

## The Way the Earth Works: Plate Tectonics

### Plate Tectonics

The paradigm of "how the Earth works"

- Earth's outer shell is broken into rigid plates that move

A case study of scientific revolution

- It allows scientists to predict geologic events, and...
- Reconstruct the geologic past

Tectonic theory evolved in the 1960s

Previous research provided a strong foundation

- Wegener (1915) -evidence supporting continental drift
- Hess/Dietz (1968) -the sea-floor spreading hypothesis
- By 1968, evidence for tectonics was overwhelming

Sea floor spreading + continental drift = plate tectonics

Plate tectonic theory provides a unified mechanism explaining:

- Igneous sedimentary, and metamorphic rocks
- The distribution of earthquakes and volcanoes
- The origin of continents and ocean basins
- The distributions of fossil plants and animals
- The genesis and destruction of mountain chains
- Continental drift

### Lithosphere

Tectonic plates are fragments of lithosphere

- Lithosphere is made of BOTH crust and the upper mantle
- The lithosphere is in motion over the asthenosphere

Lithosphere bends elastically when loaded

Asthenosphere flows plastically when loaded

### Buoyancy

- First described by Archimedes more than 2.2 Ka
- Floating solids displace water equal to their mass
- An iceberg "sinks" until the mass of water it displaces is equal to the total mass of the iceberg
- This concept applies to lithospheric plates

2 types of lithosphere

Continental ~150km thick

- Granitic crust
- 35-40 km thick
- Lighter (less dense)
- More buoyant -floats higher

Oceanic ~7 to 100 km thick

- Basaltic crust
- 7-10 km thick
- Heavier (more dense)
- Less buoyant -sinks lower

Plate boundaries

- Lithosphere is fragmented into ~20 tectonic plates
- Plates move continuously at a rate of 1 to 15 cm/yr
- Plates interact along their boundaries'

Global earthquakes

- Outline lithospheric plate
- Specific types of earthquakes occur at different types of plate boundaries

Plate boundaries

Location on Earth where tectonic plates meet

- Identified by concentrations of earthquakes
- Associated with many other dynamic phenomena

Plate interiors are almost earthquake-free

Continental margins

- Where land meets the ocean
- Margins near plate boundaries are "active"
- Margins far from plate boundaries are "passive"
- Passive margin continental crust thins seaward
- Transitions into oceanic crust
- Traps eroded sediment
- Develops into the continental shelf

Plate boundaries: 3 types

- Divergent -normal faults (e.g. mid-ocean ridge)
- Transform- strike-slips faults (e.g. San Andreas fault)

- Convergent –reverse or thrust faults (e.g. the Andes)

Divergent –Tectonic plates move apart (also called spreading boundary)

Convergent –tectonic plates move together (also called convergent margin subduction zone consuming boundary trench)

Transform –tectonic plates slide sideways (also called transform fault)

Divergent boundaries

- Sea floor spreading causes plates to move apart
- Magma wells up to fill the gap
- Magma cools, adding material to each plate
- Example – the Red Sea

Mid-Ocean Ridges

- Linear mountain ranges in Earth's ocean basin
- Example- the Mid Atlantic Ridge
- Sea floor spreading opens the axial rift valley
- Rising asthenosphere melts, forming mafic magma
- Pooled magma solidifies into oceanic crustal rock
- Pillow basalt –magma quenched at the sea floor
- Dikes –preserved magma conduits
- Gabbro- deeper magma

Ocean Crustal Age

- New crust is closer to the ridge; older crust farther away
- Oldest oceanic crust is found at the far edge of the basin

Oceanic lithosphere

- The hot asthenosphere is at the base of the MOR
- Aging ocean crust moves away from this heat...
- Cooling, increasing in density, and sinking
- Accumulating increasing thicknesses of sediment

Convergent boundaries

- Lithospheric plates move toward one another
- One plate dives back into the mantle (Subduction)
- Subduction recycles oceanic lithosphere
- Subduction is balanced by sea floor spreading
- Earth maintains a constant circumference