Chapter 10: Plate Tectonics

Hard Boiled Egg
with a cracked shell

I. The Theory

A. The Theory of Plate Tectonics states that many changes in the earth's crust are caused by forces within the earth's crust.

Volcanoes & Earthquakes - New crust
Destruction of old crust

B. The earth's crust is broken down into 8 major plates and several minor ones.

1. The major plates are:

- North American
- South American
- Indian/Australia
- Antarctic
- Eurasian
- African
- Pacific

pg 712-713

20 total plates / slabs

2. Some of the minor plates are:

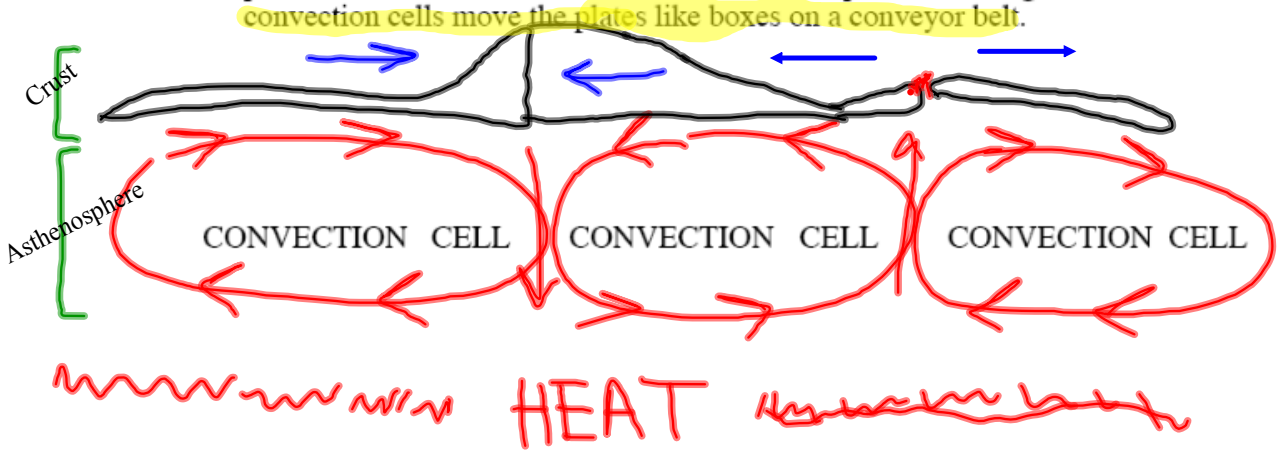
Juan de Fuca	Caribbean	Caroline	Bismarck
Cocos	Philippine	Somali	
Nazca	Scotia	Arabian	
Soloman	Sandwich	Marianna	

C. The plates are rigid blocks which make up the lithosphere. The lithosphere is the solid part of the earth. The blocks extend into the upper part of the mantle to a depth of about 100 km.

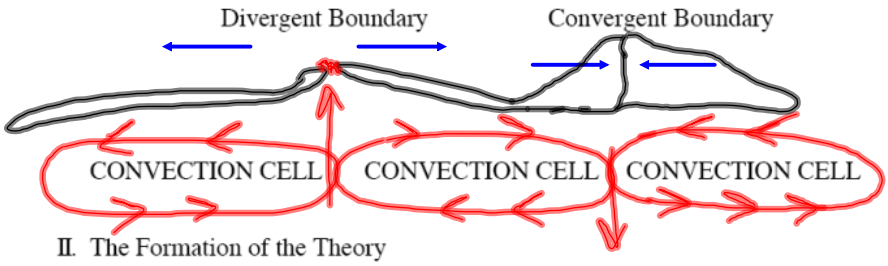
Silly Putty
pg 176 - 177

1. At a depth of 100 km. the heat and pressure from the weight of the overlying rock and radioactive decay brings the mantle near its melting point. This semi-liquid layer making the upper part of the mantle is called the asthenosphere and extends to a depth of about 200 km.

2. Convection cells form in the asthenosphere when hot molten rock flows from the bottom of the asthenosphere up to the top, at the top it moves along under the plates, as it moves it cools and sinks to start the process over again. The convection cells move the plates like boxes on a conveyor belt.



3. Where two plates move apart a divergent boundary is formed. Where two plates move together a convergent boundary is formed.



II. The Formation of the Theory

A. Before 1900 scientists believed that the continents were fixed in their locations. Though philosophers and explorers recorded passing thoughts on moving continents none were taken seriously.

B. In 1911 a german meteorologist named Alfred Wegener noticed that Africa and South America appeared to fit together like pieces of a puzzle.

"All Lands"

1. Wegener began to form the theory of **continental drift**. He suggested that the continents were once joined into a super continent which he called Pangaea.

2. Wegener's hypothesis was that the super continent began to break apart over 200 million years ago.

3. Wegener went on a world wide search for evidence that suggested the continents were moving.

4. Wegener and a group of scientists were lost in Greenland during an expedition. However, he did collect evidence to prove his theory that the continents were once joined. FALSE His theory lacked the mechanism necessary to cause the plates to move. He suggested that the Moon's pull on Earth moved the continents

C. Wegener and other scientists collected the following evidence to suggest that the continents were connected.

1. Fit of Continents - The continents have coast lines which can be matched together like pieces of a puzzle. Using computers to calculate the rate of weathering, erosion, and deposition over the past 200 million years scientists get even a better fit of the continents. Continental shelf - shallow area around the co[illegible]ts

2. Glacial Deposits - Erosional and depositional features created by glaciation have been found in Africa, South America, and Antarctica. These features match when the continents are fitted together.

3. Identical Fossils - of the same age are found on continents separated by oceans. Such an example is the Lystrosaurus, an ancestor to the hippopotamus, whose fossil remains are found on Africa, South America, and Australia.

4. Coal Deposits - of the same age and type are found on three different continents. When the continents are fitted back together they make one large deposit.

5. Mountain Ranges - Wegener believed that the chain of mountains known as the Cordilleras were the result of drifting continents. He also found that when the continents were fitted together many of the ancient mountain chains matched up.

D. Many scientists refused to even look at Wegener's evidence. Those who did offered evidence to disprove his theory.

1. Some scientists believed that land bridges or a chain of islands once existed which allowed animals to cross from one continent to another.

2. Others suggested that all mountains formed at once and that is why there are similarities between many of them.

3. Many suggested the fit of the continents occurred simply by chance.

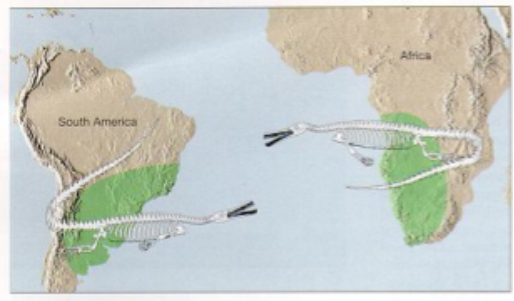
E. During the early 1960's new evidence emerged that helped validate Wegener's theory. Evidence had been compiled during the International Geophysical Year of 1957/58.

1. During a voyage of a research vessel called the Glomar Challenger scientists located a huge underwater mountain chain in the middle of the Atlantic Ocean which followed the coast lines. These mountain chains were marked with active volcanos and rocked by earthquakes. Mid Atlantic Ridge 10,000 miles long

2. Using an instrument called a magnetometer scientists could measure the orientation of the iron atoms in the rocks on the ocean floor. They discovered that the magnetic alignment of the atoms reversed itself several times as they moved away from the mid-ocean ridge. 4 million years

   a. From this evidence the scientists learned that over earth's history the earths magnetic field has changed at least 9 times. At the present time a compass points to the north at other times in the earth's history, for reasons unknown, a compass would point south.

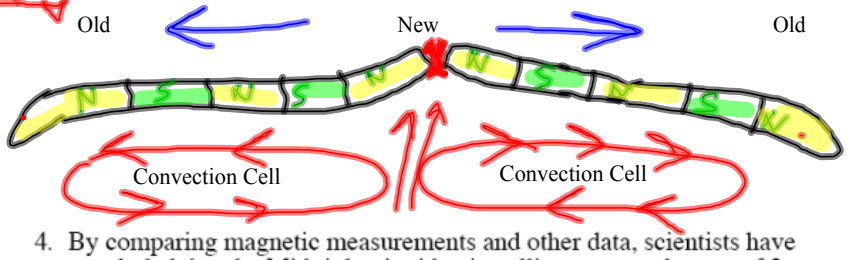
   b. As the magma from a rift zone would cool and crystallize during the times of magnetic reversal, the atoms of iron would align themselves facing south instead of north as they do now.



Plymouth Rock
Atlas Mt- Africa

3. Scientists then discovered that the same pattern of change was present as they towed it away from the ridges in the exact opposite direction. Scientists also found that the seafloor was very young near these mountain chains and got older and older at the same rate as they moved away on either side. This evidence led to

The Theory of Seafloor Spreading

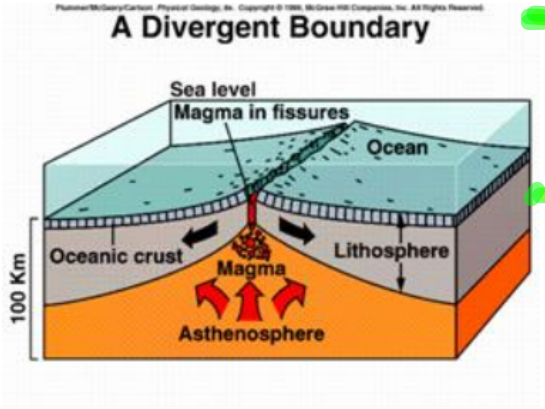


4. By comparing magnetic measurements and other data, scientists have concluded that the Mid-Atlantic ridge is pulling apart at the rate of 2 cm/year and in some places up to 1 meter/year. (This is comparable to able the same rate at which your fingernails grow)

III. The Results of Plate Movement

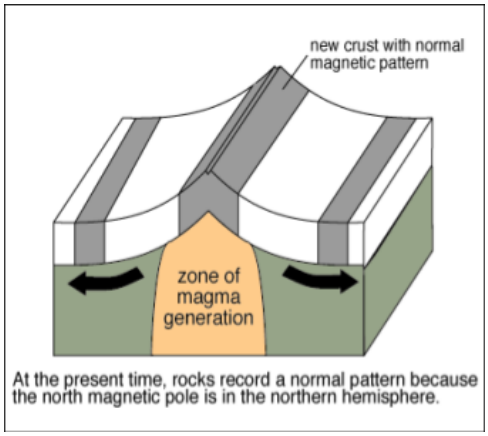
A. The result of plate movement depends on two factors; (1) the direction of the movement of the plates and (2) if there is continental or oceanic crust on the plate edges. There are 5 possibilities as a result of plate movement.

1. Divergent Plates (Spreading) - Two plates move away from each other. This occurs along mid-ocean ridges and where Africa is moving away from Eurasia. Great Rift Valley



Continental Crust / Rock — Felsic
Granite
Molten State: Cool ~800 degrees C
Thick and Pasty Very High in Silica
Produces Explosion Eruptions Light Color
(Low Iron & Magnesium) Low Density

Ocean Crust / Rock — Mafic
Basalt
Molten State: Hot ~2000 degrees C
Thin and Runny
Produces Quiet Eruptions Dark Color
(High Iron & Magnesium) High Density



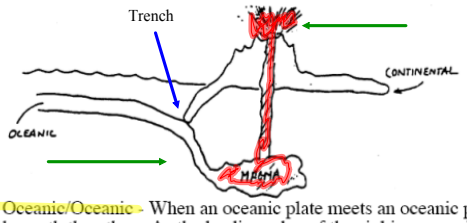
At the present time, rocks record a normal pattern because the north magnetic pole is in the northern hemisphere.

2. Collision: Continental/Continental - When two plates of continental material crash into each other and pile up since both are the same density. This is occurring where the Indian/Australian Plate crashes into the Eurasian Plate forming the Himalayas. only place in the world for this plate boundary

No Volcanoes
Mountain Ranges
Earthquakes = Yes

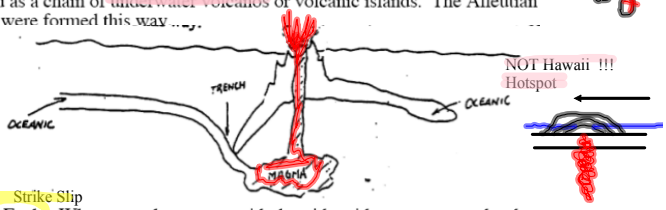
Subduction

3. Convergent: Continental/Oceanic - When a continental plate and an oceanic plate crash into each other the oceanic plate sinks beneath the continental plate because it is more dense. The area where the one plate is forced beneath another is called a subduction zone. The subduction zone forms a deep sea trench. As the leading edge of the oceanic plate dives into the asthenosphere it begins to melt building heat and pressure which is finally released as a volcano. Mt. St. Helens of the Cascades formed in this fashion.



Subduction

4. Convergent: Oceanic/Oceanic - When an oceanic plate meets an oceanic plate one is forced beneath the other. As the leading edge of the sinking oceanic plate dives into the asthenosphere it forms a subduction zone and a deep sea trench. The leading edge begins to melt building heat and pressure which is finally released as a chain of underwater volcanos or volcanic islands. The Alleutian Islands were formed this way ...

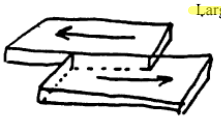


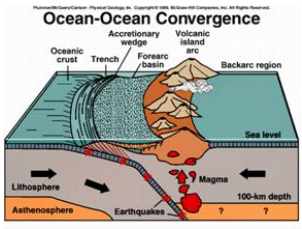
NOT Hawaii !!!
Hotspot

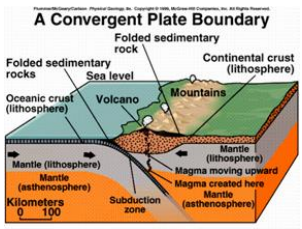
Faulting Strike Slip

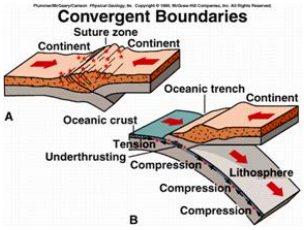
5. Transform Fault- When two plates move side-by-side with respect to each other. As the plates move passed each other, they occassionally catch and build up pressure until enough pressure builds up, and releases in the form of an earthquake. This type of situation is present where the North American Plate is sliding by the Pacific Plate at the San Andreas Fault.

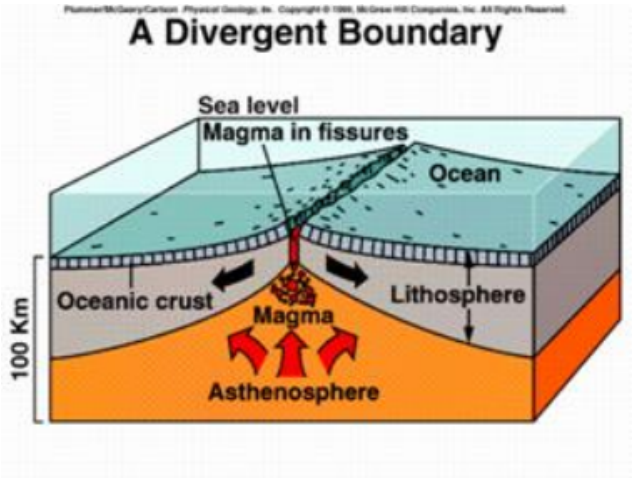
No crust created or destroyed
No volcanoes
Large number of earthquakes

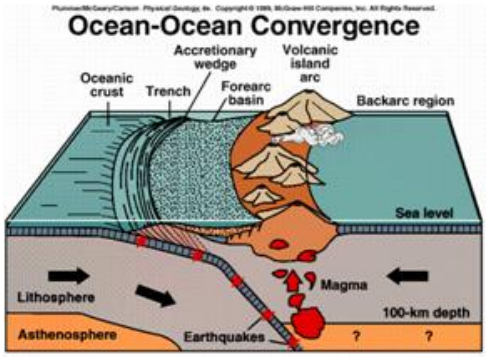


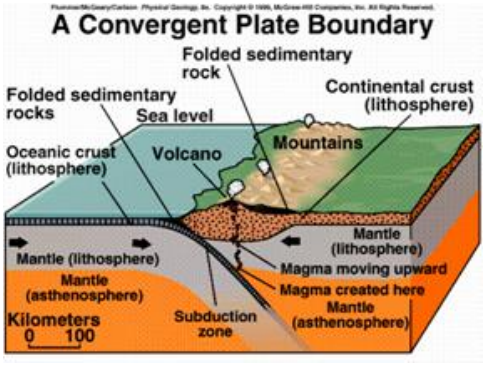


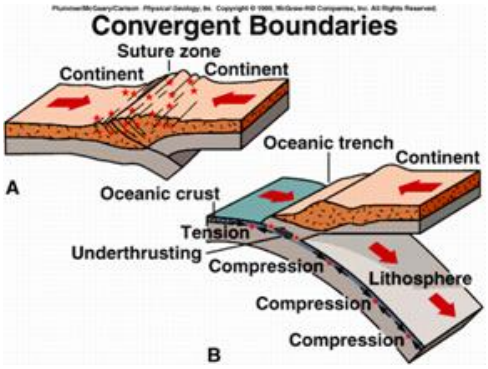


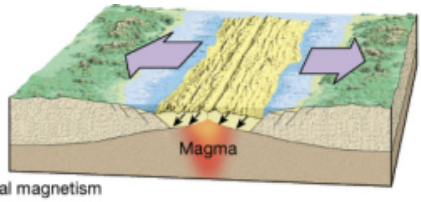




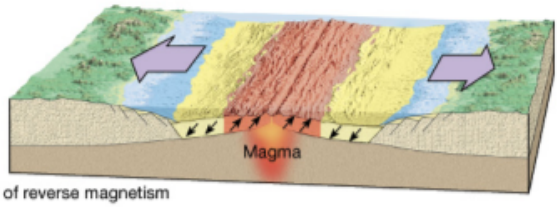




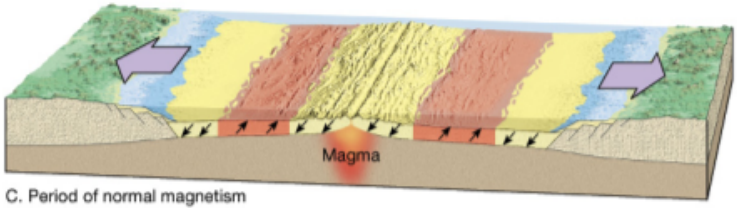




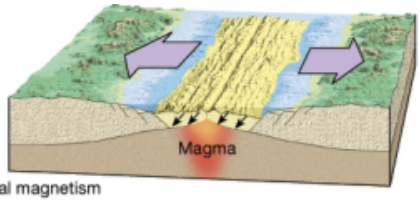
A. Period of normal magnetism



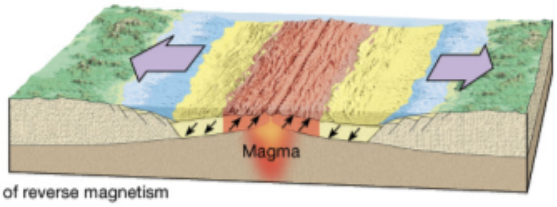
B. Period of reverse magnetism



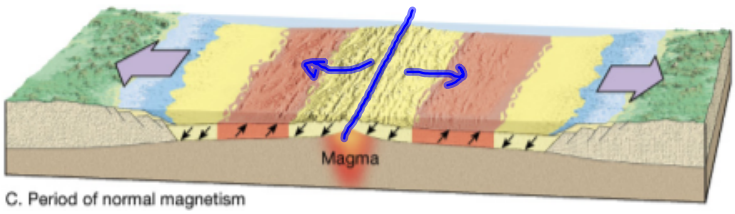
C. Period of normal magnetism



A. Period of normal magnetism



B. Period of reverse magnetism



C. Period of normal magnetism

Plate Tectonics Map Activity

1) Trace the edges of all the plates (using the map on pages 712-713 and the laminated map)

(Look for features: trenches, rises, rifts, ridges, mountains)

2) Label the plates with their proper names (1st page of the notes) 20 total

3) Identify the plate boundary type

A) Spreading / Divergent

Create a key

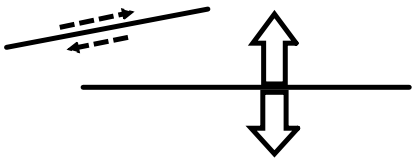
Convergent

B) Collision (Continental / Continental)

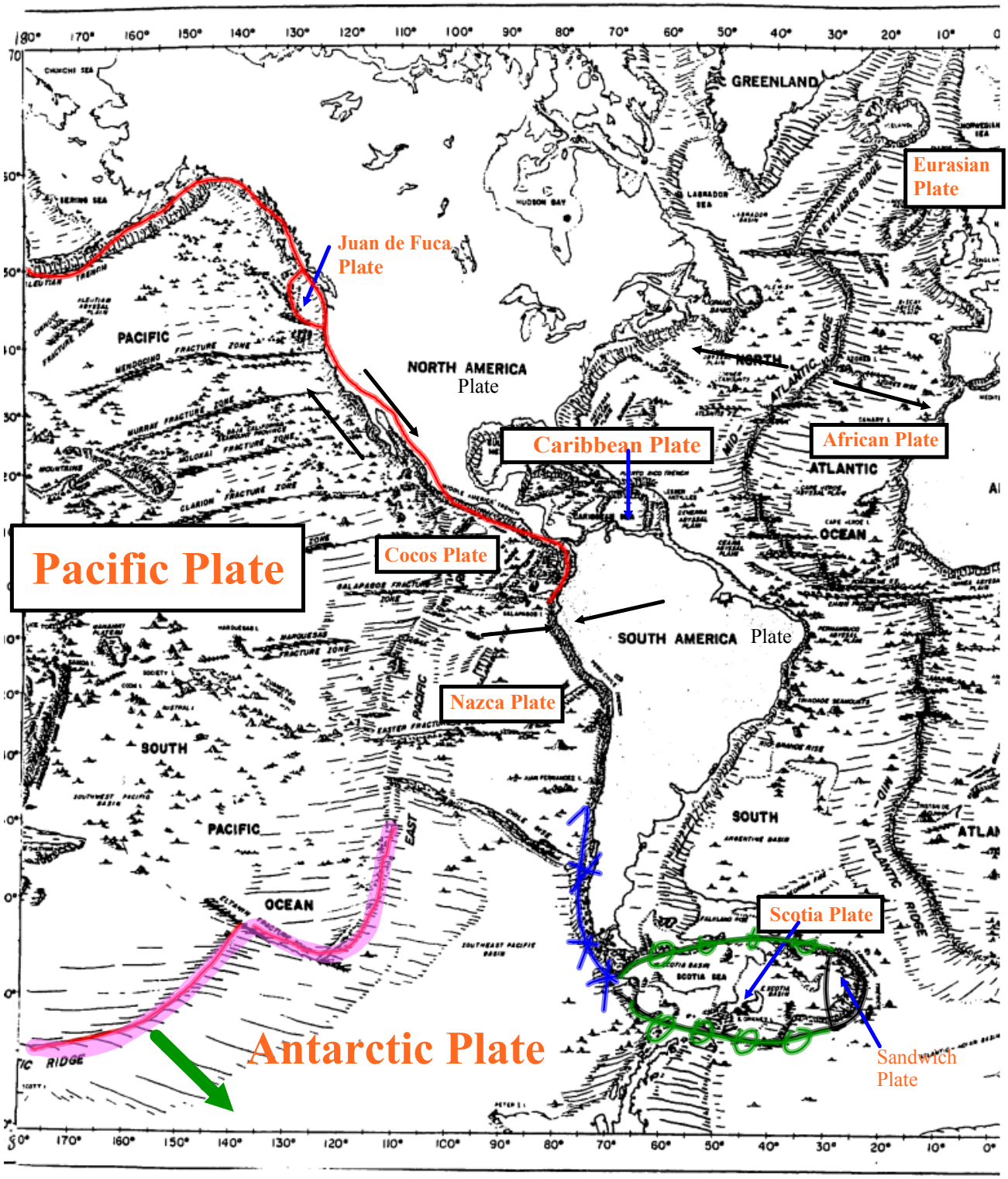
C) Subduction (Continental / Oceanic)

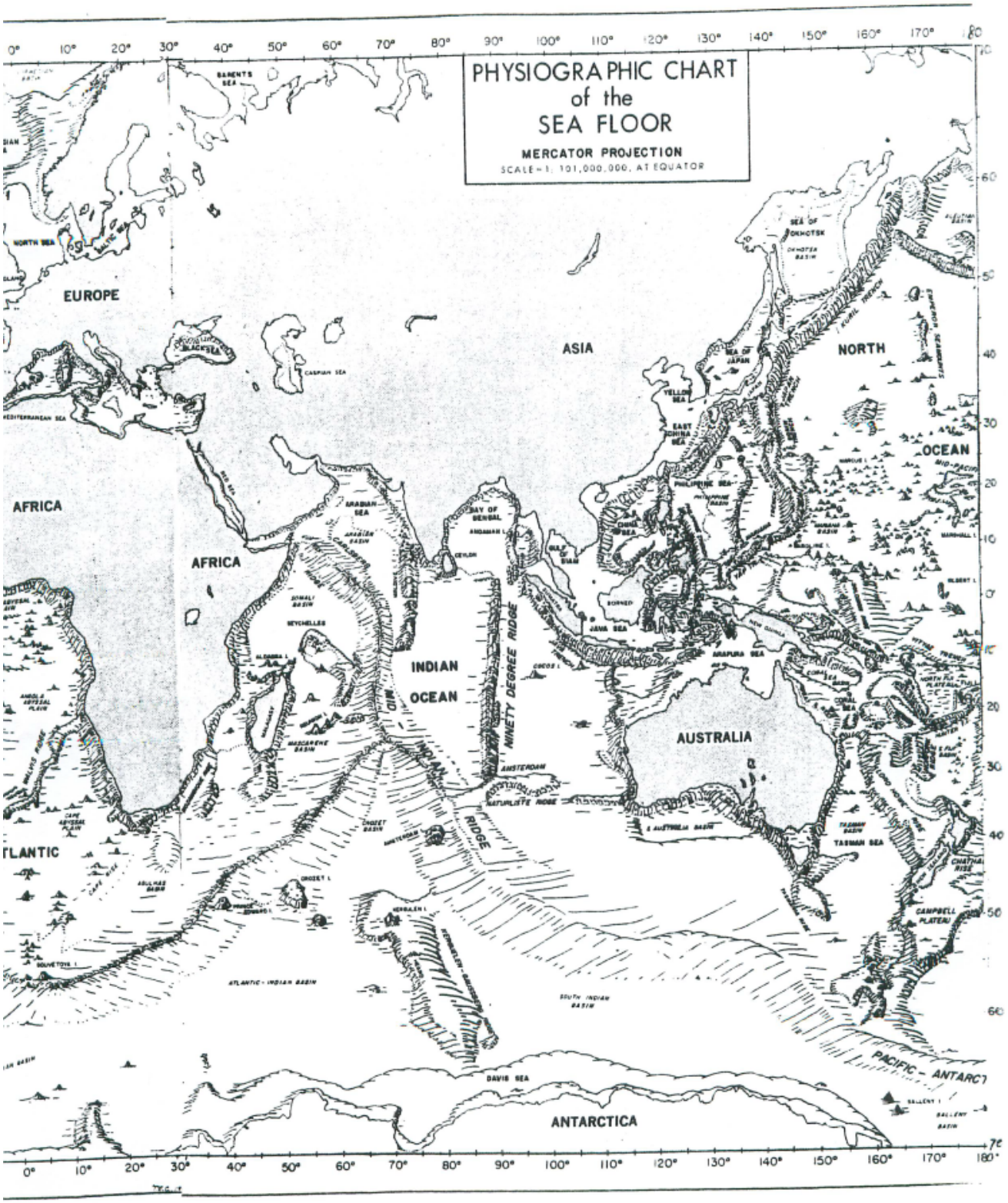
D) Subduction (Ocean / Ocean)

E) Faulting / Transform / Strike-Slip



4) Draw arrows of Movement


GREENLAND
Eurasian Plate
Juan de Fuca Plate
PACIFIC
NORTH AMERICA Plate
Caribbean Plate
African Plate
ATLANTIC
OCEAN
Pacific Plate
Cocos Plate
SOUTH AMERICA Plate
Nazca Plate
SOUTH
PACIFIC
OCEAN
SOUTH
Scotia Plate
Antarctic Plate
Sandwich Plate
Spreading / Divergent Boundary
Subduction / Continent-Ocean
Faulting


PHYSIOGRAPHIC CHART
of the
SEA FLOOR
MERCATOR PROJECTION
SCALE 1: 101,000,000, AT EQUATOR
EUROPE
ASIA
NORTH
OCEAN
AFRICA
AFRICA
INDIAN
OCEAN
AUSTRALIA
NINETY DEGREE RIDGE
ANTARCTICA
PACIFIC - ANTARCT
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180°