

# PLATE TECTONICS NOTES

These are my lecture notes for Plate Tectonics. Always keep in mind that these are **notes** and are not in complete sentences nor do these notes in any way replace the textbook. If these notes help you understand and learn the topic of Plate Tectonics, then you are welcome to use my notes. If, however, these notes are not complete enough for you, then do not use these notes and return to using your textbook, the CD-ROM and the videos in the LPC LRC and internet search engines.

# PLATE TECTONICS NOTES

## THE THEORY

the earth's surface is broken into approx 12 large pieces – and the pieces are moving

## History/Evidence...in the order that it was discovered.....

### Students open textbooks to PT chapter

by 1850's worldwide mapping good enough to see....

- CONTINENTS FIT TOGETHER – jigsaw puzzle
- ROCKS match.....
- MOUNTAINS match
- FOSSILS match
- CLIMATES make sense

...So.... → **Continental Drift**....does NOT explain HOW or WHY....just states that they were together and moved apart.....

...its now the end of the 1800s and the beginning of the 1900s

...and **worldwide exploration moves to the oceans....**

...submarine warfare... → need to map the ocean floor

...NOT FLAT!!!!

...AND the middle portions of the ocean are not the deepest....the ocean is not just a big lake!!!!

## →the Mid-Oceanic Ridge???

trace around Atlantic...to Indian...to Pacific Ocean

ITS ONE MTN RANGE!!!!

45,000+miles long, 2-3miles high,

as tall as the Rocky Mtns....how no one knew it existed?

How to explain this mountain? How could the continents move over this mountain?

No answers....at this time....just more questions....

# PLATE TECTONICS NOTES

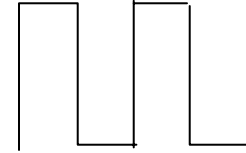
## →magnetic stripes

WWII....searching for submarines....

...sonar is too slow....have to be in contact with the water....can only go 5mph or so...way too slow to search the ocean for hiding subs....

...fly over ocean in planes over 100mph – much better for sub hunting in a huge ocean....but can't use sonar from planes...so....

→magnetometers...basically very sensitive compasses....



- Draw magnetic record...→
- Higher than avg and lower than avg readings....
- CD Animation??
- Fly back and forth....SAME PATTERN! -- Draw on board...
- What is this?
- ...the rocks on the ocean floor are magnetized!!!
- ...in stripes.....!!!
- ...alternating stripes....mag pointing north and south...!!!!
- Show how this works with the mag record....

⇒ *Were geologists and oceanographers surprised to discover that the rocks on the ocean floor were magnetized? (NO)*

⇒ *Were geologists and oceanographers surprised to discover that the rocks on the ocean floor were magnetized North and South? (NO)*

⇒ Were geologists and oceanographers surprised to discover that the rocks on the ocean floor were magnetized? No...we already knew that rocks could be magnetized...we have lots of them on land....

- Describe cooling lava and magnetite crystal formation
- So....they were NOT surprised the find out that the rocks on the ocean floor were magnetized

⇒ So....Were geologists and oceanographers surprised to discover that the rocks on the ocean floor were magnetized North and South? No....!!!! We have lots of rocks on land....magnetized North and South!!!!

- Geomagnetic Record *in students books*
- We already had a geomagnetic time scale from land rocks
- ...and ocean floor rocks agreed
- ....all rocks of the same age point the same direction!!!! ocean and land rocks!

⇒ So...what was surprising about the ocean floor magnetism?

- THE STRIPED PATTERN...rocks on land are in “blobs”

# PLATE TECTONICS NOTES

## THE EARTH'S MAGNETIC FIELD

- The Mag Field from a Bar Magnet

*in students textbooks*

→ What does the geomagnetic time scale tell us about the Earth's magnetic field???

*in students books*

→ It has REVERSED....

- How many times?
- Over and over again....
- Is there a regular interval?
- When is the next reversal coming?

→ **How does the Earth's magnetic field reverse? What causes the reversals?**

- **What could be creating the Earth's magnetic field?**
- Do we have a bar magnet inside the Earth? That is flipping over?? NO....
- Magnetized rocks in the crust or mantle?
  - This wouldn't explain the reversals....
- How about the solid inner core?
  - How do you explain how or why the inner core would flip 180°???
  - Doesn't make sense.....
- Hard to explain the magnetic reversals with "solid state magnetism"...
- Is there any other kind of magnetism?
  - Any other way to create magnetic fields? YES!!!
- Demo with current.....
  - A current creates a magnetic field....!!!
  - Reversing the current...reverses the magnetic field...!!!!
  - So...are there currents inside the Earth...???
  - YES!!! ...this is the current (ha ha) theory for the formation of the Earth's magnetic field and how it reverses....
- Current Loops create the same magnetic field as a bar magnet...the same magnetic field as the Earth....
  - Reverse current...reverses the magnetic field....
- **So...the current theory is that there are current loops in the molten liquid outer core....*students refer to diagram in their texts***
  - Not just simple current loops...but swirling loops...like "weather in the core"....and each current loop creates its own magnetic field....these add together to form the Earth's magnetic field....
  - The liquid is always moving...bumping against the bottom of the mantle and the top of the solid inner core...creating new current loops....and the Earth's magnetic field changes....or reverses.....

**THIS IS THEORY NOT FACT – we have not been to the core!**

# PLATE TECTONICS NOTES

## OK...so back to the main topic....Plate Tectonics.....

- Continental Evidence....jigsaw puzzle, rocks match, fossils match, etc....
- Oceanic Findings...
  - MOR??? (doesn't appear to "help"!)
    - Magnetic stripes...these don't appear to "help" explain PT either)
    - Sigh.... ☺
- Now...it's the 1960s....
  - What happened in the 60s? students make list
    - Of these events, which affected what we know about the ocean?
    - The moon....but not the way you'd think....
  - **1968 DSDP**
    - multinational drilling ship -- *pic in students texts*
  - **found ocean sediments too thin and too young!**  
*Where have 90% of the seds gone?*
  - **symmetry about the MOR**
    - rock ages, sediments thicken, magnetic stripes, heat flow
    - ocean floor is basalt with seds on top....
  - **So....just what is the MOR???**
    - A volcano???
    - Does that explain the basalt? Yes
    - Does that explain the heat? Yes
    - Does that explain why the oldest rocks are farthest from the MOR? NO....
    - Think about a volcano on land....oldest rocks are on the bottom...youngest rocks are on the top....
    - This MOR volcano is different....
    - So, how can we explain the oldest rocks being farthest from the ridge?
    - The MOR is...SPREADING???? RIFTING???? Being ripped apart??  
YEP!
    - Video Clip: Iceland....what is Iceland???
    - the MOR above sea level....
    - so, what is Iceland...it's a volcano – yep!
    - and its being ripped apart!

## → Sea-Floor Spreading

*students textbooks*

# PLATE TECTONICS NOTES

## Sea Floor Spreading...is happening....

- So what does this mean on a globe???
- Atlantic is widening....continents moving apart...
- ...more crust is being made...more and more is taken from inside the earth...
- so...is the Earth getting bigger...and hollow???
- No...measurements show that the Earth is staying the same size
- ...not getting bigger....
- BUT...if the continents are moving apart....and the ocean between is widening.... and the earth is NOT getting bigger or hollow....
- Then what is happening “on the other side of the earth”?
- Continents must be colliding....
- And if the Earth is not getting hollow, then some rocks must be getting shoved back inside the Earth... → Global Recycling!

## \*\*\*3 types of plate edges

**Plate Edges** == Plate Margins == Plate Boundaries == broken pieces of the lithosphere

- **Divergent** == Sea Floor Spreading == Rifting
- **Convergent** == Collision
- **Transform** == Slide-By

**Divergent** == MOR...already discussed

## Convergent

1. Continent to Ocean
  - Andes
  - Subduction
  - Benioff Zones
2. Ocean to Ocean
  - Marianas or Japan
  - Island arc
3. Cont to Cont
  - Himalayas
  - No subduction...no volcanoes
  - No Benioff Zone

## Transform Margins

- San Andreas Fault
- No subduction...no volcanoes....

# PLATE TECTONICS NOTES

## Edges of the Plates....

Location of earthquakes worldwide..... not randomly scattered  
...in distinct lines....or zones....

Where do earthquakes occur???? At Plate Edges!

Look at volcanoes around the world....in the same places as the earthquakes!

Where do volcanoes occur??? At Plate Edges!

**USE THE VOLCANOES & EQ to determine the edges of the plates & which way the plates are moving**

1. Edges of the South American Plate
2. Edges of the North American Plate
3. Edges of the African Plate
4. Edges of the Pacific Plate

*Note: you can use EQ & Volcanoes & MOR & Trenches.....*

# PLATE TECTONICS NOTES

## HOT SPOTS

So... if earthquakes and volcanoes occur at plate edges...what is that smack in the middle of the Pacific Plate? Yes...its Hawaii...Hawaii is a volcano....IN THE MIDDLE OF THE PLATE??? What is going on here?

- ...the Hawaiian Islands are in a straight line...what is going on?
- The islands get older and older to the NW...what does this remind you of?  
...the ages around the MOR???
- Hawaii is not on the MOR...
- Where else do we find lines of volcanic islands? Ocean-ocean collision....but Hawaii is not on a trench....sigh....
- So what is Hawaii???
  
- A Hot Spot....
  
- Which way is the plate moving...to the NW....
  
- **How to explain the “bend” in the chain of volcanoes?**
- Ages get progressively older to the north.... Locate Midway Island....
- What happened....Plate changed direction....!!!!
  
- How or Why did the Pacific Plate change direction?  
40 mya...India smashed into Asia....collision rate slowed down and other plates had to adjust speed and directions....
  
- Is Hawaii the only Hot Spot?
- No....
- Check out that one in the continental US....
- Yellowstone...

# PLATE TECTONICS NOTES

So...

- Spreading rates...how fast are the plates moving?
  - Students guess
  - Look at your fingernail....WATCH IT GROW....
    - About as fast as your fingernails grow....
  - The Atlantic is getting...wider...at ...2"/year....
  - The Pacific is getting wider at...???...hmmmm....its NOT getting wider...its getting smaller

Hmmm

- Why do earthquakes and volcanoes occur where they do?
- Are the plates moving? Yes...

## →So...is Plate Tectonics a Theory or a Fact?

Are the plates moving? Yes...we can measure that...we can watch that...

Do volcanoes and earthquakes and mountains occur mostly at plate edges? Yes...

So...why is Plate Tectonics a theory?

- We don't know what causes the plates to move....
- Example:
  - The Sun...theory or fact....  
the sun is a fact...  
what causes the sun to "burn" is a theory....
  - The Plates are a fact...  
what causes the plates to move is a theory...

## Mantle Convection

- Student textbook diagrams
- Mantle convection is a theory...not a fact

# PLATE TECTONICS NOTES

## WHAT CAUSES MTNS?

- ⇒ The Andes?
- ⇒ The Himalayas?
- ⇒ The MOR?
- ⇒ What causes mtns – in general?
  
- ⇒ The Urals????
  - How do you get mtns in the middle of a plate?
  - Hot Spot?...then the rocks should be volcanic....and should get older and older in one direction or the other....
  - That doesn't fit the geology of the Urals....
  - Hmm...smashed seashells....in the Urals....how?
  - Old plate edge...cont to cont...
  
- ⇒ The Appalachians....??
  - On a plate edge? No....
  - The Appalachians are in the middle of the NA plate....
  - How?
  - Does anyone remember what we said about the Appal. at the beginning of Plate Tectonics?
  - Appalachians match with the mtns in Great Britain, etc...
  - Hmm....so, what where were the Appalachians when Pangea was together?
  - In the middle of Pangea!
  - How do you create mountains in the middle of Pangea?
  - Formed just like the Urals....
  - From when continents collided....
  - When...
  - Pangea came together....
  - In other words, when the earth formed, did Pangea exist?
  - No!
  
- Brief history of plate motion
  - ...did Pangea exist when the earth formed?
  - ...Was Pangea the only supercontinent?