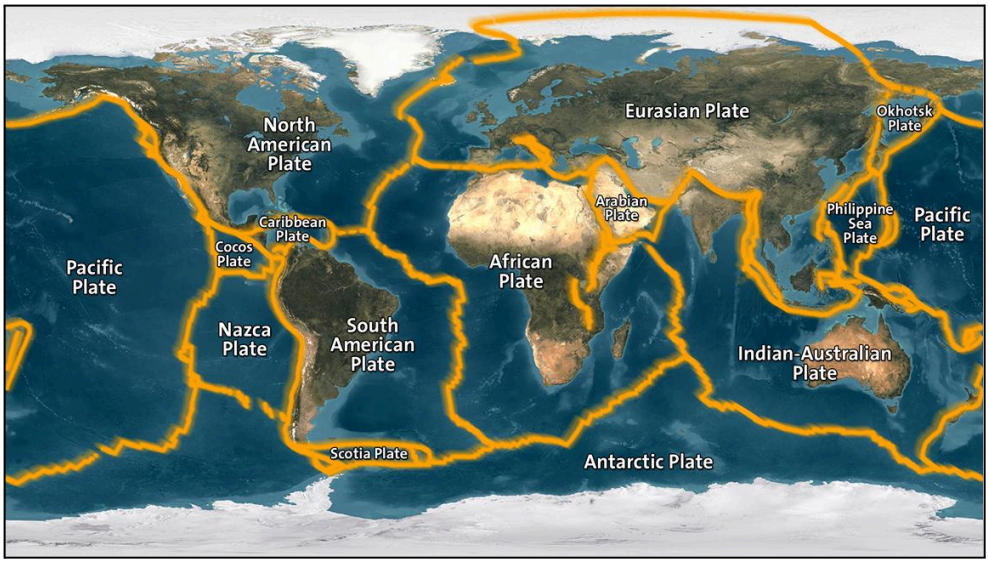
Earth's Dynamic Machine: Basics of Plate Tectonics

Text adapted from *The Earth Machine: The Science of a Dynamic Planet* by Edmond A. Mathez. Columbia University Press, 2007.

Our planet Earth might seem like one hard ball of rock, but it is made up of different layers.

The strong, solid outer layer of Earth is called the **lithosphere**. It is broken into many large and small pieces called **tectonic plates**.

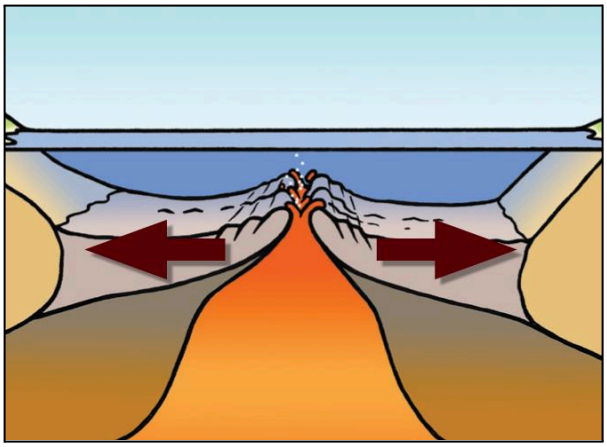


Under the lithosphere is a layer of solid rock called the **mantle**. The mantle flows in slow, enormous circular motions called **convection currents**. These currents are caused by the intense heat and pressure deep inside Earth. Geologists use the theory of **plate tectonics** to describe how these plates move and interact.

Because of plate tectonics, Earth's surface is in constant motion. Plates separate. They slip past one another. They move above and below each other. They even collide with one another!

For example, Arabia has been moving away from Africa, opening up the Red Sea. North America has been moving away from Europe at about one inch per year. That's roughly the rate at which a fingernail grows! Large regions of the Pacific seafloor are moving beneath the continents around them. And India is also pushing north into Asia. This movement is helping to slowly push up the world-famous mountain range called the Himalayas.

Plates Moving Apart



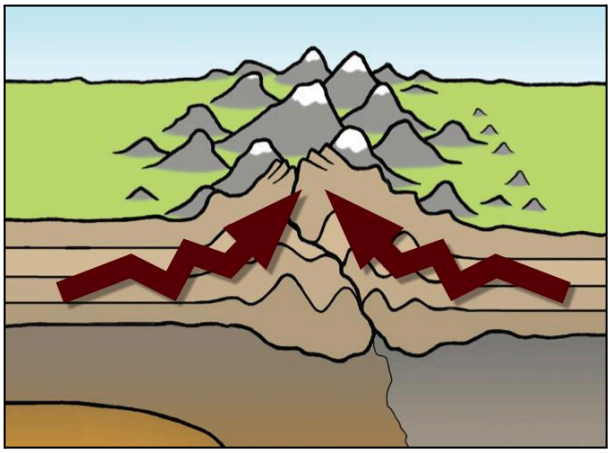
Places where plates separate, or diverge, are called **divergent boundaries**. Ocean basins are created there. Eighty-five percent of Earth's volcanic eruptions occur along divergent boundaries. Many small earthquakes happen there too. The earthquakes happen at shallow depths (less than 6 miles). As the plates move apart, magma rises from the mantle to fill the empty space. The magma hardens into rock. That means the plates grow as they separate. By this process, entire ocean basins re-form about every 200 million years.

Most divergent plate boundaries run through the world's oceans. In the Atlantic, the boundary divides the ocean basin almost exactly in half. This boundary is called a **mid-ocean ridge**. This term means that there is a range of volcanic mountains at the bottom of the Atlantic Ocean. This range is part of a worldwide system of ranges. Together, they all form a system of mountain ranges 50,000 miles long.

The **lithosphere** near the mid-ocean ridges is thin and warm. As the lithosphere moves away from the mid-ocean ridge, it cools and becomes denser. Then it sinks. That means the ocean is deeper when you go farther from a mid-ocean ridge. Mid-ocean ridges are chains of volcanoes sitting on broad rises in the sea floor. They have vast, deep oceanic plains on both sides.

Divergent boundaries are not always in the middle of ocean basins. In a few places, divergent boundaries run right through continents. In those places, the lithosphere stretches and thins. This causes giant cracks called rifts to form in the continental crust. This is how it happens: Basaltic magma pushes up into the thinned lithosphere. It then erupts onto the continent. It's so hot that it sometimes melts parts of the continental crust. That melted rock turns into lava too. When these rifts develop long enough, an ocean begins to form. The Red Sea is one such rift. It may eventually grow as large as the Atlantic Ocean!

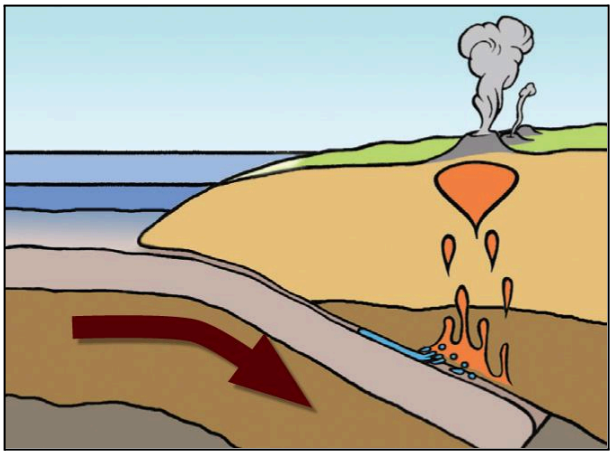
Plates Coming Together



Places where plates collide, or come together, are called **convergent plate boundaries.** Landforms are created there. These can include mountains, volcanic island arcs, and deep-sea trenches. Convergent plate boundaries produce large and small earthquakes. They build great, explosive volcanoes as well. Exactly what happens at a convergent plate boundary? That depends on what collides with what.

Most plate convergence occurs between oceanic and continental plates. Oceanic plates are colder and denser than continental plates. When they converge, the oceanic plate sinks below the continental plate. It sinks

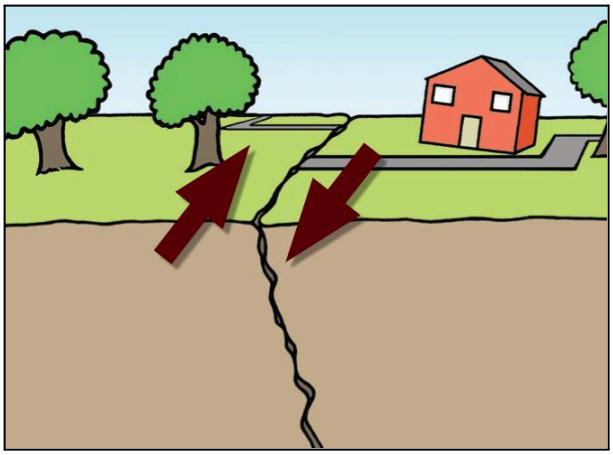
into the mantle. That process is known as ***subduction***. The boundary where it occurs is called a subduction zone.



The subducted plate becomes heated by the mantle, and it loses water. This produces a fluid that moves up into the mantle above it. That makes some of the mantle melt and turn into magma. The magma rises up through the mantle and crust. It feeds volcanoes on the surface. This process usually produces volcanic mountain chains, such as the Andes.

If two oceanic plates converge, then the older, colder plate sinks beneath the younger, warmer plate. An arc of islands forms, like the Aleutians off the coast of Alaska. Deep-sea trenches are created along **convergent margins**. That is where the oceanic lithosphere bends into the subduction zone. Trenches are the deepest parts of the ocean. Some are more than 36,000 feet deep.

Plates Sliding By



Where plates slip past each other, they form long grooves in the lithosphere called **transform boundaries**. These boundaries are typically hundreds to thousands of miles long. At transform boundaries, crust is not created. It does not disappear, either. The plates

on each side of the fault may be moving in opposite directions. Or they could be moving in the same direction, but at different speeds.

Many people have heard of the San Andreas Fault in California. Or perhaps they know about the Anatolian Fault that runs through northern Turkey. Both of these transform faults are among the most active earthquake zones on Earth, and both have been struck by devastating earthquakes.

Where transform faults bend, one of two different structures will form. A long, narrow dip called a **pull-apart basin** may grow. Sediment collects there. Or it may fill with water. The Dead Sea between Jordan and Israel is a pull-apart basin.

On the other hand, when plates move, they may make blocks of crust jam together. That creates ridges and folds called transverse ridges. A good example of this is the Transverse Ranges in California, to the north of Los Angeles. There, a bend in the San Andreas Fault causes the crust to wrinkle.

What Plate Tectonics Tell Us

The theory of plate tectonics teaches us a lot about Earth. It describes how the mantle and crust of Earth interact with each other. It explains why mountains, ocean basins, and continents form where they do. It also explains why volcanoes and earthquakes so often appear on plate boundaries.