
Metamorphic Rock

Learning about Metamorphic Rock

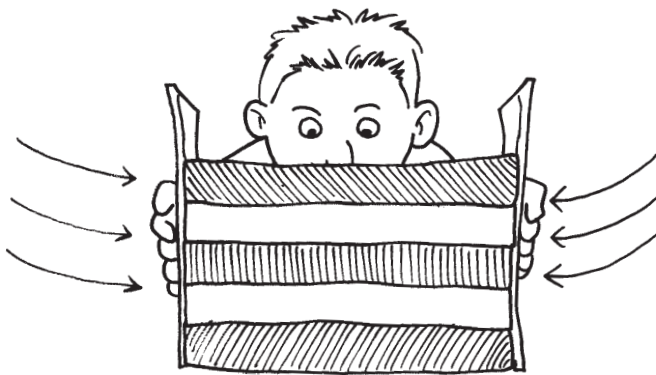
Metamorphic rocks represent one of the three major classification categories of rocks. Metamorphic rocks have been changed by pressure and/or temperature. This activity models how forces in the Earth can cause those changes, altering the form of rock.

Students will create a miniature model of the Earth's crust by layering the clay or dough in a small box to represent three or four rock layers. Modeling clay will be rigid enough to be reusable if the students are careful and separate the layers after the activity. Modeling dough demonstrates the viscosity and malleability of the Earth more graphically but probably lasts for one simulation only.

To begin, students will cut off the ends of the box and use them to push in on the layered section of "Earth" to cause folding and uplifting. You can also have students place the model on a large piece of cardboard and then squeeze it by two smaller pieces of cardboard to apply the force. Explain that this demonstration resembles some of the processes that cause geological features to change over long periods of time.

Materials per Team

- small cardboard box or cardboard section
- scissors
- different colors of modeling clay or dough
- samples of gravel, sand, and dirt



Have the students diagram the layers of clay before and after the rock was metamorphosed. This model works only by pressure and does not produce heat necessary to alter the materials. In reality, metamorphic activity is driven by pressure, heat, or both forces together.

You can use the models to demonstrate three types of tectonic, or large plate, movements. Plate tectonics, a major geological theory of the twentieth century, also creates conditions of high temperature and pressure. Plates are the thin uppermost sections of the Earth's crust that move about slowly atop lower layers. Remake the model, using only two colors and thicker layers to represent plates.

Convergent plates move toward each other. Again, press the ends of the box or two pieces of cardboard inward. This time, have students help one plate override the other, a process called *subduction*. The lower plate goes back into the Earth and is melted. In a different scenario, watch the plates collide and both be pushed upward. This process models how some mountain ranges are formed.

Transform plates attempt to slide past one another. Angle the cardboard pieces while pushing in so the plates pass by each other at a border. This creates friction that causes earthquakes at real fault lines.

To model divergent plates, gently bend the box or cardboard base and use the smaller pieces to push in opposite directions away from the center. A rift is left as the plates move away from each other. Molten material from deeper in the Earth will emerge through a rift and the layers will continue to spread out from the center. Ocean floor spreading is an example of divergent plates at work.

Help students connect their hands-on modeling to the real world using a map showing the plates of the Earth. Find out where the three types of plates can be seen in action in modern times and where scientists think activity occurred in the past. Plate tectonics theory is a powerful investigating tool and has come to be accepted by most scientists.

READING:

Putting the Squeeze On

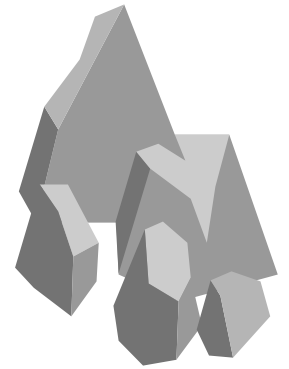
People often say something is “as hard as a rock.” Strong forces in the Earth can change even the strongest rocks. These changed rocks represent one of the three major rock categories and are called **metamorphic** rocks. The root *meta-* means “later” and *morph* means “change.”

Metamorphic rocks have been changed by **pressure** and/or heat from their previous structure into a different kind of rock. Geologists investigate how the “parent,” or preexisting, rock has become altered by examining its shape, **crystal** structure, and chemistry. Then they can form **hypotheses** about the history of the Earth in that region.

Changes to metamorphic rocks can happen in several ways. Hot **igneous** rock sometimes flows as **magma** and comes in contact with solid rock, affecting its minerals. Other hot fluids from the Earth can create metamorphic rock, too. In other cases, high temperatures and pressures beneath the surface of the Earth cause changes to rock underground. **Stress** occurring at a **fault**, or break, in the Earth can produce heat and force that can then change, or metamorphose, rock.

The surface of the Earth is constantly changing but many of the changes are too slow for us to notice. In 1620, Sir Francis Bacon (1561–1626) of England noted that the coastlines on each side of the Atlantic Ocean seemed to match like pieces of a puzzle. As European exploration of North America increased, mapping became more accurate, and the puzzle pieces looked more likely to fit. But the idea of huge parts of the Earth moving did not make sense.

In the 1890s, Eduard Suess (1831–1914) of Austria proposed that the southern continents were once together in a super continent named Gondwanaland. Suess found that similar fossils could be found on the southern continents, leading him to believe they were all once connected. By 1912, Alfred Wegener (1880–1930) of Germany thought all the continents had been together as one landmass, Pangaea (“all lands”). The concept of a drastically changing Earth surface over time seemed more likely. Discovering the engine for this movement was yet to come.



Most geologists today believe that the outermost layer of the Earth is composed of sections called **plates**. The plates travel around slowly, floating on a layer beneath. In 1929, Englishman Arthur Holmes (1890–1965) explained that heat within the Earth could provide the energy to move the plates. The theory of plate movement is called **plate tectonics**.

The processes of plate tectonics are a major cause of many types of metamorphic rock. Plate tectonics theory changed geology in the twentieth century by explaining how the Earth surface can be in constant movement.

The Earth's plates collide in three basic ways. **Convergent** plates hit head on. Either mountains are pushed up where they meet or one plate slips under the other and down into the hot Earth to be melted. **Transform** plates rub together as they try to slide past one another, causing earthquakes and other movement.

Divergent plates move apart, often under the sea where new rock flows up from the Earth's interior.

Divergent plates create new ocean floor in a process named **seafloor spreading**. Seafloor spreading can push continents apart. Scientists estimate the rate of movement of different parts of the Earth to be between 2 and 12 centimeters per year. Do the math—how far does a **continent** move in a million years?

Many useful and beautiful rocks are classified as metamorphic rocks, including **marble** and **slate**. Now we have an idea how these rocks form. What other theories will be proposed to explain how the Earth's rocks and surface features are formed and change?



Twisted layers of metamorphic rock
(photograph by Loopack, courtesy of stock.xchng)

Vocabulary Words

| | |
|------------------------------|---|
| continent..... | a large landmass on Earth |
| convergent..... | plate boundary in which the plates collide |
| crystal | arrangement of matter in which the molecules are aligned in a regular, repeating structure |
| divergent | plate boundary in which plates move apart |
| fault..... | a fracture in the Earth's crust |
| hypothesis | explanation or theory (plural, <i>hypotheses</i>) |
| igneous..... | category of rock formed when magma (molten rock) solidifies |
| magma | molten rock below the Earth's surface |
| marble | rock created when limestone undergoes metamorphosis from heat and pressure |
| metamorphic | rock that has been changed by temperature, pressure, or chemical process |
| plate | large segments of the Earth's lithosphere that move around, affecting the surface configuration of the continents, oceans, and other features |
| plate tectonics theory | theory that states that the movement of plates below the Earth's surface drives the geological processes on the surface |
| pressure..... | a measure of the concentration of force on a specific area |
| seafloor spreading | process in which new seafloor is created under the ocean at a divergent plate boundary. Magma emerges from beneath the seafloor as the plates separate. |
| slate | a type of metamorphic rock |
| stress | force per unit area on an object |
| transform | plate boundary where one plate slides past another horizontally |

