



## PROCESSES THAT SHAPE THE EARTH

**FOCUS:** Look closely at a map of the Earth. Do the continents look like puzzle pieces that have drifted apart? If you have a map you can cut apart, see if you can join the land regions together to form one land mass.

**PURPOSE:** When you have completed this lesson, you should be able to do the following items.

1. Explain how the plates on top of magma affect the Earth's crust.
2. Describe how plate motion causes major geological events.
3. Describe how convection of energy from the deep interior of the Earth results in movement of material in the Earth.
4. Describe the relationship of gravity and density on the movement of material in the Earth.
5. Summarize the variety of effects of plate tectonic activity including:
  - a. magma generation
  - b. igneous intrusion
  - c. metamorphism
  - d. volcanic action
  - e. earthquakes
  - f. faulting and folding
6. Explain sea-floor spreading and continental drift using fossil evidence, evidence of magnetic reversal, and radiometric dating.

### WHAT YOU NEED TO KNOW

#### VOCABULARY:

- |                          |                           |                         |
|--------------------------|---------------------------|-------------------------|
| 1. Aa                    | 16. Fold                  | 31. Rift                |
| 2. Asthenosphere         | 17. Heat flow             | 32. Sea-floor spreading |
| 3. Batholiths            | 18. Hot spot              | 33. Shear force         |
| 4. Caldera               | 19. Igneous intrusion     | 34. Sill                |
| 5. Contact metamorphism  | 20. Lava                  | 35. Strike-slip fault   |
| 6. Continental drift     | 21. Lithosphere           | 36. Subduction          |
| 7. Convection current    | 22. Magma                 | 37. Surface wave        |
| 8. Convergent boundary   | 23. Magnetic field        | 38. Tectonic plate      |
| 9. Density               | 24. Mantle                | 39. Transform boundary  |
| 10. Dike                 | 25. Metamorphism          | 40. Trench              |
| 11. Divergent boundary   | 26. Normal fault          | 41. Tsunami             |
| 12. Earthquake           | 27. Pyroclastic flow      | 42. Volcanic mountain   |
| 13. Fault                | 28. Regional metamorphism | 43. Volcano             |
| 14. Fault-block mountain | 29. Reverse fault         |                         |
| 15. Faulting             | 30. Ridge                 |                         |



9. Satellite data and lasers have been used to measure small amounts of movement in the Earth. This data supports the idea that the plates in the Earth are moving.

### Earthquakes

1. Earthquakes occur during movement along a fault when rocks are stressed past their elastic limit.
2. Rocks may stretch, compress, bend, or change shape before they reach their limits and break apart along the fault causing the earthquake.
3. Rocks catch and halt as they move past each other.
4. Vibrations from the earthquake may be unnoticeable or very intense.
5. Rocks may move up, sideways, or down against one another.
6. The movement of the tectonic plates puts stress on the rocks.
7. Earthquakes occur near plate boundaries.
8. Surface waves can also occur in the ocean.
  - a. The movement of the ocean floor pushes the water and causes a wave to occur.
  - b. Large waves, called tsunamis, can reach a crest of 30 meters and cause severe damage and loss of life along the ocean shoreline.

### Volcanoes

1. A volcano is an opening in the Earth's surface where gas, ash, and lava come through the Earth's crust.
2. Layers of ash, lava, and other materials can build up to make mountains.
3. The most active volcanoes are found in Hawaii and Iceland.
4. The lava flows and pyroclastic flows will burn everything in their paths. The ash and sulfurous gases will severely impact water supplies, animal life, and the surrounding vegetation.
5. Inside the Earth, heat and pressure melt the rock to form magma.
  - a. Magma is less dense than rock and slowly rises.
  - b. After thousands of years the magma reaches the Earth's surface through a vent.
  - c. The magma is now called lava. It flows outward and forms the steep sides of the volcano's crater.
6. Active volcanoes are located at hot spots and where plate boundaries are moving together or apart.
  - a. Divergent plate boundaries occur when plates move apart.
    - This forms a rift where the lava flows out.
    - Layers are formed and eventually may rise above the surface of the ocean to create islands such as Iceland.
  - b. Convergent plate boundaries occur when plates move together.
    - This may happen when an oceanic plate slides below a continental plate, or one oceanic plate slides below another oceanic plate.
    - Magma forms when the plate sliding below melts. The magma is then pushed upward to form a volcano.
  - c. Hot spots are areas away from the boundaries of plates that are unusually hot.
    - As magma melts the crust and flows, volcanoes are formed.
    - The Hawaiian Islands are examples.
7. As magma slowly cools underground, it forms rock bodies called intrusive igneous rock features.
  - a. The largest bodies are called batholiths.
    - Batholiths form when magma is cooled and solidified as it pushes up toward the surface.
    - Sometimes they are exposed due to erosion and weathering, such as the granite domes in Yosemite National Park.



- Hot water, steam, liquids, and gases provide the chemical action.
  - Pressure squeezes the mineral grains close together, and heat and chemicals rearrange the grains to form new rock.
- b. Contact metamorphism occurs in a smaller area.
- Magma comes into contact with overlying rock and bakes it.
  - Hot liquids and gases in the magma react with the minerals causing a chemical action.
  - The less rock is affected, the less pronounced are the changes.
5. Volcanic action occurs when magma makes its way upward through the crust.
- a. Magma is formed in the asthenosphere and at plate boundaries when movement and stress produce enough heat to melt the rock.
- b. Magma is less dense and moves upward.
- c. Volcanoes flow or erupt depending on the amount of silica and gases in the magma.
- d. High silica content magma flows are thick and move slowly. The gases trapped in the magma cannot escape easily as it cools; therefore, eruptions are explosive.
- e. Low silica content magma is thinner and moves quicker. The gases are able to escape the magma easily, and the lava flows without an explosive eruption.
- f. Volcanoes occur at divergent boundaries where plates move apart. The movement creates a rift for the lava to flow out.
- g. Volcanoes can occur at convergent boundaries when an oceanic plate slides below another plate.
- Magma forms when the lower plate and mantle melt slightly and the less dense magma is forced upward through the crust.
  - These volcanoes tend to be more explosive.
- h. Volcanoes occur at hot spots where no boundaries exist.
- Hot magma breaks through the crust to form a volcano.
  - Hot-spot lava forms a cone-shaped volcano.
  - Hot spots tend to stay in the same place. As the lithosphere plate moves, the lava comes through the crust in a different area forming a new volcano.
  - The Hawaiian Islands were formed this way.
6. Earthquakes occur when rocks on the edge of tectonic plates move past each other, catch, and let go, creating waves.
7. Faults and folds are formed when forces occur between layers of rock.
- a. Normal faults occur when rock above the fault moves downward relative to rock below the fault.
- b. Compression forces between rocks create reverse faults. Forces push from opposite directions causing the rock above the fault to be forced up and over the rock below the fault.
- c. Strike-slip faults form when rocks move past each other horizontally and create shear forces. There is little up and down movement.
- d. Folds occur when the continental plates collide and the edges crumple into folds.
- e. Some mountains are formed by folded rock.

### Continental Drift

1. Continental drift is the theory that the continents of the Earth fit together and drifted apart.
2. Over 400 years ago, Abraham Ortelius first noted the fit between South America and Africa.
3. In 1912, Alfred Wegner hypothesized that at one time all the continents were joined.
4. His hypothesis was not accepted until after his death when more evidence was discovered.



3. Earthquakes tend to occur when \_\_\_\_\_.
  - a. plates slide in opposite directions
  - b. sea-floor spreading allows magma to rise and form a new crust
  - c. two oceanic plates collide
  - d. an oceanic plate and a continental plate collide
4. The energy to move the plates is provided by \_\_\_\_\_.
  - a. radiation from the core
  - b. convection currents of heat
  - c. oceanic tides
  - d. wind

Plate movement can produce different types of mountain ranges, earthquakes, volcanoes, rift valleys, and ocean ridges. Plate movements have been measured.

5. The movement of the plates causes forces to change in the Earth's crust. Faults are formed when large sections of crust break apart. As rock layers tilt and move down, \_\_\_\_\_.
  - a. volcanoes may be formed
  - b. strike-slip faults are formed
  - c. fault-block mountain ranges are formed
  - d. reverse faults are formed
6. The sudden movement of plates sliding past one another occurs when one plate sticks and then suddenly lets go. The result of this is usually a(n) \_\_\_\_\_.
  - a. volcano
  - b. earthquake
  - c. rift
  - d. ridge
7. The measurement of the plate movement has been accomplished with \_\_\_\_\_.
  - a. lasers
  - b. sonar
  - c. radar
  - d. light wave movement

Earthquakes occur when rocks catch and break apart during movement along a fault. Vibrations are set up and move outward. These waves cause the destruction. The waves can be used to determine the epicenter of the earthquake.

8. The movement of rocks against one another produces earthquakes. This would indicate most earthquakes begin \_\_\_\_\_.
  - a. near mountains
  - b. near coastlines
  - c. along plate boundaries
  - d. near ocean ridges



17. The plates slowly move as the magma rises. This movement is \_\_\_\_.
- outward
  - inward
  - horizontal
  - perpendicular

18. Magma is able to rise because its density \_\_\_\_.
- decreases as the rock melts, and gravity cannot pull on it as strongly
  - increases as the rock melts, and gravity cannot pull on it as strongly
  - decreases as the rock melts, and gravity pulls harder on it
  - increases as the rock melts, and gravity pulls harder on it

As tectonic plates move, many activities occur above and below the Earth's surface. Heat is formed, and rocks are melted and reformed. Boundaries move against and away from one another. Many of these activities involve changes in landforms.

19. Rock melts to form magma when exposed to enough heat and pressure. All of these are sources of heat and pressure except \_\_\_\_.
- radioactive decay of elements
  - movement and stress at the plate boundaries
  - explosive eruptions of volcanoes
  - leftover heat from the formation of the Earth

20. As magma rises and cools it may squeeze into cracks and openings where it hardens. This forms \_\_\_\_.
- metamorphic rock
  - intrusive igneous rock
  - extrusive igneous rock
  - earthquakes

21. Intrusive igneous rock forms deep in the Earth. This causes igneous rock to be \_\_\_\_.
- easily seen on the surface of the Earth
  - covered by other rock and sediment until erosion occurs
  - cooled quickly forming large mineral grains
  - found only on the ocean floor

22. During mountain building, a rock experiences heat, pressure, and chemical action to form \_\_\_\_.
- intrusive igneous rock
  - metamorphic rock
  - extrusive rock
  - volcanoes

23. Metamorphic rock development is characterized by \_\_\_\_.
- mineral grains squeezed close together
  - explosive release of hot water and steam
  - low pressure and heat
  - lack of movement in the rock layers



eastern coastline of South America was first noticed 400 years ago. Evidence of continental drift was not discovered until much later.

31. Which of the following is not evidence to support the idea of continental drift? \_\_\_\_\_
- Fold mountains in the Andes match fold mountains on the east coast of Australia.
  - Rocks in eastern South America and western Africa match up.
  - Fossils of warm-weather organisms have been found in the Arctic.
  - Fossils of the same plant have been found in five different regions.

Sea-floor spreading provided evidence for Wegner's idea of continental drift. Harry Hess proposed the idea of sea-floor spreading in the 1960's. Evidence for this theory comes from the characteristics of the rock.

32. The magnetic field of the Earth has reversed four times in Earth's history. This is seen in the \_\_\_\_\_.
- striations formed on rock by a glacier
  - direction of the ridge formation on the sea floor
  - parallel bands of polarity in rock on the sea floor
  - direction of fault formation during plate movement
33. As magma rises, it forms a ridge. Evidence of sea-floor spreading is seen when the age of the rock around a ridge is determined. The youngest rock is found \_\_\_\_\_.
- farthest away from the ridge
  - closest to the ridge
  - at the edge of the nearest plate
  - below the surface of the older rock

## INDEPENDENT PRACTICE

- Volcanoes can be formed when the continental and oceanic plates collide and the denser oceanic plate sinks. This is \_\_\_\_\_.
  - sea-floor spreading
  - subduction
  - a transform boundary
  - the asthenosphere
- Plates sliding past one another formed the San Andreas Fault in California. One would expect to find a \_\_\_\_\_ boundary at this location.
  - divergent
  - convergent
  - transform
  - subduction
- When plates move, they cause changes in the Earth. When a large section of crust breaks and one layer of rock moves upward, a \_\_\_\_\_ is formed.
  - reverse fault
  - fault-block mountain
  - strike-slip fault
  - rift valley