



SCIENCE

STUDENT BOOK

► **9th Grade | Unit 3**

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SCIENCE 903

Physical Geology

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Physical Geology

Introduction

"Surely there is a vein for the silver, and a place for gold where they find it. Iron is taken out of the earth, and brass is molten out of the stone...." (Job 28:1-2) "As for the earth, out of it cometh bread; and under it is turned up as it were fire. The stones of it are the places of sapphires: and it hath dust of gold." (Job 28:5-6). "My substance was not hid from thee, when I was made in secret, and curiously wrought in the lowest parts of the earth." (Psalm 139:15)

The purpose of God in creating our planet is revealed in Isaiah 45:18: "For thus saith the Lord that created the heavens; God Himself that formed the earth and made it; he hath established it, he created it not in vain, he formed it to be inhabited...."

In fulfilling His intention to create an inhabited planet, God placed within and on the earth all things needed for human life: the minerals of which our bodies are made (Psalm 139:15), which come from the ground by agriculture (Job 28:5).

God has put into the rocks of earth all minerals needed by organisms. He has also taken care that deadly poisons are not present in soil in more than trace amounts. As essential minerals are removed from the soil, rocks chemically disintegrate and make new soil.

Heat, generated by radioactive elements, causes deeply buried elements to expand and come to the surface where minerals needed for life become available. Lowly worms and bacteria reprocess dead bodies of animals and plants into soil nutrients. Psalm 139:15 states that

God formed the substance of our bodies when the minerals were "in the lowest parts of the earth."

Besides providing the necessities of life, God has put within the stones materials necessary for industry and commerce, as Job said in chapter 28, verses 1–6. The earth's magnetic field and its atmospheric electric charges gave man information about the nature of atoms and the particles of which they are made. This structure makes electronic communication possible. It reveals scientific principles by which to perform technological wonders. The marvelous ingenuity of man's mathematical systems and technical inventions demonstrate that the divine Creator made man a special creation like no other.

In space God is highly glorified by His creation of billions of galaxies. The distances between galaxies (measured in millions of light years) give man an understanding that God "inhabits eternity," and that Jesus' "goings-forth have been of old, from everlasting." (Micah 5:2)

Since God is eternal, economy of time means nothing to Him, except within the historical framework of His plan of redemption. The time frame involves the generations of patriarchs and prophets preparing the way, the Gospel age in which salvation is declared to every tribe and nation, and Christ's coming kingdom. Exactly how God created this planet, we are not told. In Genesis 1:1 the fact of creation is stated, and the account goes on from that point with the various parts of the surface environment. This topic will be taken up in detail in this LIFEPAAC®.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAAC. When you have finished this LIFEPAAC, you should be able to:

1. Glorify God by explaining how this world is designed as an environment for living creatures, including ourselves.
2. Trace the history of the concept of the earth's shape.
3. Name the three rock classes, to describe their origin, and name representatives of each class.
4. Describe the earth's layers and the ways geologists have to investigate them.
5. Name and describe igneous structures.
6. List the types of mountain structures
7. Explain the effects of weathering, erosion, and sedimentation.
8. Name the agents of weathering.
9. Describe evidence of movements in the earth's crust.
10. Explain the current theory that explains the origin of volcanoes, earthquakes, mid-ocean ridges, ocean trenches, and mountain ranges.

This image shows a single sheet of white paper with horizontal blue lines, resembling notebook paper. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

1. EARTH STRUCTURES

Section 1 presents evidence from ancient writings that people have known the earth to be a sphere for thousands of years. The sphere is made up of several layers of differing compositions. The top layer—the earth’s

surface—consists of three classes of rock. Two of the classes are derived from the original igneous rock. The surface has experienced movements that have produced a variety of landforms.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

1. Glorify God by explaining how this world is designed as an environment for living creatures, including ourselves.
2. Trace the history of the concept of the earth’s shape.
3. Name the three rock classes, to describe their origin, and name representatives of each class.
4. Describe the earth’s layers and ways geologists have to investigate them.
5. Name and describe igneous structures.
6. List the types of mountain structures.

VOCABULARY

Study these words to enhance your learning success in this section.

asthenosphere (as then’ u sfir). A plastic, semi-liquid region of the earth’s mantle directly beneath the crust.

crust (krust). The solid outer layer of the earth.

mantle (man’ tul). The part of the earth beneath the crust and above the outer core.

Note: All vocabulary words in this LIFEPAK appear in **boldface** print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.

Pronunciation Key: hat, āge, cāre, fār; let, ēqual, tērm; it, īce; hot, ōpen, ōrder; oil; out; cup, pūt, rūle; child; long; thin; /ʒh/ for then; /zh/ for measure; /u/ represents /a/ in about, /e/ in taken, /i/ in pencil, /o/ in lemon, and /u/ in circus.

SHAPE

Ancient Asiatic Indians are said to have thought the earth was flat and supported by pillars. It is said they thought the pillars were moral principles, such as truth and justice. Actually, however, they knew the earth was a sphere and used the diameter of the earth as the base of a triangle to calculate the distance to the moon.

They concluded that this distance is thirty times greater than the diameter of our globe.

Eratosthenes, a Greek scientist who lived in Egypt, is usually credited as the first to calculate the circumference of the earth. At noon on the first day of summer, he measured the angle of the sun’s rays at Alexandria and at Syene (Aswan), both in Egypt. Since the difference in

angle was almost one-fiftieth of a circle, the earth's circumference was fifty times the distance between the towns. Eratosthenes might have been merely confirming a conclusion that Egyptian surveyors had made long before.

Aristotle, the Greek philosopher honored and studied in the Later Middle Ages, said that the earth was a globe because the earth's shadow (seen crossing the moon during an eclipse) is always round. The only shape that gives a round shadow from every direction is a sphere.

Saint Augustine of Hippo wrote, "It has been scientifically proven that the earth is a sphere," although he doubted that people were living on the opposite side of the globe.

Astronomy taught in the Middle Ages was the teaching of the first-century Greek-Egyptian author, Ptolemy. Ptolemy was incorrect that the sun and other planets circled the earth. He was correct when he described the earth as a sphere with an equator, North Pole, and South Pole.

From the fourth to the fourteenth centuries, kings in Europe held a globe to represent the world in their hand during their coronation ceremony. Countless incidental remarks preserved in historical chronicles and poetical works

confirm that the reading public all through the Middle Ages took for granted that the earth is a sphere. Textbooks used in monastery and cathedral schools, as well as in later medieval universities, are unanimous in saying that the earth is a sphere.

Sir Isaac Newton reasoned that the earth bulges slightly at the equator, and that the earth is flattened at the poles. Measurements show that his reasoning was true. The bulge is less than one-sixth of 1 percent of the diameter, and the flattening at the pole is about as large. One of Newton's friends, William Whiston, read a manuscript of an ancient Greek author, Aqatharcides. This author was told by an Egyptian priest and college professor that the greatest pyramid near Cairo was designed to be one-eighth of a minute of latitude in width, or one-480th of a degree of latitude on each side. When sand was dug away from the base of the pyramid, its width was found to be within a few inches of that size. Possibly, ancient Egyptian surveyors knew about the spherical shape of the earth, had measured it, and had passed on their knowledge to Greeks who traveled or lived in Egypt. Therefore, Egyptians of the pyramid age should more properly be given credit for first calculating the circumference of the earth.



Complete these sentences.

- 1.1 The Greek scientist usually credited as the first to calculate the earth's circumference was _____.
- 1.2 The first century Greek-Egyptian whose explanation of astronomy was taught in Europe and the Middle East was _____.
- 1.3 Textbooks used in monastery and cathedral schools, and in medieval universities, taught that the earth is a _____.



Answer these questions.

1.4 What evidence did Aristotle present for a spherical earth? _____

1.5 According to an ancient Egyptian priest, a pyramid near Cairo was built with a certain basal dimension. What was the dimension? _____

ROCKS

The three main categories of rock in the earth's crust are igneous, sedimentary, and metamorphic. Igneous rocks were originally molten; then they were crystallized by cooling. Sedimentary rocks were laid in place by moving water, ice, or wind. Metamorphic rocks are rocks that were under enough pressure, or heat combined with pressure, to twist the crystals without melting the rock.

Igneous rocks. Igneous rock that flowed out on the surface is lava; lava blown out of a volcano in explosive eruptions is volcanic ash, or tuff. Igneous rock beneath the surface is magma. Igneous rock that contains separate crystals of quartz (silicon dioxide), feldspar, and mica is granite. Igneous rock with the same minerals as granite, but in microscopic crystals, is rhyolite. A type of igneous rock which has more magnesium than aluminum is basalt, whether it hardened above the ground as lava, below the ground and frozen into rows of pillars, or under water where it makes piles of "pillow lava."

Sedimentary rocks. Sedimentary rock made mostly of sand is sandstone. Pieces of rock larger than sand are called gravel, pebbles, cobbles, or boulders, depending on how large they are. Seashells and other forms of calcium

carbonate are cemented together in limestone. Any sedimentary rock that contains rounded stones and sand is called conglomerate. Rock containing broken pieces of rocks that have not been rounded is called breccia. Sedimentary rock made from mud is called siltstone, and rock made from clay is called shale.

Metamorphic rocks. Metamorphic rocks differ according to what kind of rock they are made from, and according to the degree to which they have been changed by heat and pressure. Shale can be mildly metamorphosed into slate or further changed into schist. Limestone can be changed by pressure into marble. Sandstone can be metamorphosed into quartzite.

When high heat and pressure distort the crystal structure of previously formed rocks without melting them, the result is a metamorphic rock. Some metamorphic rocks are changed a small amount from their original conditions. Bituminous (tar-containing) coal, for example, can be slightly metamorphosed into anthracite (hard coal, used for steelmaking). Greater pressure can cause further stages of metamorphism, turning anthracite into graphite, the material from which pencil "lead" is made.



Write true or false.

- 1.6 _____ The equivalent of granite with crystals too small to be seen is rhyolite.
- 1.7 _____ Metamorphic rock originated under conditions of high heat and pressure.
- 1.8 _____ A characteristic that helps identify granite is crystal size.

Complete these sentences.

- 1.9 Rocks that originated from the liquid phase are classified as _____ .
- 1.10 Igneous rock that flowed out on the surface of the ground is called _____ .
- 1.11 Igneous rock beneath the surface of the ground is called _____ .
- 1.12 Lava blown out of a volcano in explosive eruptions is called a. _____ , or
b. _____ .
- 1.13 Granite is composed of crystals of a. _____ and the minerals b. _____ and
c. _____ .
- 1.14 A type of igneous rock with more magnesium than aluminum is _____ .

Complete these activities.

- 1.15 Explain how the three categories of rock are formed.
 - a. igneous _____

 - b. sedimentary _____

 - c. metamorphic _____

- 1.16 Complete the chart of sedimentary rocks.

Pieces	Rock
sand	a.
rounded stones	b.
angular rocks	c.
mud or clay	d.

1.17 Complete the chart of metamorphic rock.

Sedimentary Rock	Metamorphic Rock
shale	a.
limestone	b.
sandstone	c.

TEACHER CHECK

initials

date

LAYERS

The upper layers of the earth include these:

- the atmosphere: 78 percent nitrogen and 21 percent oxygen
- the hydrosphere: salty water covering 71 percent of the earth to an average depth of about 4 kilometers
- sedimentary rock: covering most of the continents and ocean basins to an average depth of about $\frac{3}{4}$ kilometers (more than 16 kilometers in some places)
- granite cores of the continents: averaging about 30 kilometers thick (about 50 kilometers thick under mountain ranges)
- a floor of heavier rock, called basalt: under the oceans in layers about 5 kilometers thick

Crust. Sedimentary rock layers, granite continent foundations, and basaltic sea floors together are called the earth's **crust**. Just under the crust is a change in the speed of earthquake shock waves, indicating that a different type of rock is found below. Volcanoes sometimes bring up solid rocks along with liquid lava. In some places the entire crust has been broken and tilted, showing parts of the underlying rock.

Mantle. The body of rock from the crust down to the iron core of the earth is called **mantle**.

The mantle is made of rocks that contain more iron than rocks of the crust. Rock within the

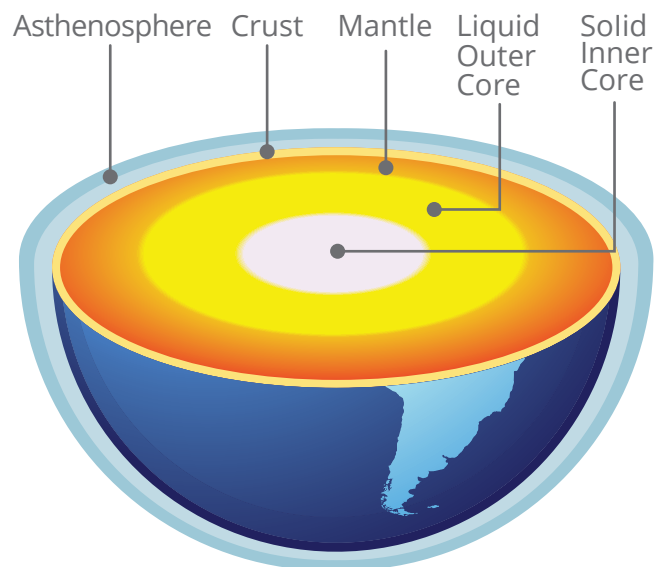


Figure 1 | Major Layers of the Earth

mantle gets heavier with depth until the melted outer core is reached.

Within the mantle, at depths of about eighty to one hundred sixty kilometers, is a partially melted zone called the **asthenosphere**. The movement of rock into the areas where it comes to the surface in volcanoes or remains under the surface to raise ranges of mountains indicates that partly or completely melted rock can be found at almost any depth. The passage of earthquake waves shows that most of the upper mantle is solid.

Temperatures in the interior of the earth are so high that the rock would melt if the pressure were not so great. Radioactive atoms break up at a slow rate, keeping the temperatures high. Some mantle rock partially melts (some minerals melt, but others do not) and forces its way up to the surface. The minerals in the mantle that melt are the silicon compounds that make up the earth's crust. A small decrease in temperature would allow crystals to form and the rock to solidify. However, rock is so poor at transmitting heat that it cools very slowly.

Core. The gravitational pull of the earth shows that the weight of the earth is about five and a half times the weight of the same volume of water. The weight of rocks near the surface of the earth is only about three times that of water, so the interior must be made of much heavier materials such as iron and nickel.

The earth's magnetic field shows that the core can hold or cause a strong magnetic field. Iron

is the logical material. Since some meteorites (thought to come from smashed planets) are made of iron with nickel, scientists have concluded the earth's core is made of iron and other heavy metals.

Shock waves started by earthquakes produce two kinds of movement: compression waves, which push molecules closer together temporarily as they move away from the earthquake, and sideways shaking motions (vibrations). Compression shock waves move through both solids and liquids (faster through solids). Sideways vibrations do not move through liquids. Vibrations from earthquakes show that the sideways waves get lost in a liquid zone about 2,900 kilometers under the surface. The compression waves that go through the planet are bent as they go in and out of this liquid outer core. They show that the middle part of the earth's core is solid.



Write true or false.

- 1.18 _____ Compression shock waves move through both solids and liquids.
- 1.19 _____ The atmosphere contains 21 percent nitrogen and 78 percent oxygen.
- 1.20 _____ Granite mountain cores have thicknesses of fifty kilometers.
- 1.21 _____ Mantle rocks differ from crustal rocks by the amount of iron they contain.
- 1.22 _____ Temperatures in the earth's interior are above the normal melting point of rock.
- 1.23 _____ Rock transfers heat rapidly.

Write the letter for the correct choice in each blank.

- 1.24 The gravitational pull of the earth is greater than the mass of an equal volume of water by _____ times.
a. $1\frac{1}{2}$ b. $3\frac{1}{2}$ c. $5\frac{1}{2}$ d. $7\frac{1}{2}$
- 1.25 Pressure waves passing through the liquid outer core are _____.
a. bent b. reflected c. absorbed d. canceled

- 1.26** Oceans cover almost _____ percent of the earth's surface.
a. 21 b. 50 c. 71 d. 78
- 1.27** In some places, sedimentary rock extends as deep as _____ kilometers.
a. 50 b. 16 c. 71 d. 2,900

Complete these sentences.

- 1.28** Oceans make up the earth's layer called the _____.
- 1.29** The floor of heavier rock under the oceans is composed of _____.
- 1.30** Sedimentary rock layers, granite continent foundations, and basaltic sea floors together are called the earth's _____.
- 1.31** The layer between the crust and the core is the _____.
- 1.32** A partially melted zone in the mantle is called the _____.

Answer these questions.

- 1.33** What evidence exists for a heavy core? _____

- 1.34** What two lines of evidence exist for an iron and nickel core?
a. _____

b. _____

- 1.35** What are the two kinds of earthquake shock waves?
a. _____

b. _____

- 1.36** What evidence exists for a liquid outer core? _____



View 903 Earthquake Shock Waves, from the Grade 9 SCIENCE EXPERIMENTS Video



Try this experiment to demonstrate earthquake waves.

These supplies are needed:

- pencil
- desk or small table
- long sheet of paper
- string
- brick

Follow these directions. Place a check in the box when each step is completed.

- ☐ 1. Tie the pencil to the brick so the pencil extends past the end of the brick. Hang both from the top of a doorway, pencil point downward, about as high as the top of a table.
- ☐ 2. Place a student desk or small table under the hanging brick, and adjust the height of the pencil so that its point touches on the desk.
- ☐ 3. Place books on both sides of the desk so that a long sheet of paper can be pulled between the two rows of books.
- ☐ 4. Pull the paper and observe the pencil drawing a straight line on the paper.
- ☐ 5. Repeat the experiment while someone stamps his foot nearby.
- ☐ 6. Repeat the experiment with someone bumping the desk hard enough to shake it. If the paper is being pulled steadily when the table is bumped, the line should show marks like the record of earthquake waves made by a seismograph.

Record what you saw.

1.37 Describe the marks drawn by the pencil in each case for the previous experiment.

a. straight pull of paper: _____

b. stamping foot: _____

c. bumping of table: _____



Earthquake Shock Waves Experiment

IGNEOUS STRUCTURES

Igneous rocks contain silicon and oxygen. Silicon combined with oxygen alone forms quartz (SiO_2). Silicon and oxygen combine with metals—potassium, aluminum, sodium, magnesium, calcium, and iron—to form other minerals. Only a small amount of carbon is present in igneous rocks.

The size of crystals in an igneous rock tell whether it hardened rapidly or slowly. If an igneous rock is smooth and separate crystals cannot be seen, it hardened quickly. If large crystals are visible, like fruit and nuts in a fruitcake, the rock crystalized slowly. Slow cooling gives molecules in the melted rock time to move by heat vibrations. The moving molecules came in contact with other molecules of the same compound or of a compound with similar physical and chemical qualities and grow into bigger crystals.

Intrusive structures. Rocks in the upper mantle have temperatures so high that they would melt if they were not under pressure from the weight of rock above them. The heat within the earth comes from radioactive minerals, mostly uranium and potassium. Heat from radioactive minerals melts and expands surrounding rock so that it rises toward the surface as magma or comes out on the surfaces as lava, releasing the heat. The magma or lava contains decay products of radioactivity as well as radioactive minerals. The decay products in the magma give igneous rock apparent “radioactive ages” much older than the actual time of the intrusion or lava flow.

Zones of mantle that contain radioactive minerals expand and become lighter than surrounding rock. The hottest rocks become soft and are squeezed upward, like toothpaste, through zones of weakness in the earth’s crust. If this hot, soft rock reaches any place where the pressure is released further, it melts and

comes up as magma. The magma fills a fault or a fissure crack caused by an earthquake, injecting itself between layers, raising up lighter and weaker layers. Sometimes this hot magma melts the rock above it and pours out on the surface as lava, an extrusive igneous rock.

Magma that penetrates buried rocks, but does not reach the surface, is called *intrusive* rock. A large mass of hardened igneous rock beneath all layers of sedimentary rock is called a *batholith*. A vertical wall of formerly melted rock that fills a fault, or fissure, is called a *dike*. Intrusive rock injected between layers is called a *sill*. A dike or sill may be only a few centimeters thick, or it may be meters thick. It may extend for kilometers, or it may be only a few meters wide. Intrusive rock that pushes its way horizontally between sedimentary strata, but pushes the strata in the middle upwards, is called a *laccolith*.

In *shield* areas like Quebec and Newfoundland, the roots of mountains now worn away are exposed. The igneous rocks that originally formed cores of mountain ranges had cooled and cracked. Lava intruded and filled these *joints*. In some cases the liquid rock was squirted into many tiny cracks, leaving a striped appearance.

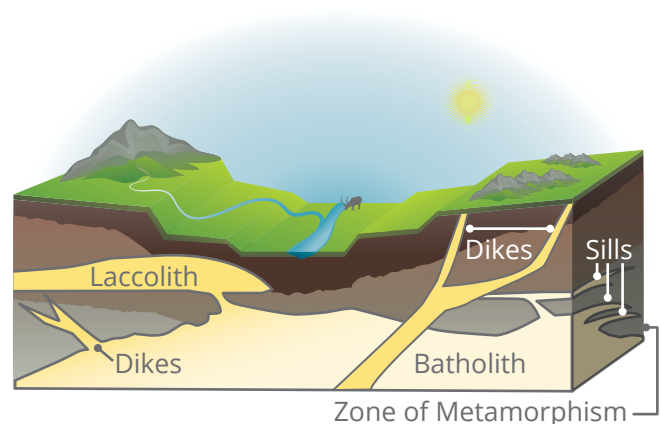


Figure 2 | Intrusive Structures

As magma cools, water dissolved in the melted rock rises and is forced into any available cracks in the top of the igneous rock or in formations above. Often this super-hot water

contains dissolved metals, which are deposited in *veins*, filling cracks in the batholith or laccolith. Veins like these yield gold, silver, copper, and other valuable metals.



Write true or false.

- 1.38** _____ Release of pressure converts mantle rock from solid to liquid.
- 1.39** _____ Lava is extrusive magma.
- 1.40** _____ A vertical wall of intrusive rock is a batholith.
- 1.41** _____ The cores of continents are made mostly of basalt.
- 1.42** _____ Basalt is lighter than granite.

Write the letter of the correct choice in each blank.

- 1.43** A large mass of hardened igneous rock extending from beneath all layers of sedimentary rock is a _____.
 a. sill b. dike c. batholith d. laccolith
- 1.44** Water-rich solutions carrying metallic salts fill cracks and form _____.
 a. sills b. veins c. joints d. dikes

Complete these statements.

- 1.45** Igneous rocks contain compounds of the two elements, a. _____ and b. _____.
- 1.46** The rate at which igneous rock hardened is indicated by the _____ of the crystals.
- 1.47** The factor that keeps mantle rock from melting is _____.
- 1.48** Magma that does not reach the surface is called _____ rock.
- 1.49** Intrusive rock injected between horizontal layers of other rock is called a _____.
- 1.50** Cracks in rock are called _____.
- 1.51** Mountain roots, which are the remains of mountains worn away, are called _____ areas.



Complete these activities.

1.52 List the two most common elements in igneous rocks.

- a. _____
- b. _____

1.53 List five other common rock-forming elements.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

1.54 Explain why slow cooling produces large crystals. _____

1.55 Start a classroom rock collection.

Visit a quarry, a mine, or a company that makes tombstones. Tell a company representative the purpose of your visit. Listen respectfully to anything he may say about company operations or about the stones on which his company works. Politely ask if you may have small, useless broken pieces of rock that are waste material from their operations. Ask the company representative what kind of rock each one is. Place a label on each stone right away. Paper labels should be replaced by labels written in ink on adhesive tape and taped to one rock of each kind.

Examine the rocks you have collected. Looking at them through a magnifying glass will help you to see their crystal structure. Granite is a common type of igneous rock, and in many places small broken samples can be obtained from companies that cut tombstones. Granite has three or four types of crystals big enough to be seen easily: feldspar, quartz, and biotite, or mica. Quartz crystals are clear, partly transparent and consist of silica, the main mineral used in making window glass. Crystals of feldspar may be either pink, white, green, or gray, and are the main mineral in granite. They give the whole stone its color when seen from a distance. Crystals of mica are flat, shiny, transparent or dark-colored flakes. Light reflects from exposed surfaces of mica crystals, so you can find the mica by looking for places where the granite glitters under strong light. Biotite is chemically almost the same as mica, but comes in small, black chunks.

You may experiment with rocks you think might be limestone by putting a weak acid such as vinegar on them. If the weak acid reacts to form bubbles of carbon dioxide, lime (calcium carbonate) is present in the rock.

Extrusive structures. Lava that flows out of a fissure, or long crack, in the earth is a *lava flow*. Lava flows in Iceland, eastern Oregon, the Deccan Plateau of India, and other places on the earth extend for many miles in length and width. Flows have been repeated in the same area until depths of thousands of feet built up, surrounding mountains like islands within a lake. Only a very few large lava flows have formed in modern times.

Indians in Washington and Oregon have traditions that tell of a time when melted rock flowed along the ground and the air was exceedingly hot. According to the tradition, Indians who jumped into rivers or lakes were scalded, and those who fled into the hills lived to tell the story. These Indian traditions, confirmed by pottery found below the most recent lava flows, show that the lava flowed out recently, not many thousands of years ago.

When lava erupts at one point, the result is a *volcano*. Lava often comes forth with such pressure that it is thrown into the air and hardens as it falls. Depending on size, lava thrown into the air may be called *ashes*, *cinders*, or *bombs*. Gas dissolved in lava (mainly steam, but also sulfur dioxide and carbon dioxide) expands into bubbles. A volcanic rock may even float

in water if enough of its volume consists of bubbles.

Eruptions often begin with the mountain swelling, smoke emerging from the top, and showers of cinders. These phases are followed by liquid flows down the side of the volcano. If the lava is a thin liquid, it will flow rapidly before it hardens. Large quantities of basaltic lava often flow like rivers. Smaller quantities will harden into twisted forms, like sections of rope.

Volcanoes that have fast-flowing liquid lava will be wide like shields. Examples are the Hawaiian Islands. Thicker lava is more likely to erupt explosively and throw cinders or ashes in the air. Thick lava forms steeper, narrower cones of cinder and lava layers. Volcanoes made mostly of cinders can be built up in just a few years, but will also erode more quickly than cones of hardened flows.

The most destructive volcanic eruption in modern times was the explosion of Krakatoa in the East Indies in 1883. The eruption killed all life on the island. It also drowned thousands of people in villages on other islands by causing huge waves of ocean water. The eruption was heard thousands of miles away. Dust blasted into the sky and caused cooler seasons and

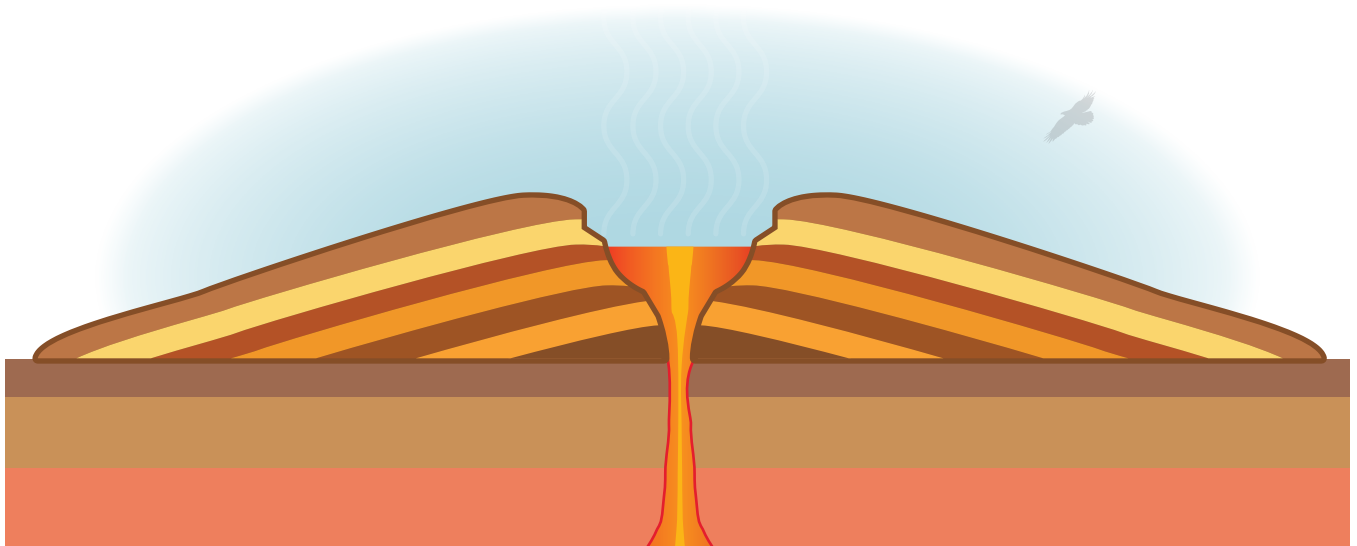


Figure 3a | Cutaway view of shield type volcano, an extrusive structure

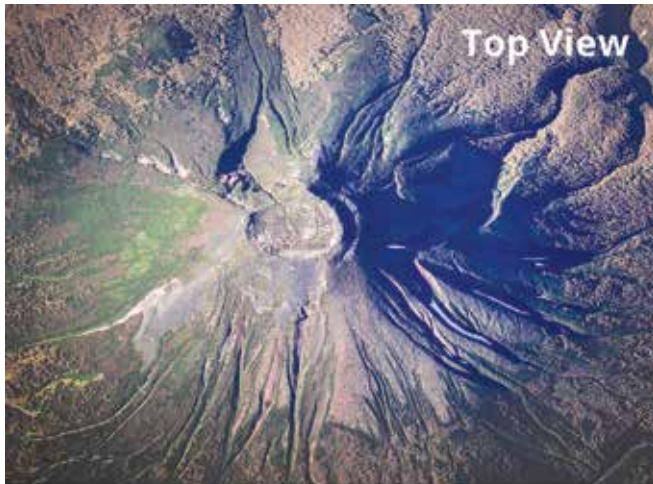


Figure 3b | Extrusive Structure

heavier snowfall around the world for the next two years.

Most of the small islands in the world's oceans were made by volcanoes. One of these new



Figure 4 | Guyot

islands is Surtsey, near Iceland, which appeared in 1963. Geologists inspecting the island a few months later were surprised to find some processes, predicted to take thousands of years, had been completed in a few weeks in this unusual environment. Former volcanoes now under the sea are called *seamounts*. A flat-topped seamount (a volcanic island that has been cut off by wave erosion) is called a *guyot*.

Basaltic lava is sometimes explosively erupted under water. It makes a formation like a pile of pillows on the sea bottom. *Pillow basalt* crystallizes quickly from the outside to the inside of each "pillow." Lava of this type forms only under deep water. It has been found on upper slopes of Mount Ararat, where Noah's ark landed, showing that Mount Ararat was erupting while underwater in the Flood.



Write true or false.

- 1.56 _____ Lava flows seldom occur more than once in any area.
- 1.57 _____ Volcanic ashes, cinders, and bombs are identical except for size.
- 1.58 _____ Gasses form bubbles in lava.
- 1.59 _____ Highly liquid lava forms wide shieldlike mountains.
- 1.60 _____ Pillow basalt seldom originates under water.



Write the letter for the correct choice in the blank.

- 1.61** Gases in a volcano are primarily _____.
a. water vapor b. carbon dioxide c. sulfur dioxide d. nitrogen
- 1.62** Former volcanoes now under the sea are called _____.
a. submarine shields b. cinder cones
c. seamounts d. andesites

Complete these activities.

- 1.63** Explain the difference between a lava flow and a volcano.

- 1.64** Describe a destructive side effect of a volcanic eruption. _____

- 1.65** Find and read articles about three different recent volcanic eruptions. One of the articles might be about the island of Surtsey. You can find such articles in the National Geographic Magazine. Write what you learned about volcanic eruptions. Submit your report.

TEACHER CHECK



_____ initials

_____ date

MOUNTAINS

Mountains are made of sedimentary rock, igneous rock, or a combination.

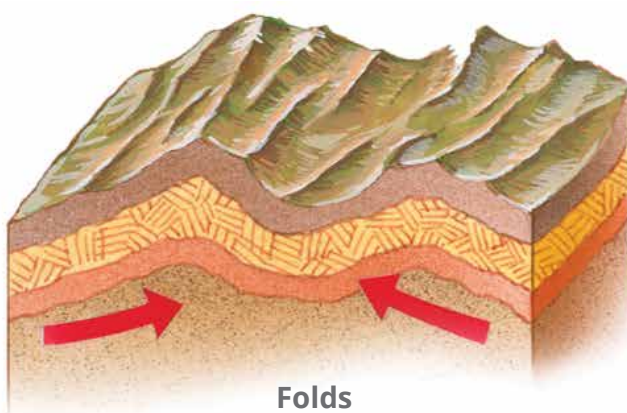
Volcanoes. The simplest mountains to understand are volcanic mountains, which consist of shields of lava flows, cones of volcanic cinders that were exploded into air above a vent, or combinations of the two. A cinder cone can begin on a flat field and can grow into a small mountain in a few weeks. It will be eroded much faster than other mountains.

Volcanoes are not spaced evenly all over the world. They are found along zones of weakness where the earth's crust has been broken, or over "hot spots" where magma has forced its way up from lower zones by melting rock in its way.

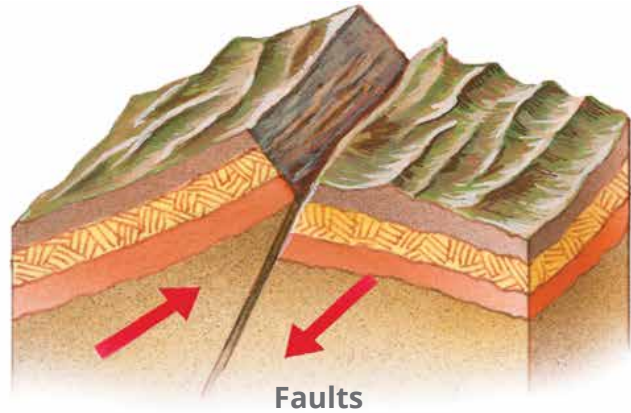
Folded mountains. Sedimentary rocks were originally laid down in nearly flat layers in a sea, lake, or flood plain; then they have been folded by pressure from one side.

Fault-block mountains. Mountains that were raised upward without folding have an edge of the raised zone, called a *scarp*, coming up from a fault, or crack, where the earth's crust was broken. Sometimes several raised and lowered blocks stand side by side. An eroded scarp looks like other mountains when viewed from the lower side; but, when viewed from an airplane, one side of the mountain is very steep, and the other slope is at a lower angle.

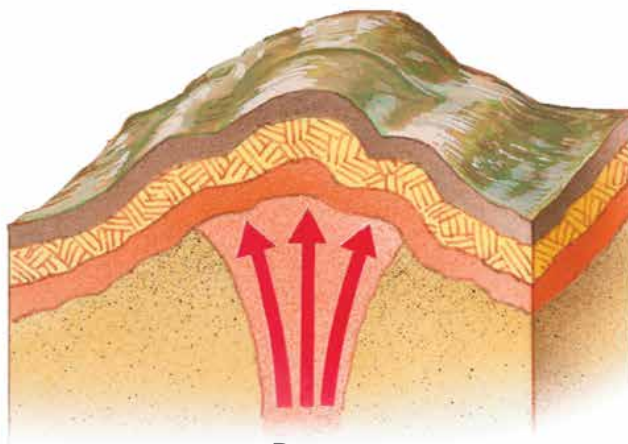
Dome mountains. Dome mountains are caused by huge masses of intrusive magma that have pushed sedimentary rock upward



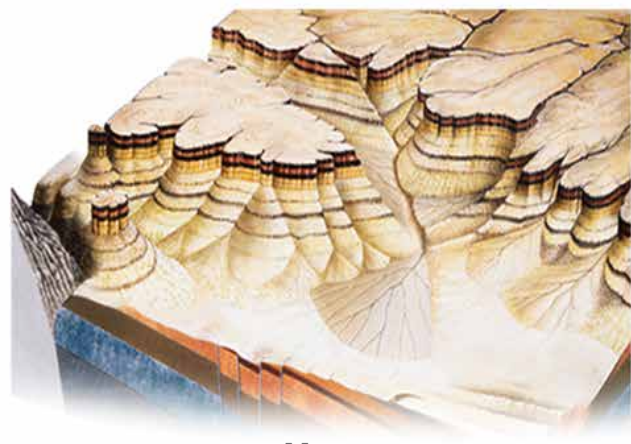
Folds



Faults



Dome



Mesa

Figure 5 | Folded Mountains, Fault-Block Mountains, Dome Mountains, Erosional Remnants

in a dome, tilting the sedimentary strata on all sides. After erosion removes the top of a dome, granite is exposed in the highest, central part of these mountains. The central granite dome is usually surrounded by valleys, filled with sand and mud from erosion.

Erosional remnants. Plateaus consist of nearly flat sedimentary rock. If the edge of a plateau is exposed, erosion will soon start forming gullies along its sides. The gullies that cut into the lower parts of the highland will get most of the runoff. Those that get the most rainwater will become steep-sided, narrow valleys, or canyons. When canyons have removed much of the terrain, the remaining flat-topped highland is called a *dissected plateau*. When most of

the plateau is removed by erosion, the flat-topped hills that remain are called *mesas*. If a whole range of mountains has been removed by erosion, leaving steep-sided granite cores surrounded by a lowland, the mountain or hill remaining is called an *erosional remnant*.

Erosional remnants originally came from a dissected plateau. They are separate from mountain ranges and are left after erosion has removed highland areas that once surrounded them. The Rock of Gibraltar is an erosional remnant.

Mountain ranges may be one of the types of mountains listed or may be a complex of more than one type.



Write true or false.

- 1.66 _____ Volcanoes are fairly evenly distributed all over the world.
- 1.67 _____ Folded mountains start from flat-lying sedimentary rock.
- 1.68 _____ Dome mountains result from rock layers folded by pressure from one side.



Complete these sentences.

- 1.69 Mountains that were raised without folding have an edge called a _____.
- 1.70 Dome mountains are pushed upward by masses of _____.
- 1.71 Flat-topped hills that are smaller than plateaus are called _____.
- 1.72 The Rock of Gibraltar is an _____.

Complete these activities.

1.73 List the two kinds of locations that produce volcanoes.

- a. _____
- b. _____

1.74 Describe the three kinds of volcanoes.

- a. _____
- b. _____
- c. _____

1.75 List five kinds of mountains.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____



Review the material in this section in preparation for the Self Test. The Self Test will check your mastery of this particular section. The items missed on this Self Test will indicate specific areas where restudy is needed for mastery.

SELF TEST 1

Match these items (each answer, 2 points).

- | | | |
|--------------|---|---------------------|
| 1.01 | _____ first to calculate earth's diameter | a. sedimentary |
| 1.02 | _____ deduced earth's shape | b. crust |
| 1.03 | _____ reasoned that earth bulges at equator | c. Ptolemy |
| | | d. atmosphere |
| 1.04 | _____ rock cooled from magma | e. pyramid builders |
| 1.05 | _____ rock made from particles | f. core |
| 1.06 | _____ rock changed by heat and pressure | g. igneous |
| | | h. mantle |
| 1.07 | _____ outer shell of the earth | i. Newton |
| 1.08 | _____ interior layer of rock | j. metamorphic |
| 1.09 | _____ central sphere of iron | k. Aristotle |
| 1.010 | _____ earth's layer of gas | |

Write true or false (each answer, 1 point).

- 1.011** _____ Oceans cover almost 50 percent of the earth's surface.
- 1.012** _____ Conglomerate is primarily mud or clay.
- 1.013** _____ Metamorphosed limestone is marble.
- 1.014** _____ The rock that underlies the oceans is granite.
- 1.015** _____ The asthenosphere is located in the upper mantle.
- 1.016** _____ Some meteorites have the same composition as the earth's core.
- 1.017** _____ Igneous rocks contain large amounts of carbon.
- 1.018** _____ The mantle is apparently molten throughout.
- 1.019** _____ Rapidly cooled rock contains small crystals.
- 1.020** _____ Dome mountains are pushed upward by sideways pressure.

Write the letter of the correct choice in each blank (each answer, 2 points).

- 1.021** The equivalent of granite that has crystals too small to be seen is _____.
 a. basalt b. rhyolite c. sandstone d. biotite
- 1.022** Metamorphic rock originated under conditions of _____.
 a. low temperature and low pressure b. high temperature and high pressure
 c. low temperature and high pressure d. high temperature and low pressure
- 1.023** The type of mountains resulting from sideways pressure on the crust is _____.
 a. volcanic b. fault block c. dome d. folded
- 1.024** Shield volcanoes result from _____.
 a. liquid lava b. cinders c. bombs d. ash
- 1.025** Igneous intrusions injected between horizontal layers are _____.
 a. batholiths b. dikes c. sills d. cones
- 1.026** Mantle rock becomes liquid when _____.
 a. temperature is reduced b. core rock becomes liquid
 c. pressure is reduced d. pressure is increased
- 1.027** The partially melted zone in the upper mantle is the _____.
 a. hydrosphere b. atmosphere c. biosphere d. asthenosphere
- 1.028** Igneous rocks are made mainly of compounds of _____.
 a. carbon and hydrogen b. silicon and oxygen
 c. carbon and silicon d. carbon and oxygen
- 1.029** Magma that does *not* reach the surface is called _____ rock.
 a. intrusive b. extrusive c. metamorphic d. imbricated
- 1.030** Extrusive rock is *not* associated with _____ mountains.
 a. shield b. seamount c. cone d. remnant

Complete each sentence (each answer, 3 points).

1.031 The mountain type that results from fluid lava is the _____.

1.032 Volcanoes are located along zones of _____ in the crust.

1.033 Submarine mountains that were once active volcanoes are called _____.

1.034 A large mass of intrusive igneous rock that is beneath the earth's surface is a _____.

1.035 Cores of continents are made chiefly of the rock called _____.

1.036 Extraterrestrial indicators of the earth's internal composition are _____.

1.037 The deepest part of the earth is the _____.

1.038 The most abundant gas in the atmosphere is _____.

1.039 The category of rock that results from pressure and heat is _____.

1.040 The sedimentary rock that may become quartzite is _____.

64

80

SCORE _____

TEACHER _____

initials

date

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