

CRIBSHEET #11

PLATE TECTONICS

What are the dynamic processes that drive volcanic eruptions and seismic activity on Earth?

For centuries, mapmakers noted that the Earth's continents seem to fit together like giant puzzle pieces, as if they had once been united. This observation, along with discoveries of identical fossils on the coasts of South America and Africa, led early-20th-century scientists to propose that continents, far from being immobile, could in fact move and drift about on the Earth's surface. This theory fell short, however, of explaining the mechanism by which such continental movement could actually occur.

In the 1950s and 60s, several oceanographic studies confirmed many of these earlier ideas and helped create the theory of **plate tectonics**. The theory posits that over time, movements and interactions of rigid slabs of rock called "plates" profoundly alter the Earth's surface. These plates (the Earth's **lithosphere**, composed of the crust and upper mantle) float and slide atop a deeper, hotter layer of rock (a slippery layer of the mantle called the **asthenosphere**) that deforms and flows at rates of inches per year. This was the missing mechanism.

THE PROCESSES

Plates can spread apart, collide together, or slide horizontally. These interactions are called **divergent**, **convergent**, and **transform**, respectively.

DIVERGENCE

When two plates spread apart from each other at divergent boundaries ①, hot magma from the mantle wells up to fill the gap between the rifting plates, creating new crust as it cools ②. This upwelling also pushes up the lithosphere around the divergent plate boundary, forming the **mid-ocean ridges** that wrap like seams around our planet. New crust is made continuously at a rate of 20 cubic km per year.

CONVERGENCE

As newly formed oceanic crust cools over tens of millions of years, it gradually becomes denser than the underlying mantle and sinks back into the Earth in a process called **subduction**. Subduction occurs at convergent plate boundaries, where two plates collide ③. Denser oceanic plates collide with and sink beneath lighter continental plates.

QUAKES AND VOLCANOES

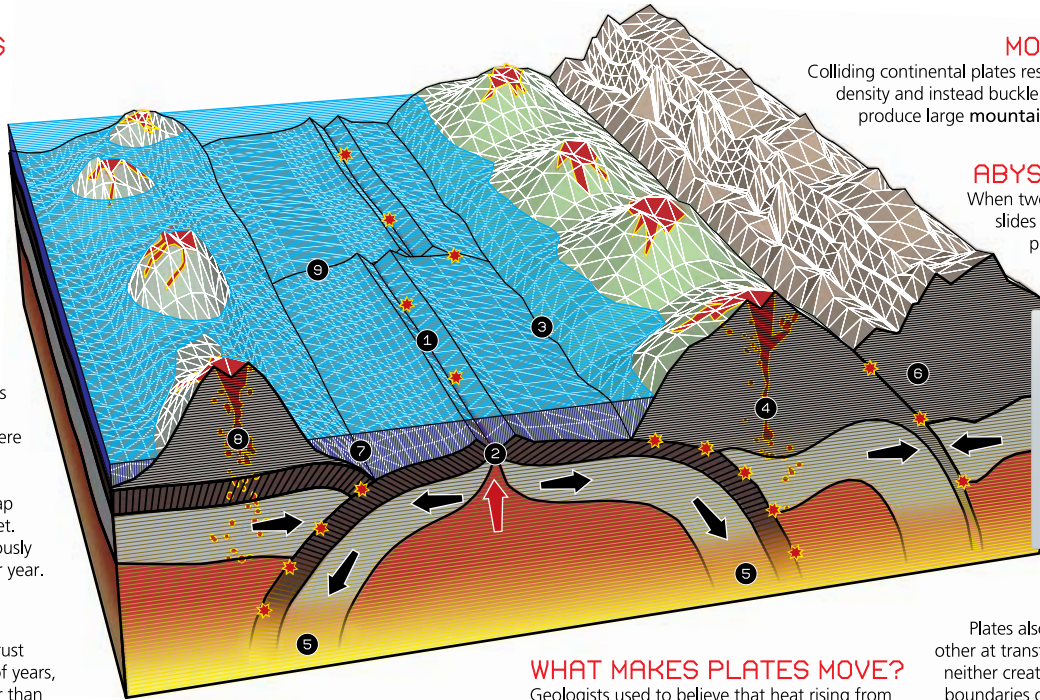
As a plate descends into the Earth's interior, grinding against other plates and partially melting from increasing heat and pressure, it creates deep **earthquakes** ④ and **volcanoes** ⑤ above the subduction zone.

MOUNTAIN BUILDING

Colliding continental plates resist subduction due to their light density and instead buckle and stack the overlying crust to produce large **mountain ranges** like the Himalayas ⑥.

ABYSSES AND ISLANDS

When two oceanic plates collide and one slides beneath the other, the bending plates form **oceanic trenches** ⑦ and volcanic island chains ⑧.



LEGEND

- Plate movement
- ↑ Upwelling mantle
- ★ Earthquakes
- ▨ Oceanic crust
- ▨ Continental crust
- ▨ Lithosphere
- ▨ Asthenosphere

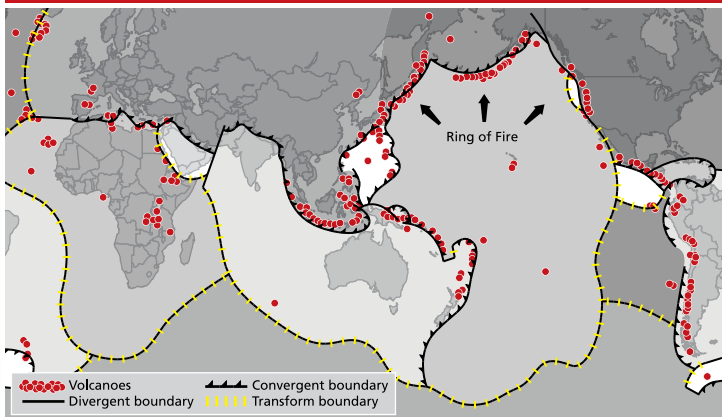
TRANSFORM

Plates also slide horizontally against each other at transform boundaries, where crust is neither created nor destroyed ⑨. Transform boundaries offset the mid-ocean ridges, but they also cut across continents. In the ocean, these boundaries are typically clean slices that produce only faint earthquakes ★. Transforms on land are usually contorted, so that the sliding plates stick and then break suddenly in strong earthquakes that threaten cities such as San Francisco and Istanbul.

WHAT MAKES PLATES MOVE?

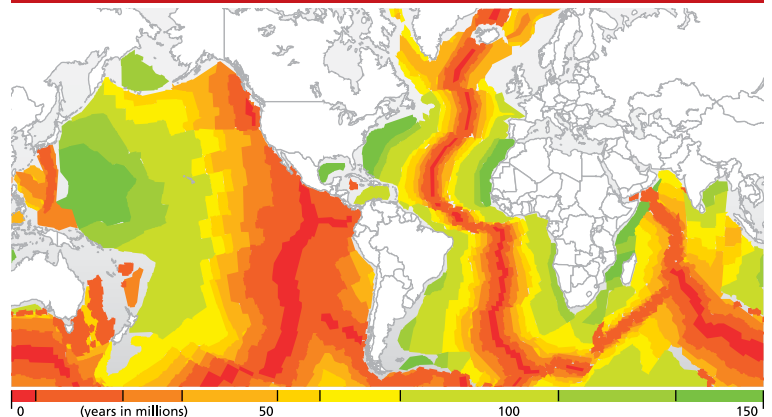
Geologists used to believe that heat rising from within the Earth was the dominant force in plate movement. Now, we know when the edge of a plate sinks, **gravity** drags the rest of the plate with it. This driving force, called **slab pull** ⑤, pulls plates apart at divergent boundaries and sucks them down at subduction zones to be recycled deep in the Earth's interior.

PLATES, BOUNDARIES, AND VOLCANOES



The Earth's surface is broken into about 20 tectonic plates. Volcanoes and earthquakes tend to cluster around interacting plate boundaries. The Pacific Ring of Fire is the best-known example of this correlation.

SEAFLOOR SPREADING



As new crust forms at mid-ocean ridges, older crust is pushed outward in a process called seafloor spreading. Here, the relative ages of the oceanic crust are shown to reveal this activity. Mid-ocean ridges are in the red central lines.

THE ISSUE: PLATE TECTONICS IN THE 21ST CENTURY

The 21st century will likely be marked by world population growth and increasing scarcity of resources vital for high standards of living. As populations spill over into risky areas near earthquake-prone fault zones or active volcanoes, event prediction and civil planning partially based on plate tectonics will be essential for public safety. Knowledge from plate tectonics will also prove crucial for finding new sources of water, petroleum, and valuable metals as old reservoirs are depleted and could ultimately aid development of geothermal power, a practically inexhaustible energy source.

SOUNDBITE

Plate tectonics is an engine that powers the Earth's astounding geological diversity by constantly changing and recycling our planet's entire surface.