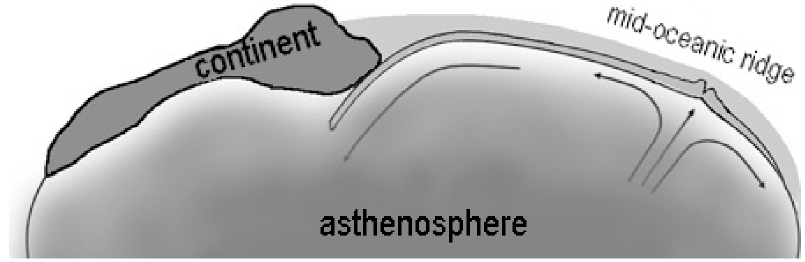
Plate TECTONICS

or

"I feel the Earth move under my feet. . ."

(and a tip o'the hat to Volcano World and the USGS for unwittingly providing images and information. . .)

The modern picture of plate tectonics:



Continents don't "plow through" the oceanic crust, as Wegener thought. Instead, they are carried by the oceanic crust as if on a conveyor belt. The driving force is thought to be convection in the asthenosphere.

Both continental and oceanic crust form *tectonic plates*.

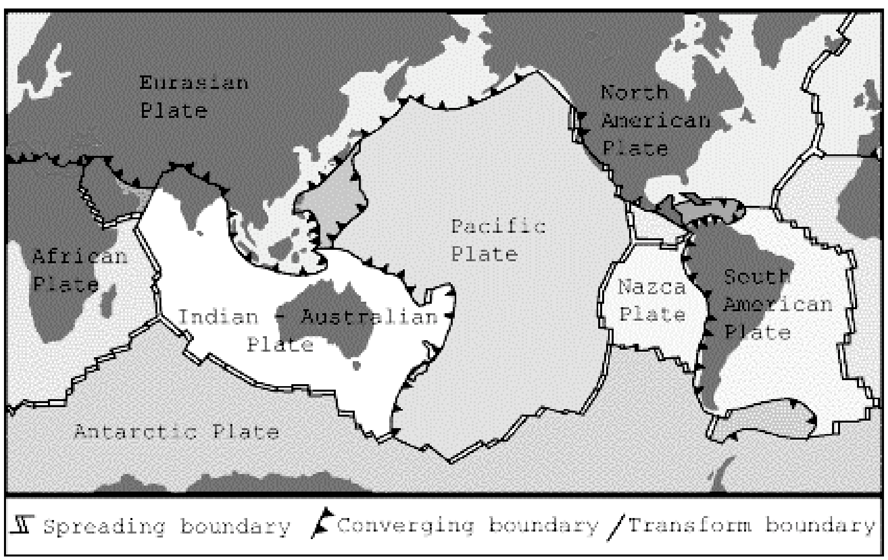
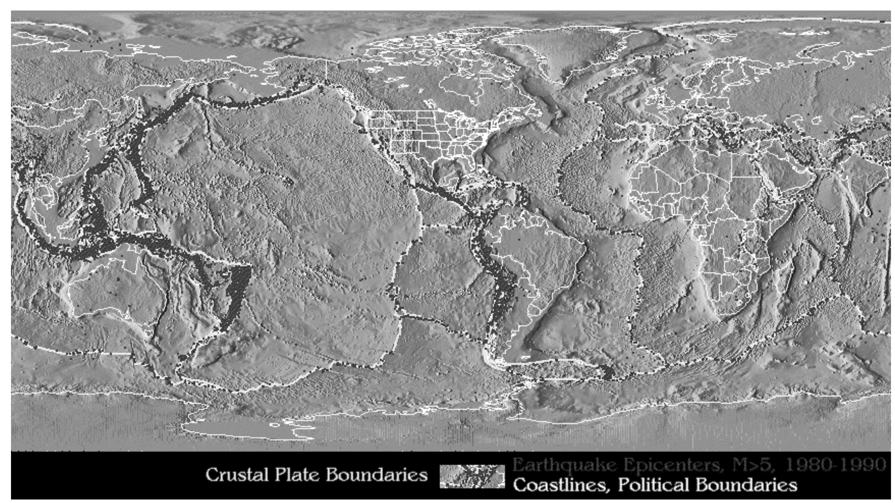
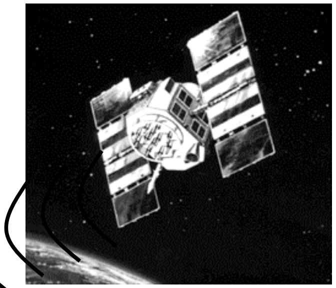
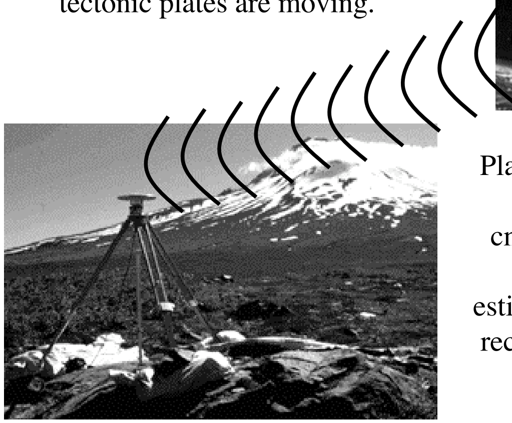


Plate margins are often associated with earthquakes (shown as red dots) and with volcanoes.



GPS (Global Positioning System) and other space-based technologies are now used to measure directly how fast tectonic plates are moving.

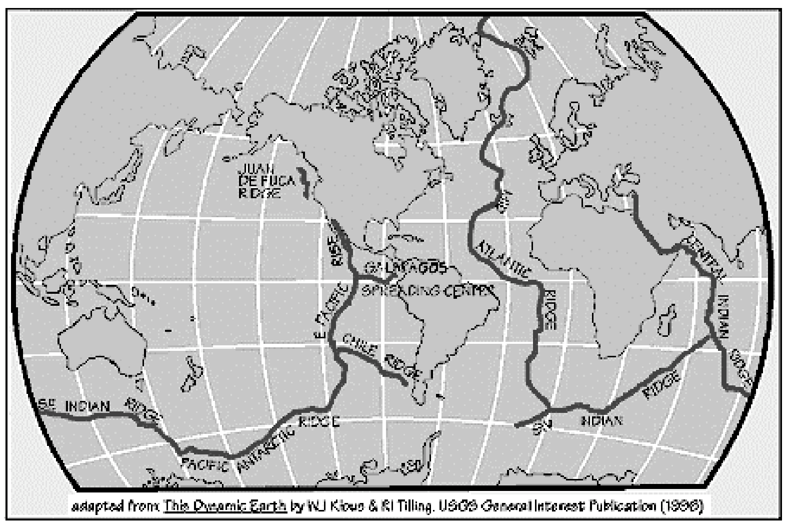




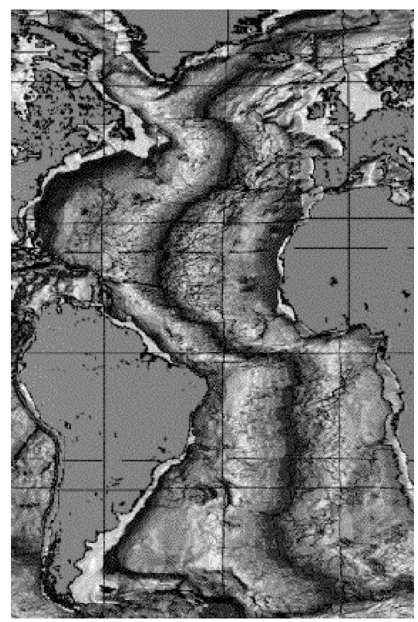
Plates today are moving at speeds of between 2 cm/year and 15 cm/year. This is in line with estimates from the geologic record of how fast they've moved over the past millions of years.

Mid-Oceanic Ridges

- New oceanic crust is constantly being produced at the *mid-oceanic ridges*.
- Along the ridges, molten rock wells up, solidifies, and forms new crust.
- Another name for this process is *seafloor spreading*.
- Older crust is pushed away to either side.

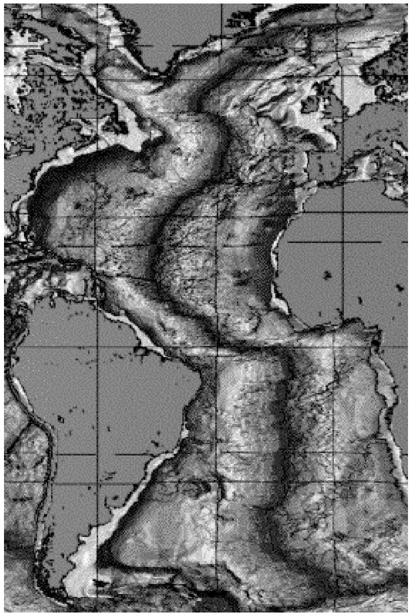


Map of the major oceanic rifts where sea-floor spreading is taking place.



Fossils on the sea floor, the amount of sediment cover, and direct dating techniques all show that the crust nearest to the mid-oceanic ridges is the youngest, and that age increases away from the ridges.

Red=youngest; blue=oldest



No oceanic crust is older than about 210 million years, whereas very many continental rocks are that old and older.

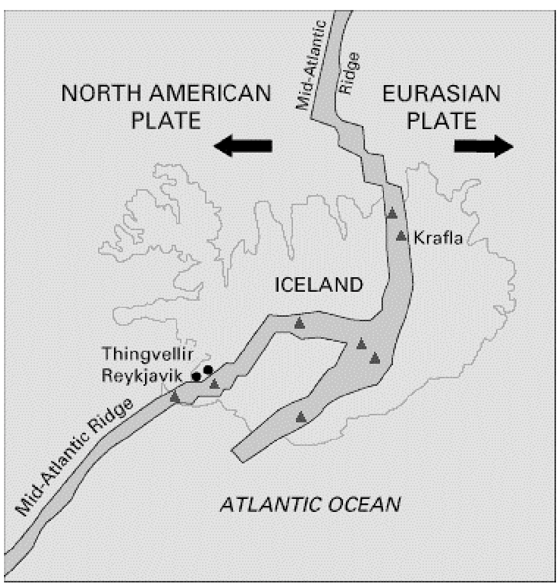
This is just what you would expect if oceanic crust is constantly being created and destroyed.

(Check out the National Geophysical Data Center for more maps like this)

This is one of the few places in the world where an actively spreading rift crosses a land area. . .

Thingvellir, Iceland

Map of Iceland showing how the Mid-Atlantic Ridge crosses the island. Red triangles are active volcanoes. (This and many other images borrowed from the on-line book *This Dynamic Earth*)



In this aerial photo of Thingvellir, you can see the elongated, narrow valley (along the right-hand side of the picture)—that is the zone where the plates are moving apart.

As might be expected, you get plenty of volcanic activity in any spot where plates are pulling apart!

Vatnajökull, Iceland

"Magnetic Stripes"

- The Earth's magnetic field periodically reverses itself.
- Igneous rocks forming at a mid-ocean rift, once they cool, are magnetized by the Earth's magnetic field
- They retain this field even after the Earth's own magnetic field reverses polarity
- Result: symmetrical "stripes" of rock with alternating magnetic polarity, on either side of a mid-oceanic rift

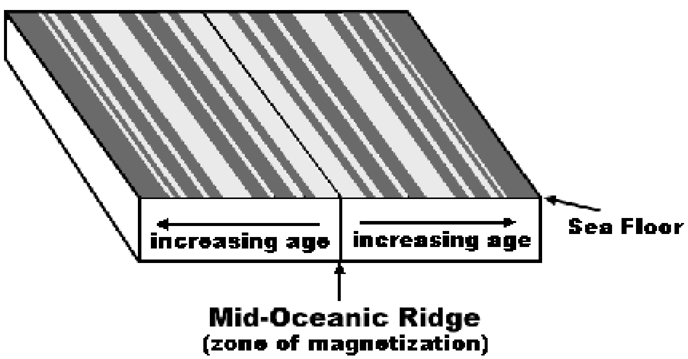
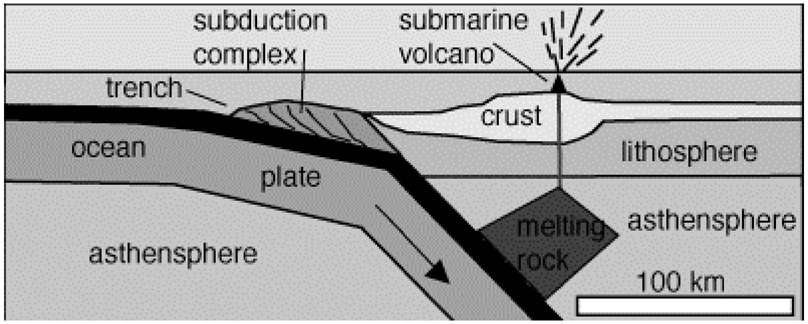


Diagram showing how magnetic anomalies form

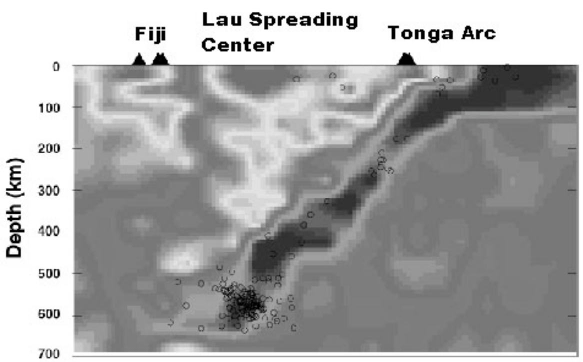
At rift vents (and other undersea volcanoes), lava is instantly chilled coming into contact with sea water. This produces *pillow basalts*, rocks that look rather like pillows (or congealed toothpaste. . .)

Subduction Zones

- If new crust is being formed, and the Earth isn't getting bigger, then crust must also be destroyed. . .
- Oceanic crust is destroyed at *subduction zones*, where one plate sinks under another.
- Subduction zones are marked by *trenches* and by *island arcs*.
- Examples: Aleutians, Philippines, Japan, Indonesia. (NOT Hawaii!!)

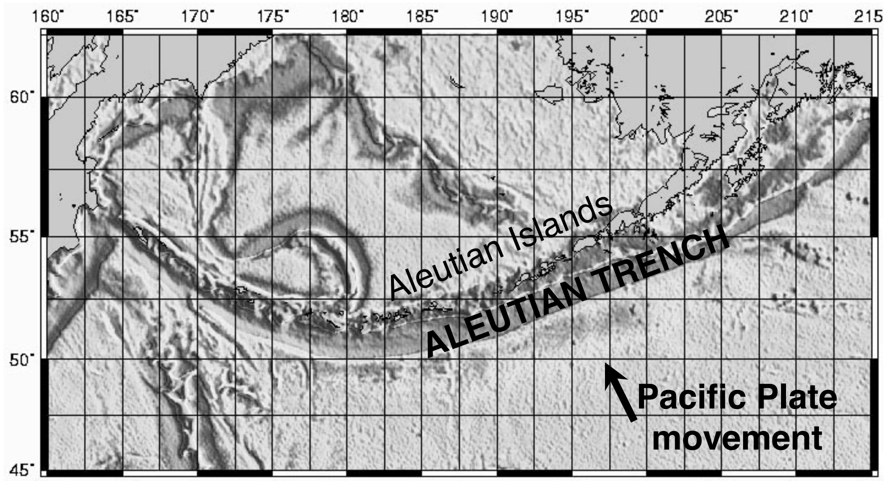


Cross-sectional diagram of a subduction zone.
As the plate sinks into the asthenosphere, not only is a trench formed, but melting rock rises and forms a line of volcanoes parallel to the trench. That's an *island arc*.

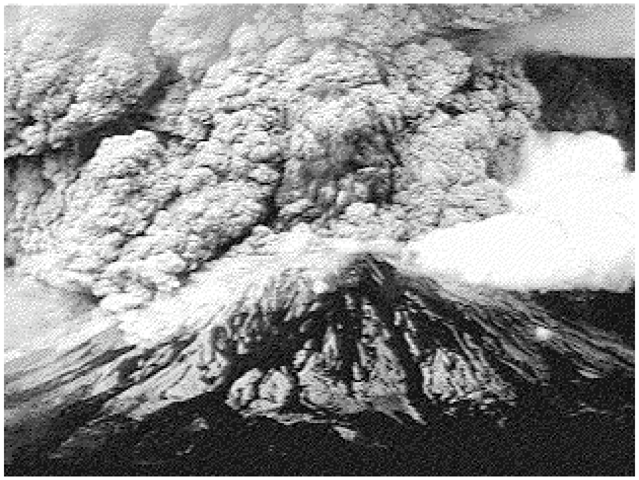


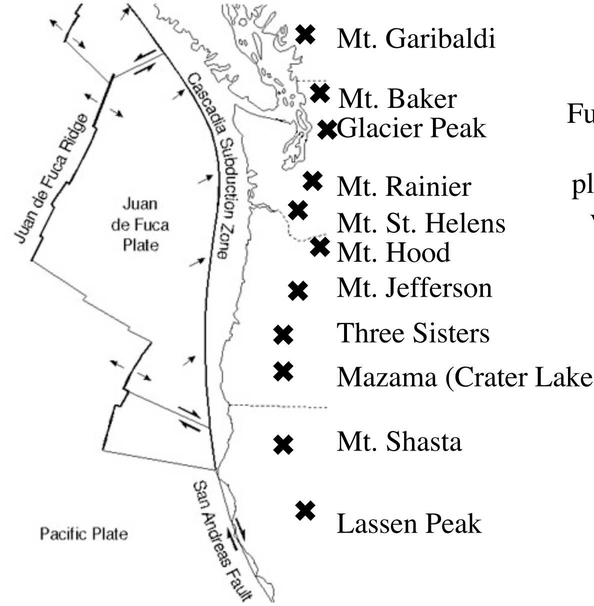
Seismic waves travel faster in cold rock than in hot rock. This actually makes it possible to "see" the colder plate (shown in blue) diving into the hotter asthenosphere (shown in green and red). This is a cross-section of the Tonga subduction zone in the southern Pacific Ocean.

Example of an island arc:
The Aleutian Islands, Alaska



Arc volcanoes may join to continents, rather than form islands. . .

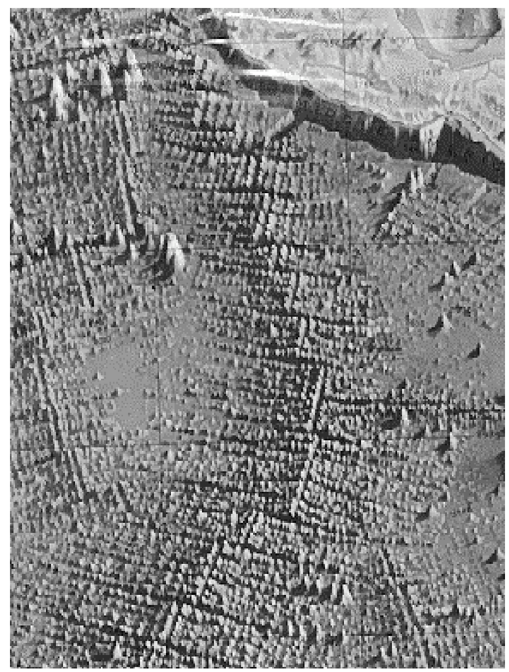




The subduction of the small Juan de Fuca Plate below the North American plate has produced a volcanic arc on the continent. The red X's mark active subduction-related volcanoes.

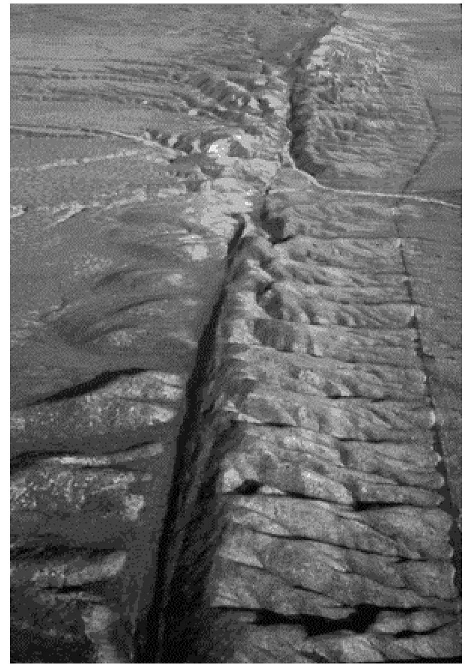
Transform Faults

- At the plate boundaries we've mentioned, plates are moving either towards each other or away from each other
- *Transform faults* occur when plates move sideways with respect to each other
- Transform faults connect two spreading zones, two subduction zones, or a spreading zone with a subduction zone.

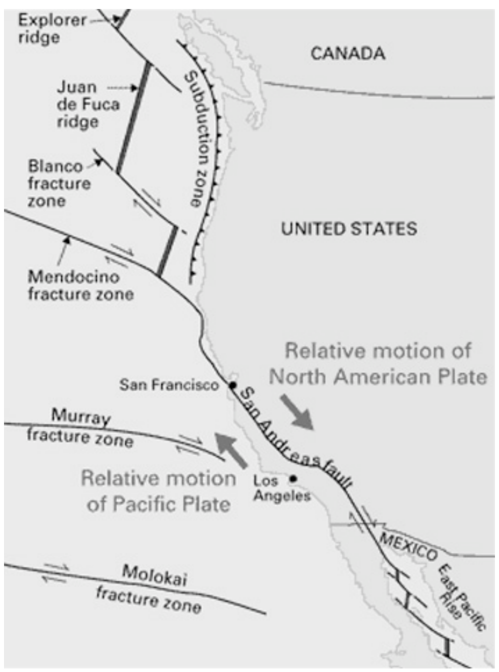


Off the Pacific coast of Mexico, many transform faults connect segments of the spreading zone, giving a "stair-step" effect.

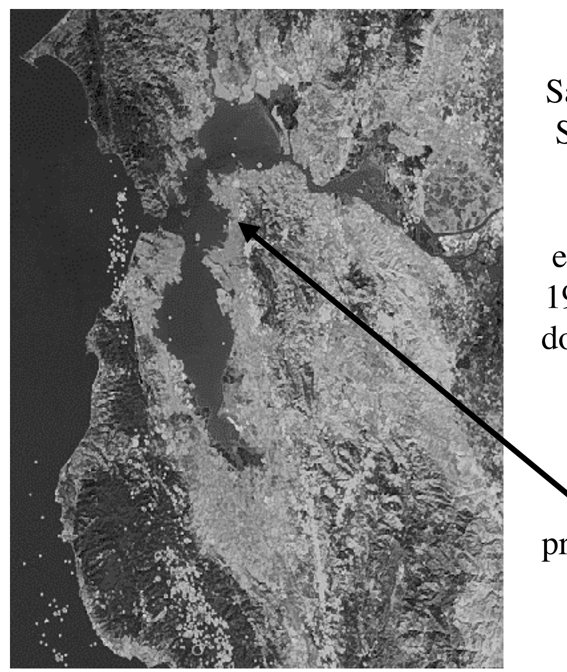
Here’s what it looks like in the color-enhanced mode. Red = spreading zone; green=transform fault



There’s only a few places in the world where transform faults cut across land, and this is an aerial photo of what is probably the best-known. . . the *San Andreas fault*, seen in this aerial photo.



The San Andreas fault connects spreading zones in the Gulf of California with zones in the north Pacific. Coastal California and Baja California are slowly sliding northwest relative to the rest of North America.



Satellite photo of the San Francisco area. Each yellow dot represents an earthquake between 1980 and 1990— the dots trace out the San Andreas fault and related faults.

Your humble professor used to live right here.

Another transform fault seen in a satellite photo. When a transform fault curves, it causes compression along the fault (which can form mountains) and extension (forming "pull-apart basins".