do

1. Design an invention that will help scientists research volcanoes. Decide what information you want your invention to monitor. Where will your machine be able to gather information? Will it be mobile? If so, how does it work? Is it a piece of clothing or a machine a scientist would maneuver?
2. Follow the procedure in your Activity Manual.

Dante II

Scientists sometimes use robots to gather information from inside active volcanoes. *Dante II* made a reasonably successful trip into Mount Spurr in Alaska. However, after retrieving data, it fell to the crater floor on its way out. NASA scientists hope that developing similar robots will also aid in exploring the harsh conditions of other planets.

23

SCIENCE BACKGROUND

Tiltmeter
A tiltmeter records unevenness in the earth's surface. Bulges and bubbles in the surface (crust) can indicate volcanic activity.

LANGUAGE

Following procedures
Guide the student in learning to read procedures. Direct the student to circle all the requirements for the project in the memo on Activity Manual page 17. Encourage him to mark each step as he completes it.

TEACHER HELPS

Active listening
To encourage active listening from the "committee," instruct each student to record the following information about each presentation: name of inventor(s), name of invention, purpose, would they give money (yes or no and why).

Objectives

- Identify the dangers and difficulties associated with exploring volcanoes
- Design a piece of equipment that would help in volcano research

Materials

- carpenter's level

Introduction

Two lesson days are allotted for this exploration. On the first day, introduce the project, set a due date, and begin planning. The second lesson day may occur when the projects are presented.

Display the carpenter's level.

A carpenter's level is used to indicate if an item is level horizontally or straight vertically. Volcanologists use an instrument called a *tiltmeter*, which is similar to a carpenter's level.

Teach for Understanding

Purpose for reading

The student should read all the pages before beginning the exploration.

Discussion

What dangers might scientists face when studying volcanoes? Possible answers: heat, uncertainty of eruption, unstable rock, poisonous gases

What equipment might scientists use to protect themselves? Possible answers: protective clothing, tools to gather samples, robots, long-range sensors

How was the *Dante II* robot used? It went into an active volcano.

Why is NASA interested in the *Dante* robot design? Answers will vary, but elicit that a robot designed to withstand conditions in a volcano might be able to endure conditions on other planets.

Activity Manual

Exploration, pages 17–18

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Objectives

- Use graphic organizers to identify related concepts
- Recognize that graphic organizers have different purposes

Materials

- *Earthquake Concept Web*, for each student
- *Volcano Concept Web*, for each student
- *Venn Diagram*, for each student

Vocabulary

graphic organizer
concept web
Venn diagram

Introduction

What topics have we studied in this chapter? earthquakes and volcanoes

You have learned many things about earthquakes and volcanoes. Today we will look at some different ways to organize the information you have learned.

Teach for Understanding

Discussion

On Activity Manual page 12, you already completed a concept web about classifying volcanoes. A concept web is a type of graphic organizer. It helps you quickly see connections between facts.

Making another concept web about volcanoes will help us see other connections. We will also make one about earthquakes as we review the chapter.

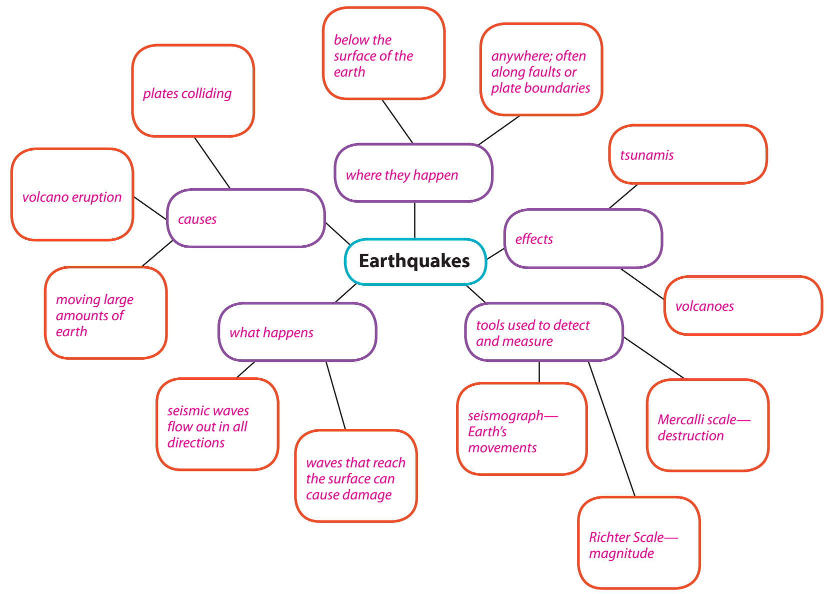
Distribute copies of the webs. As needed, think aloud as you model how to complete the webs using questions similar to the following.

The main topic or concept is written in the center of the web. The connecting facts help you see their relationship to the main concept.

Earthquake Web Key

Name ____________________

Suggested web and answers. Definitions and descriptions may be added.



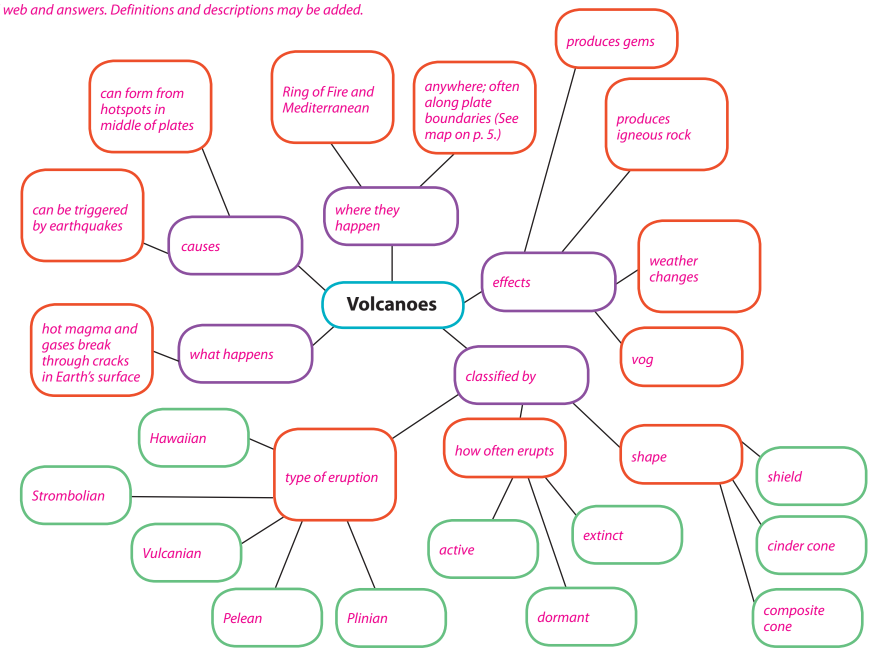
SCIENCE 6
For use with Lesson 13

Worksheets
TEACHER HELPS
Worksheets and pages for use in lessons are in the Instructional Aids (IA) section of the Teacher's Toolkit CD. Pages on the CD are marked with an icon.

Volcano Web Key

Name ____________________

Suggested web and answers. Definitions and descriptions may be added.



Science 6
For use with Lesson 13

Graphic organizers

TEACHER HELPS

Many kinds of graphic organizers exist. Several are included on the Teacher's Toolkit CD for you to adapt and use throughout *Science 6*. You may choose to provide these as models for the students to make their own as they read, or they could be filled out during the teaching of the lesson.

What kinds of things do we know about earthquakes? We know where they happen, and we know what happens during an earthquake. We learned what causes an earthquake and what earthquakes can cause.

What is a main cause of an earthquake? plate boundaries pushing and moving

What do we call breaks that happen where plate boundaries push? faults **What are the three kinds of faults?** reverse fault, normal fault, strike-slip fault

What are two other things that can cause earthquakes? volcanoes and moving large amounts of earth

Continue the questioning as needed while students complete the rest of the earthquake and volcano webs. Discuss the webs as needed.

Concept webs help us see the relationships between ideas. However, if we want to compare and contrast earthquakes and volcanoes, we need to use a different graphic organizer. Can you think of a type of graphic organizer that can compare these two topics? Possible answers: Venn diagram, T-chart

When we use a Venn diagram to compare, the overlapping part of the circles is where we write the things that are the same. What are some things that earthquakes and volcanoes have in common? Possible answers: Both often happen near plate boundaries, but can happen anywhere; both cause damage and destruction on the surface of the earth; both can cause each other.

Provide time for the student to record the things volcanoes and earthquakes have in common.

The outer parts of the circles are where we write the things that are unique to each concept.

As needed, guide the students in completing the Venn diagram.

Graphic organizers serve many purposes. Some, like these, help you see relationships or compare concepts. Others help you identify cause and effect or track a sequence of events.

You can use organizers as you read information for the first time or when you are studying.

Lessons 14–15

Student Text page 24
Activity Manual pages 19–20

Lesson 14

Objectives

- Recall concepts and terms from Chapter 1
- Apply knowledge to everyday situations

Introduction

Material for the Chapter 1 test will be taken from Student Text page 24 and Activity Manual pages 5–6, 15–16, and 19–20. You may review any or all of the material during this lesson. Questions similar to Solve the Problem or the ones in Thinking it Through, Activity Manual pages 19–20, may appear on the test.

You may choose to review Chapter 1 by playing "Volcanic Eruptions" or a game from the Game Bank on the Teacher's Toolkit CD.

Teach for Understanding

Diving Deep into Science

Information on this page reflects the vocabulary and concepts the student should know for the test.

Solve the Problem

In order to solve the problem, the student must apply material he has learned. The student should attempt to answer the problem independently. The answer for this Solve the Problem can be found using information on Student Text pages 10–11. Answers will vary and may be discussed. You may choose for the student to incorporate principles from Genesis 1:28 and Mark 12:31 about man's dominion over the earth and God's command to love others.

Activity Manual

Review, pages 19–20

These pages require written responses to application questions.

Lesson 15

Objective

- Demonstrate knowledge of concepts taught in Chapter 1

Assessment

Tests, Chapter 1

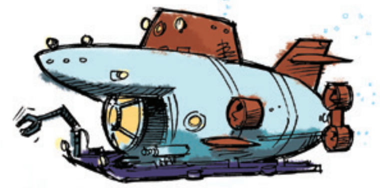
DIVING DEEP INTO SCIENCE

Words to Know

lithosphere	seismograph	tephra
plates	magnitude	pyroclastic flow
plate boundary	tsunami	vog
earthquake	volcano	debris flow
fault	volcanologist	igneous rock
focus	magma chamber	hot spring
seismic wave	lava	geyser
epicenter	Ring of Fire	mud pot
seismologist	hot spot	

Key Ideas

Theory of plate tectonics
Causes of earthquakes
Types of faults
Types of seismic waves
Measuring earthquakes
Parts of volcanoes
Causes of volcanoes
Classifications of volcanoes
Types of volcanic eruptions
Effects of volcanoes



Solve the Problem

During the night the shaking ground awakened many residents of a small town. Big buildings that were thought to be sturdy began to crack and moan. When the earthquake was over, many buildings had collapsed and lay in piles of rubble on their sandy foundations. The earthquake, however, measured only 4.8 on the Richter scale. Why do you think the earthquake caused so much damage to this city? What could people have done to prevent the massive destruction? What Bible verses teach that Christians should try to prevent this kind of destruction?

Answers will vary. The sandy foundations did not provide stability for the buildings. To have more stable buildings, they would need to be built on a deeper rock base.

Review Game

Volcanic Eruptions

Divide the class into teams. Draw two volcano shapes, both divided with equal horizontal lines. For each correct answer to a review question, the team colors a section of its volcano, starting at the bottom. The first team to "erupt" its volcano wins.