This Dynamic Earth: the Story of Plate Tectonics
Earth’s Topographic Regions

**Plains**
Local relief less than 100 m (325 ft). At the ocean edge, the surface slopes gently to the sea. Plains rising continuously inland may attain the elevation of high plains over 600 m (2000 ft).

**High tablelands**
Elevation over 1520 m (5000 ft) with local relief less than 300 m (1000 ft) except where cut by occasional canyons.

**Hills and low tablelands**
Hills—Local relief more than 100 m (325 ft) but less than 600 m (2000 ft). At the edge of the sea, however, local relief may be as low as 50 m (200 ft).

Low tablelands—Elevation less than 1500 m (5000 ft) with local relief less than 100 m (325 ft). Does not reach the sea or, if it does, a bluff at least 60 m (200 ft) high delimits the edge of the tableland.

**Mountains**
Local relief more than 600 m (2000 ft).

**Widely spaced mountains**
Discontinuous and standing in isolation with intervening areas having local relief of less than 150 m (500 ft).

**Depressions**
Basins surrounded by mountains, hills, or tablelands, which abruptly delimit the basins.
GEOLOGY OF THE USA
Atlantic Ocean
Crustal Ages

Million Years B.P.

Data for the image from "Digital Age Map of the Ocean Floor" by Miller, Roeser, Ocampo, and Sulitch, Oregon Institute of Geomorphology, 1994.
Clues to Earth’s Surface

- Mountains only in certain areas
- Rock types differ regionally
- Shields in interior of continents
- Oceans oldest near continents and youngest towards middle of oceans
The Earth is divided into three chemical layers:
- the core,
- the mantle and
- the crust

Chemical differences
THE CORE

• The core is composed of mostly iron and nickel and remains very hot, even after 4.5 billion years of cooling.
• The core is divided into two layers: a solid inner core and a liquid outer core.
Because the core is so hot, it radiates a natural heat to the upper layers. Because of this, a current of heat comes into being. Those are also known as the convection currents. The convection currents cause the movement of the tectonic plates.
MAGNETIC FIELD

• It is well known that the axis of the magnetic field is tipped with respect to the rotation axis of the Earth.
• Thus, true north (defined by the direction to the north rotational pole) does not coincide with magnetic north (defined by the direction to the north magnetic pole) and compass directions must be corrected by fixed amounts at given points on the surface of the Earth to yield true directions.
Magnetic fields are produced by the motion of electrical charges. For example, the magnetic field of a bar magnet results from the motion of negatively charged electrons in the magnet.

The origin of the Earth's magnetic field is not completely understood, but is thought to be associated with electrical currents produced by the coupling of convective effects and rotation in the spinning liquid metallic outer core of iron and nickel.

This mechanism is termed the *dynamo effect*. 
MANTLE and CRUST

Outer layers of the Earth. Plates are made of crust and rigid upper mantle.
MANTLE

- Composed of minerals rich in the elements iron, magnesium, silicon, and oxygen
- Source of mafic minerals
The crust is rich in the elements oxygen and silicon with lesser amounts of aluminum, iron, magnesium, calcium, potassium, and sodium.

Oceanic crust is made of relatively dense rock called basalt.

Continental crust is made of lower density rocks, such as andesite and granite.
The lithosphere (from the Greek, lithos, stone) is the rigid outermost layer made of crust and uppermost mantle.

The lithosphere is the "plate" of the plate tectonic theory.
The asthenosphere (from the Greek, asthenos, devoid of force) is part of the mantle that flows, a characteristic called plastic behavior.

The flow of the asthenosphere is part of mantle convection, which plays an important role in moving lithospheric plates.
CRUST/MANTLE AGAIN

- **lithosphere**
  - hard
  - ~100 km thick
  - crust floats on top
  - continental crust, 20-70 km thick
  - oceanic crust, ~8 km thick

- **asthenosphere**
  - soft
  - ~3000 km thick
  - “fluid-like”
A heavy load on the crust, like an ice cap, large glacial lake, or mountain range, can bend the lithosphere down into the asthenosphere, which can flow out of the way. The load will sink until it is supported by buoyancy. If an ice cap melts or lake dries up due to climatic changes, or a mountain range erodes away, the lithosphere will buoyantly rise back up over thousands of years. This is the process of isostatic rebound.
In the late 1950's, scientists mapped the present-day magnetic field generated by rocks on the floor of the Pacific Ocean.
When mapped, the anomalies produce a zebra-striped pattern of parallel positive and negative bands. The pattern was centered along, and symmetrical to, the mid-ocean ridge.
As magma solidifies along the edge of the oceanic plate, it preserves a magnetic record of the Earth's magnetic field at that time. In this case, the north magnetic pole is in the northern hemisphere.
If the magnetic pole is in the southern hemisphere, the rocks record a reverse magnetic pattern.
At the present time, rocks record a normal pattern because the north magnetic pole is in the northern hemisphere.
In 1962, a geologist presented an explanation for the global rift system. Harry Hess proposed that new ocean floor is formed at the rift of mid-ocean ridges.

The ocean floor, and the rock beneath it, are produced by magma that rises from deeper levels. Hess suggested that the ocean floor moved laterally away from the ridge and plunged into an oceanic trench along the continental margin.
• In 1935, K. Wadati, a Japanese seismologist, showed that earthquakes occurred at greater depths towards the interior of the Asian continent.

• Earthquakes beneath the Pacific Ocean occurred at shallow depths. Earthquakes beneath Siberia and China occurred at greater depths.

• After World War II, H. Benioff observed the same distribution of earthquakes but could not offer a plausible explanation.
• If new oceanic lithosphere is created at mid-ocean ridges, where does it go?
• The movement of oceanic lithosphere away from mid-ocean ridges provides an explanation. Convection cells in the mantle help carry the lithosphere away from the ridge. The lithosphere arrives at the edge of a continent, where it is subducted or sinks into the asthenosphere.