Earth Inside and Out

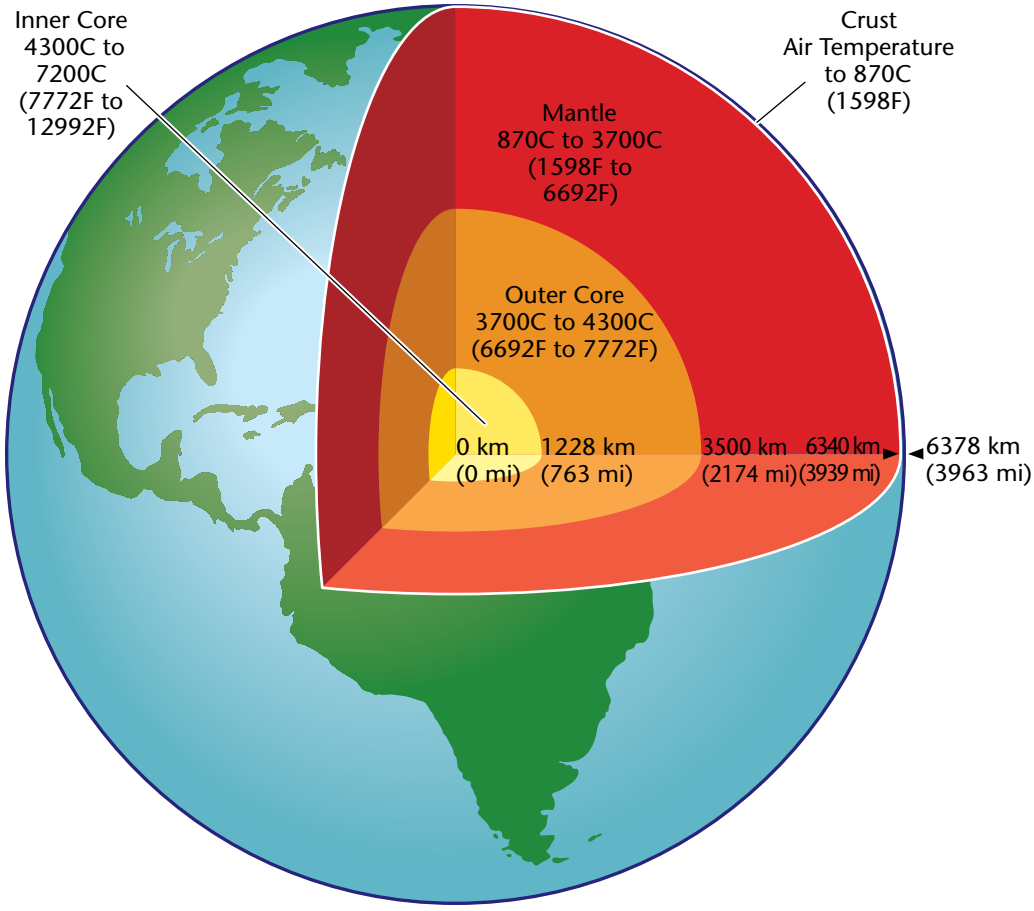
The Earth's Layers

The Earth's surface is an amazing place. Have you ever wondered what is beneath the ground you walk on?

- Is it solid all the way through?
- Does it get colder or hotter deep inside the Earth?
- What is lava and where does it come from?

Perhaps you've asked yourself one or more of these questions.

Much of what you see around you is affected by what occurs deep beneath your feet. It is hard to imagine that we are standing on a planet that is made of layers, both solid and liquid. The temperatures of those layers are hotter than anything on the Earth's surface. The deepest mines that humans have gone into are only about 3 kilometers (1.9 miles) beneath the surface. At these depths the rocks still look the same as those on the surface.



Word Connection

molten—Something that changes into a liquid when it is heated. **Magma** is molten rock.

The Earth is made up of the following four layers:

- **Inner core**—A solid layer of iron and nickel.
- **Outer core**—A liquid layer of iron and nickel.
- **Mantle**—The thickest layer of the Earth. Its upper portion is solid while its lower portion is **semi-molten** (able to flow slowly).
- **Crust**—A layer of solid rock that makes up the surface of the Earth. It includes the continents and ocean basins. Compared to the other layers of the Earth, the crust is a thin shell, like an egg shell.

Layer	Thickness		Temperature	
	Kilometers	Miles	Celsius degrees	Fahrenheit degrees
Inner Core	1228	763	4300–7200	7772–12992
Outer Core	2272	1411	3700–4300	6692–7772
Mantle	2840	1765	870–3700	1598–6692
Crust	38	24	Air temp–870	Air temp–1598

People Doing Science

How Do Scientists Know the Internal Structure of the Earth?

Scientists have used powerful drills to bore holes up to 32 kilometers (20 miles) into the Earth's crust. But, even at those depths, the rock samples are similar to those found on the surface. So how did scientists figure out the internal structure of the Earth?

The study of the movements produced by **earthquakes** is known as **seismology**. Seismology has provided many clues about how the inside of the Earth looks. Two types of movements, called seismic waves, are produced during an earthquake. One type of wave can travel through solids, liquids, and gases. The second type of wave can only travel through solids. By comparing the two types of waves during earthquakes, scientists have discovered that different parts of the Earth are made up of solid and liquid layers.

There is still much to learn about the layers of the Earth, but scientists discover more each year, as they develop new technologies and share new ideas.

Earth's Crust Moves

The Earth's crust is made up of numerous pieces called **tectonic plates**. The plates float on top of a layer of hot, semi-molten rock that composes part of the mantle. The plates that float on the Earth's mantle constantly move. But they move very slowly. Millions of years ago, these plates were in different places than they are today. The term **continental drift** describes the theory that tectonic plates moved around in the distant past and are still moving today.

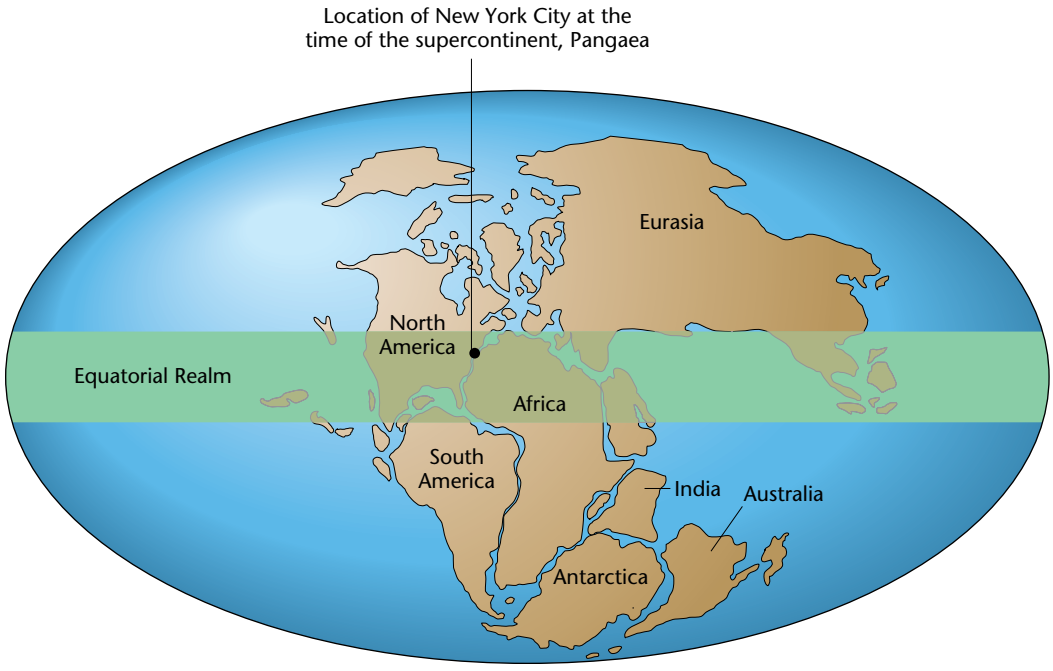


Figure 1: The supercontinent called Pangaea as it was thought to look 250 million years ago.

About 250 million years ago the Earth's plates were all joined together into one landmass, a supercontinent called **Pangaea** (pan-jee-uh). During that time, the continent of North America was in a different location than it is today. New York City, for example, (see Figure 1) was close to Africa.

Around 200 million years ago, Pangaea began to break apart. Figure 2 shows the current location of the Earth's plates. The Earth is divided into seven large plates and several other smaller ones. You can also see that some of the plates have names that are similar to the names of continents or oceans but that other plate names are unusual.

Think About It!

Can you feel the Earth's crust moving beneath your feet right now? What does this tell you about how fast the plates move? The Earth's plates move too slowly to notice—only 1–10 cm (0.4–4 in) per year. The speed the plates move is about the same rate at which your fingernails grow.

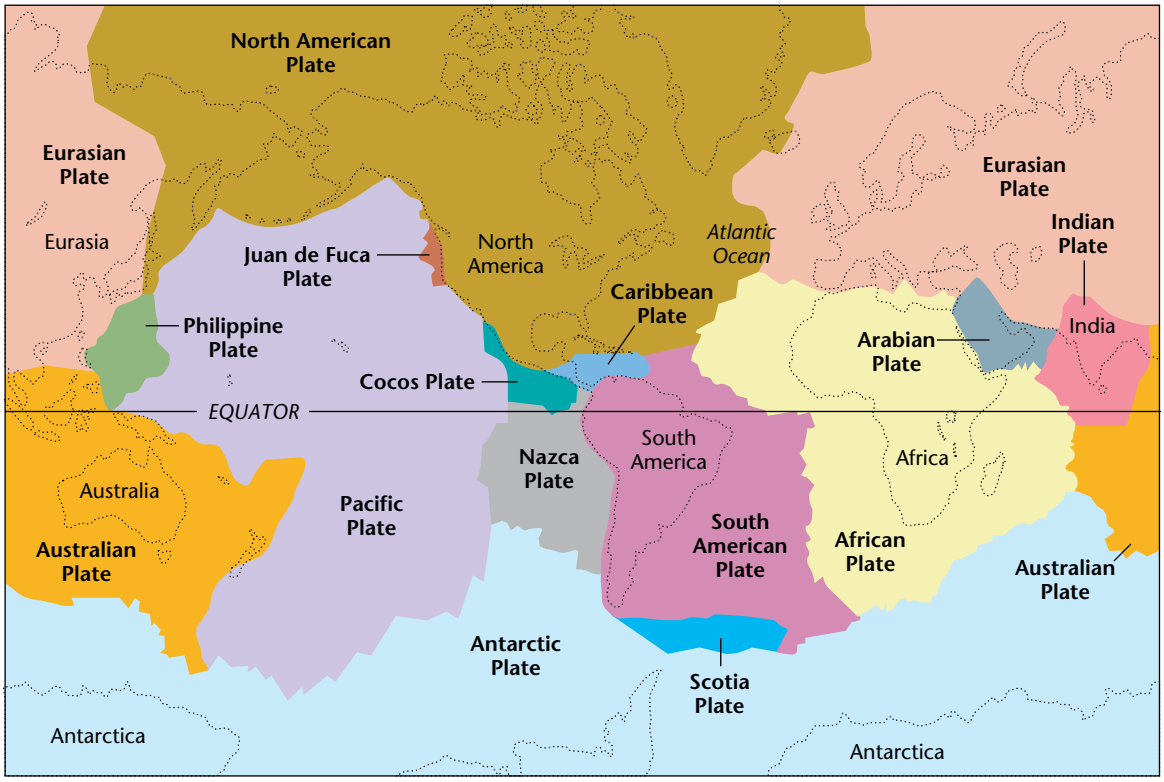


Figure 2: Current location of the Earth's tectonic plates.

People Doing Science

Alfred Wegener and His Theory of Continental Drift

Alfred Wegener (1880-1930) was the first person to propose the theory of continental drift. In 1915 he wrote a book called *The Origin of Continents and Oceans*. In it he proposed the theory that there had once been a giant supercontinent, which he named Pangaea (from the Greek for "all the Earth"). He collected evidence from the various fields of Earth science including geology, oceanography, and paleontology. This was one of the first times that work from different scientific areas was brought together to support a scientific theory. His evidence included the jigsaw puzzle fit between the coastlines of South America and Africa (see the illustration of Pangaea on the previous page). He found similar fossils in eastern South America and West Africa. This made him think that these animals once lived together on a continuous landmass – where two continents were once connected.

Many geologists made fun of Wegener for his ideas. It was only in the late 1960s, after more evidence of plate movement was discovered, that Wegener received credit for thinking up the theory of plate tectonics. Today, this theory is considered one of the most important theories about the Earth.

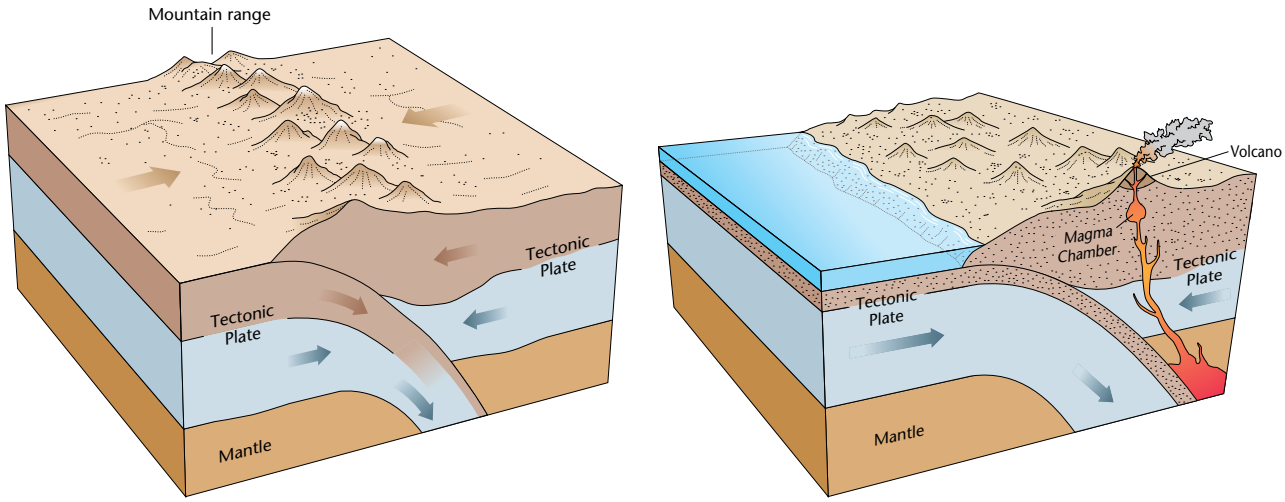
Plate Boundaries

Tectonic plates contain continents as well as oceans. Their edges, or **boundaries**, do not follow the borders of the continents. For example, look at Figure 2 on page 5. Can you see what continent makes up the North American plate? What else is part of that plate? The Atlantic Ocean also makes up part of the North American Plate. On what other plates is the Atlantic Ocean found?

Many geologic events can occur where two plates meet, including earthquakes, mountain formation, and volcano formation. For example, as the Indian Plate collides with the Eurasian Plate, the Himalayan Mountains formed. They continue to rise higher and higher each year.

In general, there are three types of plate boundaries: convergent boundaries, divergent boundaries, and transform boundaries. These terms describe what happens between two tectonic plates.

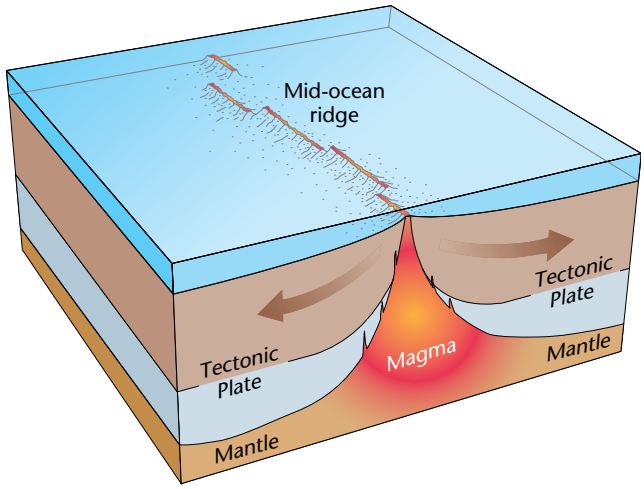
- **Convergent boundaries** occur when two plates **collide** with one another.



Two examples of tectonic plate collisions, resulting in mountains and volcanoes.

The Alps formed along a convergent boundary.

- **Divergent boundaries** are found where tectonic plates **move away** from each other, such as along a mid-ocean ridge. A **mid-ocean ridge** is an underwater volcanic mountain chain formed as two plates move away from each other.



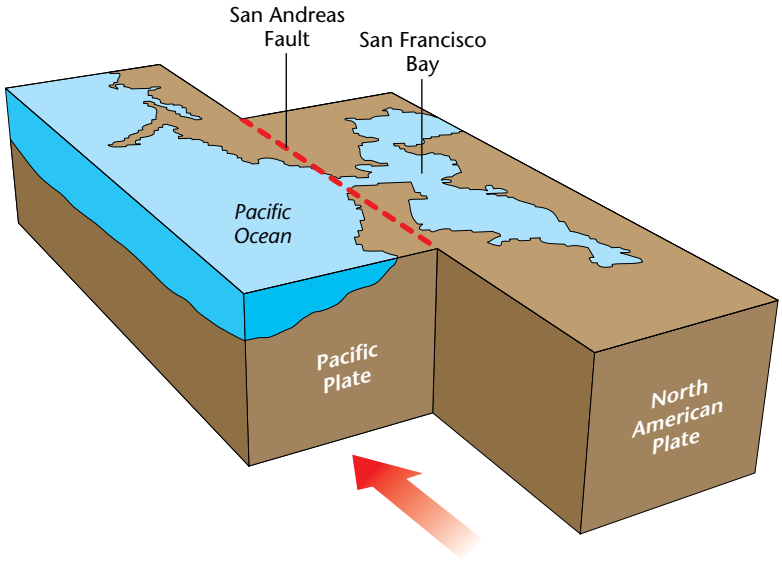
Lava erupts along the mid-ocean ridges due to underwater volcanoes. This is where new crust forms as the plates move apart.

As the North American Plate and Eurasian Plate move away from each other in the middle of the Atlantic Ocean, a mid-

ocean ridge is forming. This ridge runs right through the country of Iceland, which is known for its active volcanoes.

Location of Mid-Atlantic Ridge through Iceland. Note that the red triangles represent active volcanoes on the island of Iceland.

- **Transform boundaries** form when two plates **slide past** one another.



A transform boundary occurs where two plates are sliding past each other, such as in California where the Pacific Plate is sliding past the North American Plate (also known as the San Andreas fault).

This happens on the west coast of the United States as the Pacific Plate slides past the North American Plate. This area is known as the San Andreas fault. It is about 1,300 km (800 miles) long and extends through two thirds of the length of California. The Pacific Plate has been sliding northward past the North American Plate for 10 million years, at an average rate of about 5 cm (1.5 in) a year. At this rate of movement, the cities of San Francisco and Los Angeles will be side by side in about 10 million years!

San Andreas Fault, California.

Glossary

boundary
The edge or border of something.

continental drift
The idea that tectonic plates moved around in the distant past and are still moving today.

convergent boundary
The boundary between two tectonic plates that are colliding and pushing directly into each other.

crust
A layer of solid rock that makes up the surface of the Earth. It includes the continents and ocean basins. Compared to the other layers of the Earth, the crust is a thin shell, like an egg shell.

divergent boundary
The boundary between two tectonic plates that are moving directly away from each other.

earthquake
Shaking or trembling of the Earth's crust due to volcanic forces or the shifting of tectonic plates deep underground.

inner core
A solid layer of iron and nickel at the center of Earth.

magma
Molten rock inside the Earth.

mantle
The thickest layer of the Earth. It is outside the outer core. Its upper portion is solid while its lower portion is semi-molten (able to flow slowly).

mid-ocean ridge
An underwater volcanic mountain chain formed as two plates move away from each other.

molten
Something that changes into a liquid when it is heated.

outer core
A liquid layer of iron and nickel that is outside the inner core.

Pangaea
One landmass or supercontinent of the Earth's plates that existed about 250 million years ago.

seismology
The study of the movements produced by earthquakes.

semi-molten
Able to flow smoothly.

tectonic plate
A large piece of the Earth's fractured crust.

transform boundary
The boundary between two tectonic plates that are sliding past each other.

Credits

Page 2: Colin Hayes. **Page 4:** Lineworks, Inc.
Page 5: Lineworks, Inc. **Page 7:** (left) Lineworks, Inc.; (right) Lineworks, Inc.
Page 8: (top) Photos.com; (bottom) Lineworks, Inc.
Page 9: (top) Lineworks, Inc.; (bottom) Lineworks, Inc.
Page 10: R.E. Wallace, U.S. Geological Survey.