Plate Tectonics

Last time we took a look at the formation of the earth and the interior of the earth and now we want to concentrate on the very surface of the Earth and explain its shape.

I.) Observations (slide of earth from space Fig 2-9)

A.) Earth is mostly covered in water (sometimes called the blue Planet)

70.8% earth under water

Pacific=52%

Atlantic=25%

Indian=20%

Ice=2%

B.) Mountain ranges are long lines (~1900--global contraction hypothesis)(slide of ocean floor-Fig 2-13))

C.) Mid-Ocean Ridges

World-encircling

Fracture zones are perpendicular to the ridge lines

D.) Trenches are long lines

E.) Seamounts and island chains

Also in lines

F.) Flat portions of earth--ocean bottom (30% of earth is 4000m), sea level for continents, continental shelves

II.) Hypsographic Curve (Depth vs % earth's area)

A.) Made possible by the Challenger expedition, 1872-1876

crew of 243, 6 scientists, 68,000 miles, 492 soundings,133 dredgings, 362 hydgrographic stations (T, bottom sample, net tows, depth), 4700 new spp., third largest ship at the time, wanted to know ocean bottom so they could lay telegraph cables, thought there were a lot of fossils of past life, 8195m Challenger Deep was deepest sounding, annexed Christmas Island which was mined for phosphates and paid for it.

Debunked Thomas Huxley's *Bathybius haekelii* (deep sea slime) thought to be protoplasmic life--it was CaSO4 precipitated from alcohol

B.) BiModal Distribution (Fig 2-14)

Mt Everest=8.848 km

Marianas=11.035 km

21% of Earth's surface is near sealevel

average land elevation is 840m

average ocean depth is 3800m

Average altitude of whole earth is -2430m

Why bimodal distribution?

C.) Theories to explain observations:

1.) Erosion and precipitation tend towards sea-level. In the past (15,000 years ago--the last ice age) sea-level was about 120m lower because the ice caps trapped the water. --> shelf break.

Will readjust for sealevel change...dependent on how much water there is in the oceans. 4000 m because two types of crust floating on the mantle. Continental crust averages 800 m above sea level. The difference in heights is determined by density. 4800m. Sea level depends on how much water there is (ice ages).

2.) Isostasy--Two types of crust floating on the liquid mantle. Like ice cubes, the density of the crust determines where they will lie. Continental crust 2.67-2.8 g/cm^3. Oceanic crust is 3.0 g/cm^3. Mantle is 4.53 g/cm^3 liquid. Core for comparison is 10.72 g/cm^3. Seawater is 1.03 g/cm^3. Thus the continents have deep roots extending into the denser mantle.

Geoid--An equipotential gravity surface. Spheroid with few anomalies. Gravity is not greater at the top of a mountain than at the ocean.

We've explained the hypsographic curve, how about processes, how were the mountains built?

Contintental crust is 35-60 km

Oceanic crust is 4-10 km

III.) Uniformitarianism

Hutton, late 18th century..."the present observable processes are sufficient to explain the geologic past"

IV.) Evidence for Plate Tectonics

A.) Ring of Fire

Pacific is bounded by ridges, trenches, rifts, and active areas-volcanism and earthquake epicenters. p140, p154 Kennett--Little activity inside the plate.

B.) Magnetic Anomalies

1963--Vine and Matthews

•Iron minerals such as magnetite are formed when basalt cools below 550^{o}C (the Curie Temp.)

•These are oriented with the Earth's magnetic field.

• If you measure magnetic anomalies away from a spreading ridge, you see reversing stripes every million years or so like a tape recorder.

•Also, from deep sea drilling, falling iron minerals align themselves with the magnetic field as they settle. These agree worldwide and with spreading center data.

V.) Plate tectonics

A.) Plates

7 major plates, 12 main plates (p78, Thurman; p132, Kennett)

•Rigid, undeformable, thin, in motion (1-10 cm/yr)

How fast do plates move?

•Vine and Matthews, 1963--Northeast Pacific (Juan de Fuca). Can get a time scale of 1-2.5 cm/yr.

•Today, NASA has a program that uses lasers, radio telescopes, etc to measure plate motions to the fraction of a cm -->Atlantic moving at 1.5 cm/yr

•Two types of crust can make up a plate

Oldest crust is in North Pacific at ~220 my most younger than 200my.

B.) Convection of the mantle

C.) Plate Boundaries

There are three types of plate boundaries:

1.) Divergent--Like the Atlantic which opened 180 my. (p191, Kennett; p38, Berger)

History of the Atlantic

Just like Red Sea today

Salt from evaporites--->salt diapirs and oil

open and close yields Scottish Highlands and Appalachians

Hydrothermal Vents found on the East Pacific Rise, Mid-Atlantic Ridge, Juan de Fuca spreading zone, Galapagos

300^{o}C water circulates through vents every 10 million years

Chemosynthetic bacteria

2.) Convergent--Like the Andes or the Himalyas

Benioff Zone--earthquakes that tilt to 700km below

continent.Andesitic volcanoes occur above ~100 km

quakes.

Three types of convergent margin:

Lithosphere is rigid rock sphere including the crust and the upper mantle.

Asthenosphere is the plasic sphere of the mantle which can flow slowly.

Ocean-Ocean (Marianas, Aleutians or Tonga)

Ocean-Continent (Peru, California of old)

Continent-Continent (Himalayas, Appalachians)

3.) **Transform**--Like the San Andreas--

Here, Baja California will be off Alaska in ~200 my, Arizona will be beach front property.

D.) Hot Spots are holes in the mantle that are stationary with respect to each other and to the African Plate. Plate motions can be seen in them.

•Hawaiian chain--Emperor Seamount chain for instance shows the plate took and turn ~40my ago.(p164, Kennett). Kure atoll ~30my, Oldest seamount~65 my.

•Other chains, Cook, austral, Line Islands, Marshall Islands, Guadalupe all follow the same direction.

VI.) Mineral Resources

- Made in geological timescales of millions of years
- Used in decades
- Economic, political ramifications of redistributing mineral resources

VII.) Erosion

- Constantly battling mountain building to form landscape
- Increased due to human activity
- Hurts agriculture, water clarity