

PLATE MARGINS

As we discussed in class, while there is interesting geology all over the world, much of the most interesting and spectacular events occur where two plates meet. We refer to such regions as **plate margins**.

There are three basic types of plate margins. I will list them here, and then discuss each of them in turn. These plate margins are:

- Divergent zones
- Convergent zones (which consist of)
 1. continental-ocean collisions
 2. ocean-ocean collisions
 3. continent-continent collisions
- Transform faults

Divergent Zones

Divergent zones occur when rising magma from the asthenosphere thins and splits the lithosphere, causing lava to extrude onto the surface of the Earth. Since [ocean crust](#) tends to be thinner than [continental crust](#), divergent zones occur mostly on ocean floors.

Divergent zones (aka rift zones, aka spreading centers) are places where new ocean crust is made on the surface of the Earth. Studies of the ages of ocean rocks show that the age of ocean crust gets older with increasing distance from the rift zone. There are many divergent zones on the Earth, let's consider just a few of them here.

Likely the best known of these long divergent zones is the **Mid-Atlantic Ridge**. This rift zone separates the North American Plate from the European in its northern portions, and separates the South American plate from the African in its southern regions.

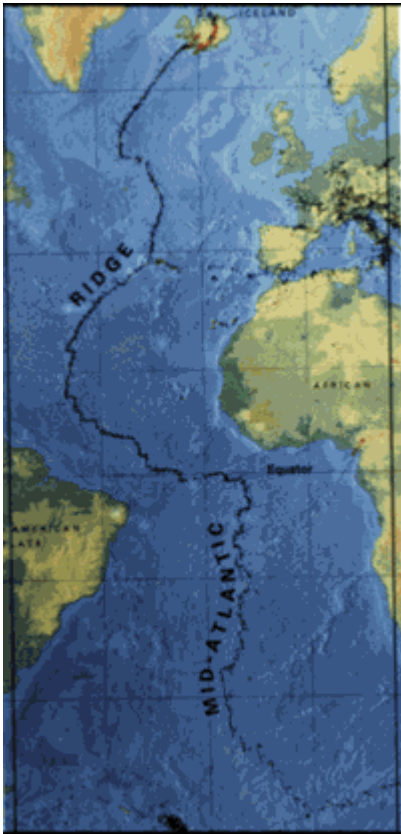


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/ridge.html>

The spreading rate of this divergent zone seems insignificant, a bit more than 2 cm/year (approximately an inch per year). Yet, in the 200 million years since this rift first formed, spreading at this divergent zone has caused North American and Europe to split apart and move to their current locations. Similarly, South America and Africa were joined 200 million years ago, and since the onset of rifting, have moved apart to their current locations.

There are some places along the Mid-Atlantic Ridge where the outflow of lava is significant enough to build the Mid-Atlantic Ridge to heights that rise above the sea level of the Atlantic Ocean. Most famously, **Iceland** is a volcanic island that rises above the Atlantic Ocean and sits astride the Mid-Atlantic Ridge.

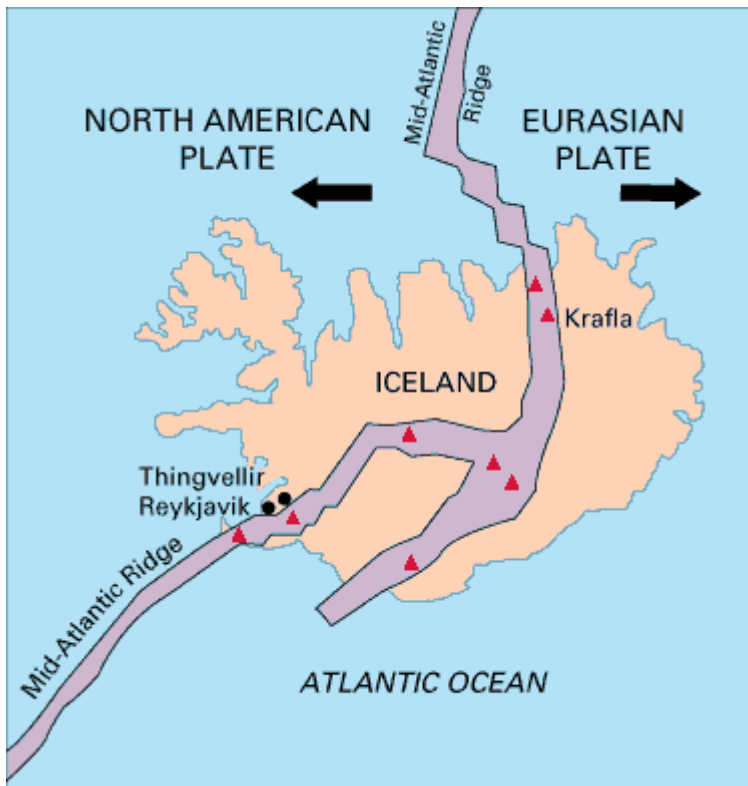


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/graphics/fig16.gif>

As the diagram shows, the rift zone runs through the middle of the island, causing tension and rifting in many places in Iceland. It is literally the case that the eastern half of the island is part of Europe and is moving eastward, and the western portion of the island is part of North America and is moving westward.

Convergent Zones

Convergent zones occur whenever two plates collide with each other. The results of this collision are related in part to the types of [crustal material](#) involved in the collision.

Convergent zones can occur when an ocean crust plate collides with a continental crust; or when two ocean plates collide; or when two continental plates collide.

Convergence Involving Ocean Crust--Subduction Zones

We learned in the section on divergent zones that new ocean crust is created at rift zones. Whenever ocean crust is involved in a plate collision, either in ocean/ocean or ocean/continent collisions, ocean crust is recycled back into the mantle at a region known as a **subduction zone**. Globally, the rate of production of new ocean crust at rift zones is matched by the rate of destruction of older ocean crust at subduction zones. (What would happen to the Earth if more new crust were formed at ocean ridges than was recycled at subduction zones?)

The basic geometry of an ocean/continent collision is shown below:

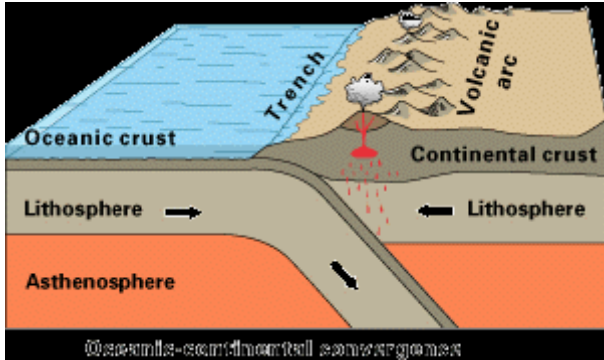


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/graphics/fig21oceancont.gif>

This is the type of convergent zone responsible for creating the Andes Mountains along the western coast of South America (at the collision of the Nazca and South American plates), and the Cascade Mountains (including Mt. St. Helens) at the collision of the Juan de Fuca and North American plates. In these collisions, the denser ocean crust sinks back into the mantle, while the lighter continental crust rides higher on the asthenosphere. These subduction zones are the regions where ocean crust is recycled back into the mantle. Because of subduction zones, there is no very old ocean crust on the Earth, the oldest ocean crust is about 200 million years old (which sounds ancient, but is only about 5% of the age of the Earth). On the other hand, continents tend to grow at the expense of ocean crust, and some very old portions of continental crust are billions of years old.

Whenever ocean crust buckles and subducts back into the mantle, a long, deep trench is created in the lithosphere of the Earth. These trenches are both steep and deep, the deepest of them (the Marianas trench in the Eastern Pacific) goes nearly 40,000 feet deep into the crust. If you remember the movie *The Abyss*, the geological feature they were trying to describe was a subduction zone.

Convergent zones involving ocean plates also generate volcanoes. As the subducting slab descends into the Earth, various factors cause the upper portion of the slab to melt, and this rising melt is the magma that will feed the growing volcano. The volcanic mountains in the Andes and along the NW coast of North America are produced at these types of convergent zones. A type of volcano called a **stratovolcano** is formed at these zones. Stratovolcanoes are the image most people have of volcanoes: tall, conical, capable of tremendously destructive explosions. However, they represent just one type of volcanic activity on Earth (remember, volcanism occurs **whenever** lava extrudes onto the surface of the Earth).

When two ocean plates meet, the plate that is older and therefore colder and therefore denser will subduct back into the mantle.

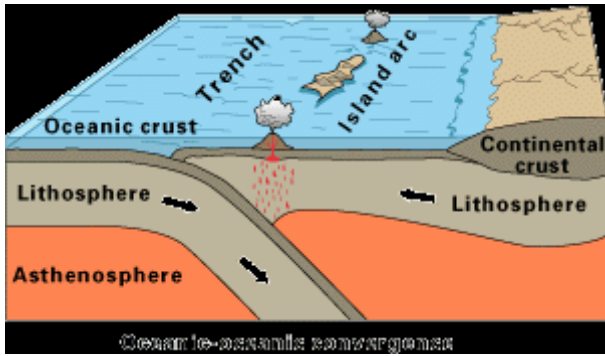


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/graphics/fig21oceanoocean.gif>

The descending slab of material heats at depth and produces magma that rises to the surface, and produces volcanic eruptions onto the ocean floor. Over time, the amount of extruded material on the ocean floor rises and can create volcanic islands that rise above the ocean level. Many of the islands of the Pacific ocean (Hawaii is **not** one of them) are formed by the convergence of two ocean plates. When two ocean plates converge, a deep subduction zone is formed, and the islands form in an arc parallel to the subduction zone.

Collisions Involving Continental Crust

Continental plates are relatively lighter than ocean plates, so when continental plates collide, they do not sink back into the mantle. Rather, collisions between continental plates cause the crustal material to deform. In these collisions, continental material buckles and is pushed aside, forming large mountain ranges. The most famous example of this sort of collision occurs in Asia at the boundary of the Eurasian plate and the Indian plate. The Indian plate broke away from the southern supercontinent 200 million years ago, and has been travelling north since that time. About 40-50 million years ago, it encountered the southern end of the Eurasian land mass, an event which initiated the massive uplift of much of Asia including the formation of the Himalayas.

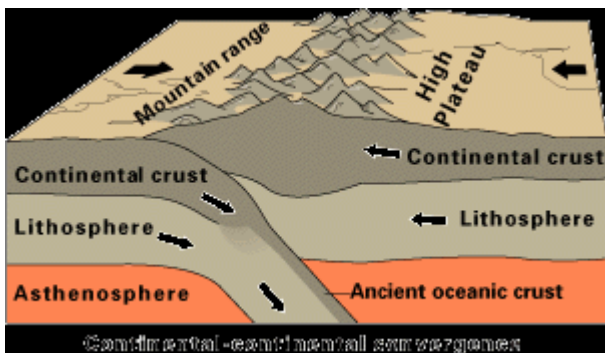


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/graphics/fig21contcont.gif>

Transform Faults

Transform faults are places where two plates of the Earth are sliding past each other. This type of fault arises because of the nature of long, divergent zones. Various forces cause divergent zones to become offset, rather than be one continuous rift zone. Transform faults are those boundaries that connect one spreading center with another. The opposing masses of Earth crust move in opposite directions along a transform fault, causing shallow and sometimes very destructive earthquakes. While these faults usually occur underwater, the most famous transform fault occurring on the land is the San Andreas Fault of California.

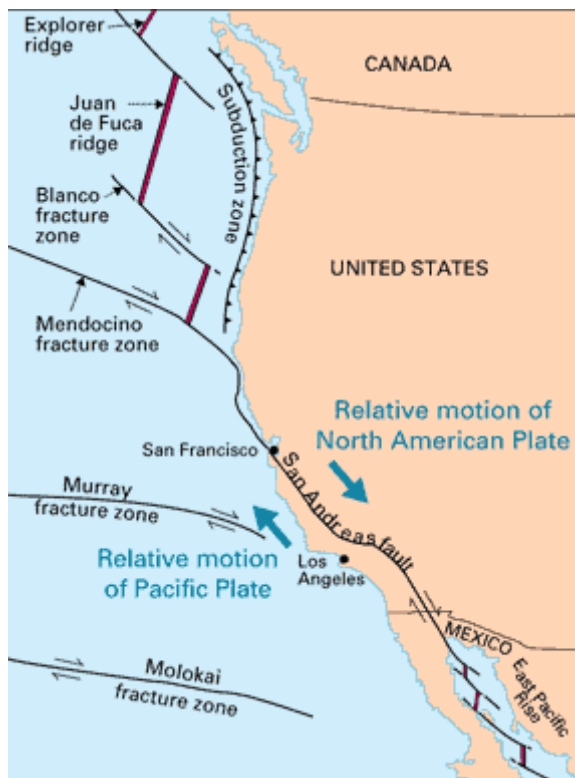


image courtesy USGS -- <http://pubs.usgs.gov/gip/dynamic/graphics/fig25.gif>

The image above shows the geometry of the San Andreas fault, connecting the spreading centers of the Juan de Fuca ridge to the East Pacific rise.

A photo of the San Andreas Fault:



image courtesy USGS -- http://pubs.usgs.gov/gip/dynamic/graphics/San_Andreas.gif