Notes: Ch 9 Plate Tectonics

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Plate Tectonics - the existance and movement of ridgid "plates" of rocks over a weak or plastic layer in the upper mantle that the continents drift on.

- early evidence - coasts fit together
  - same rock types and structures on opp. sides of ocean
  - fossil correlation
  - climate seen in sed. rocks (tropical plant fossils in the arctic)
  - earthquakes and volcanoes

Mechanics of Motion

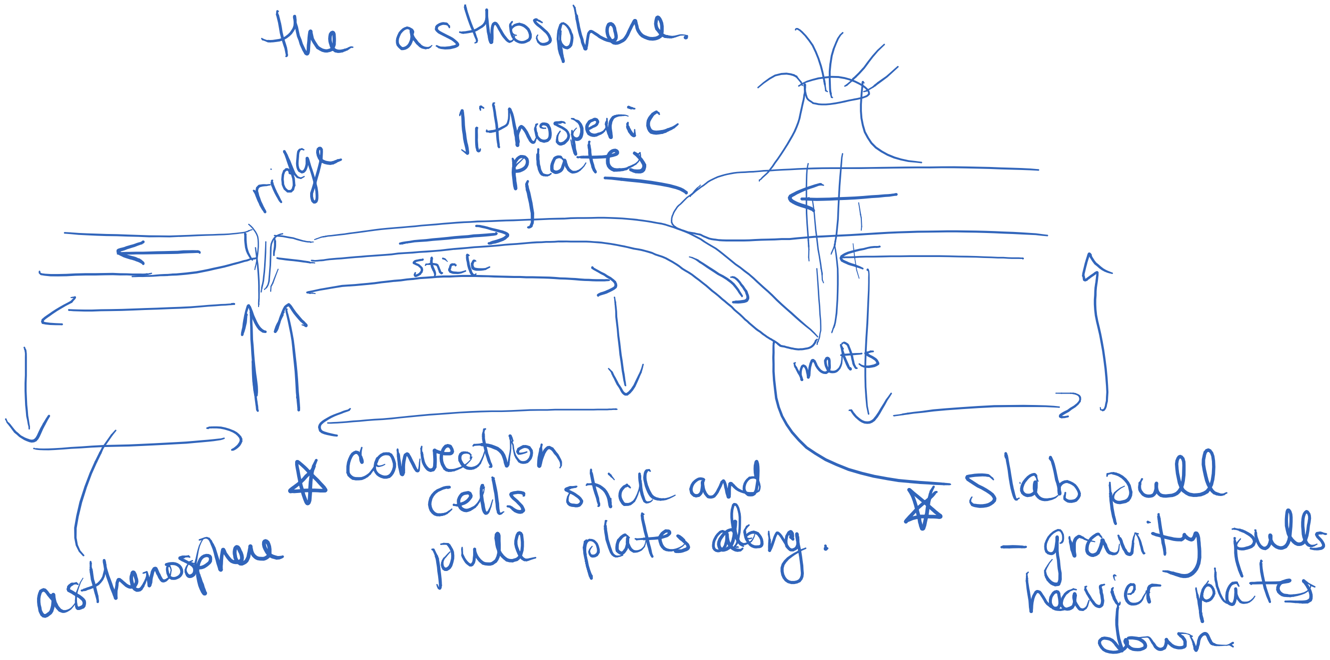
lithosphere - ⊕'s solid crust and upper mantle; varies in thickness (under oceans ~50km, under continents >100km thick) (⊕'s radius is 6370km)

- plates are made of lithosphere

asthenosphere - below lithosphere in upper mantle, average depth of 500km

- "without strength", partly molten, small % of magma in solid rock
- behaves "plastically" under stress
- makes continental drift possible

☆ The plates move by convection cells in the asthosphere.



A. Evidence for Plate Movement

1. Ocean ridges between continent that may have separated (mid atlantic ridge)
   Earthquakes and volcanoes outline the plate boundaries

2. Paleomagnetism

"preserving magnetism"

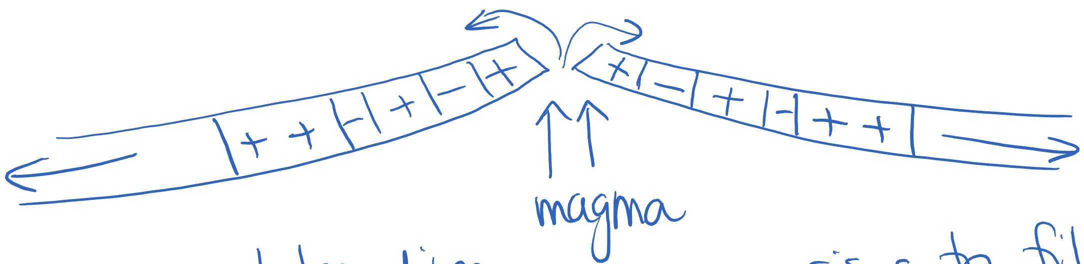
- in a melt magnetic particles are free to line up with magnetic field lines and point towards the magnetic pole - when melt solidifies particles are stuck.

- magnetic reversals - don't know how or why but does occur - possibly change in outer core convection cell direction.

  normally magnetized - rocks that crystallized when poles were oriented as they are today.

reverse magnetism – crystallized when N pole was at south

poles have reversed many times in ⊕'s history as seen in stripes on seafloor
- evidence for seafloor spreading!



- as plates diverge, magma rises to fill in ridge, as cools it magnetically aligns and is stuck ... pole reverses ... repeat.
- symmetrical stripes on both sides

3. Ages of Seafloor Rocks

- youngest rocks (newest) at the ridge; oldest near the continents (~200 my old, when Pangea split up)
- oldest rocks on ⊕ are on continents (seafloor is destroyed/melted in subduction)

4. Polar-Wander Curves

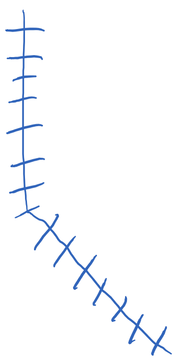
- the line resulting when direction of magnetism in rocks on continents are plotted showing the "apparent" movement of mag. poles relative to that continent
- looks like poles moved, but actually continents moved.

5. Jigsaw fit

- 200 my ago Pangea (a single super continent) broke apart.
- seafloor ridges are the lithospheric scars of this break-up.
- continents still look like they fit together (jigsaw puzzle)
  - SA and Africa especially.

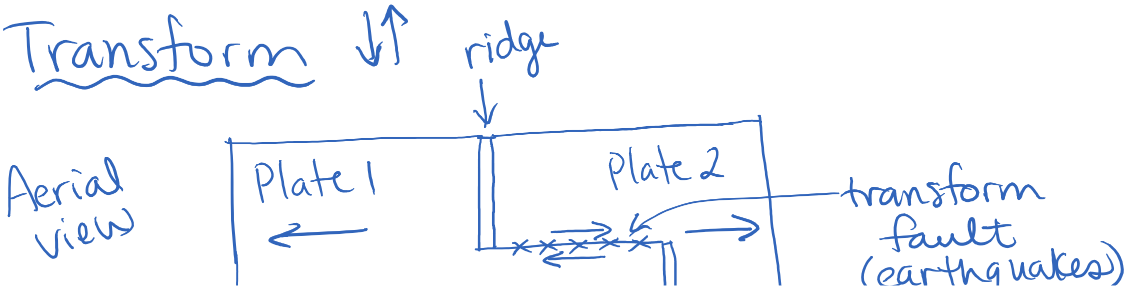
B. Types of Plate Boundaries

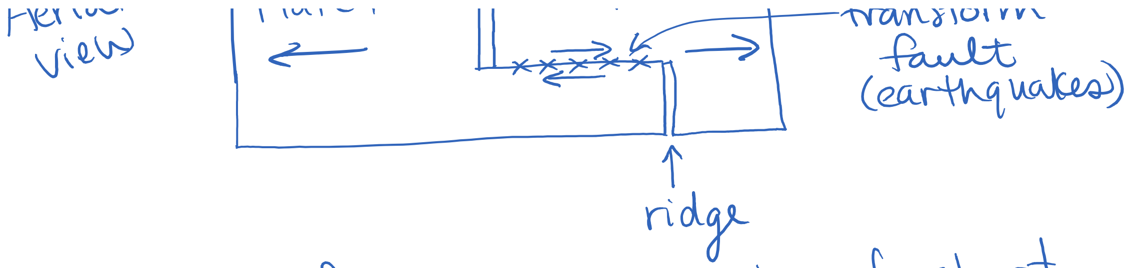
1. Divergent ← →



- lithospheric plates move apart, magma wells up, new lith is created ie mid-ocean ridges (~ 2.0 cm/yr average rate)
- volcanic activity, earthquakes
- continental rifting less common since continents are thicker. (Pangea, E. Africa, BC – Stikine)
- black smokers – water from ocean enters cracks, heated, dissolves minerals (gold), deposits as cools → one type of hydrothermal ore deposit. (mineral vein)

2. Transform ⇅



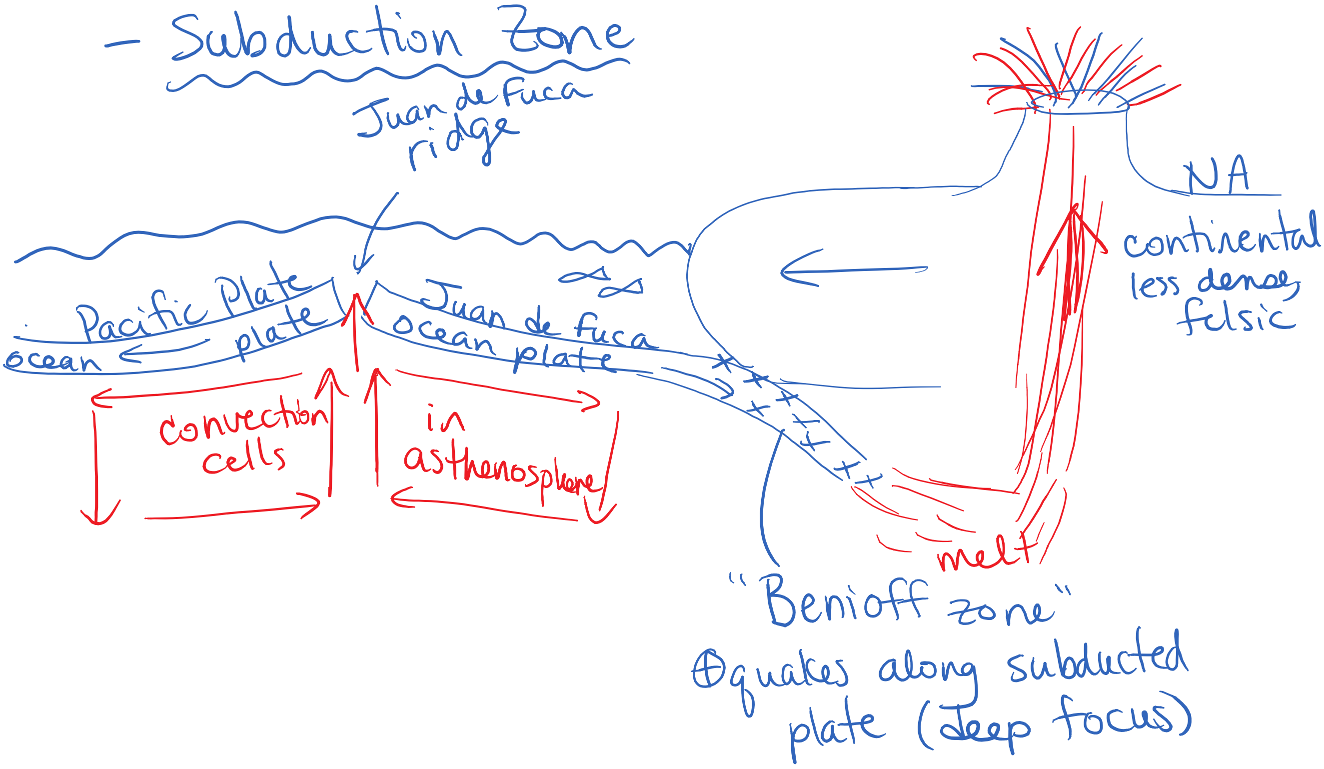


- the seafloor ridge consists of short segments slightly offset
- San Andreas fault (CA) is an example also; in BC - Queen Charlotte fault off our coast → Transform fault

3. <u>Convergent</u> → ←
   - plates moving towards each other
   - Types
     - continental - continental collisions
       - both felsic, low density, crumple up forming mountains (folding + faulting)
         ie Himalayans, Rockies
     - ocean - ocean
       - both mafic (basalt), dense, one subducts under the other and melts, magma rises creating a string of volcanic islands called an "island arc"
         ie Aleutians in Alaska, Japan
     - continental - ocean
       - dense ocean plate subducts under less dense continental, melts, magma rises creating volcanos on land
         ie Cascades (BC, WA, OR, CA),

Andes (S. America)

- Subduction Zone



- ocean plates melted/destroyed at subduction zones, created at the ridges.

Beginning Activity

Calculate the rate of plate motion in cm/y if a plate has moved 300 km in 10 million years.

Ans $$\frac{300\ km}{10\,000\,000\ yrs} \times \frac{1000\ m}{1\ km} \times \frac{100\ cm}{1\ m} = 3\ \frac{cm}{yr}$$

C. How far, how fast, how long, how come?

1. Ways to determine plate movement

- "polar wander" curves

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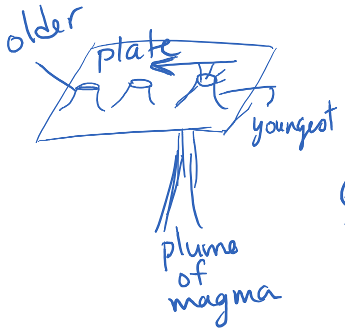
- sea floor spreading: rate = $\frac{\text{dist. moved}}{\text{rock's age}}$
- hot spots – plate moves over stationary plume of hot magma in asthenosphere, magma breaks through creating a chain of volcanos, youngest is closest to the hot spot.



ex Hawaii
Anahim chain in BC

- average rate of plate motion is 2-10 cm/yr

2. Why do plates move?

- convection cells in asthenosphere
- slab pull – gravity pulls on the downgoing subducting plate causing convection cells to start.

3. How long been going on?

- 200 my old ocean floor magnetic stripes
- "polar wander" for more than 1 billion yrs.

∴ been going on for at least 1-2 billion years but not nec. at same rate
And probably been going on since plates first cooled.

☆ Plate tectonics plays a large roll in the rock cycle (Fig 9.24)