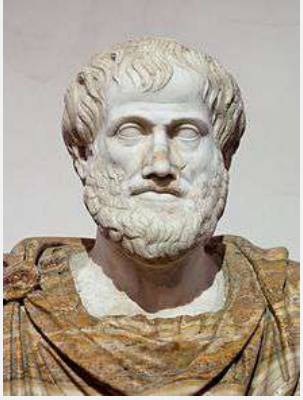


EARTH'S FORMATION AND EARLY HISTORY



HOW OLD IS THE EARTH?



HOW OLD IS OUR EARTH?

- Aristotle thought the Earth had existed eternally.
- Early Romans believed its formation was relatively recent due to no records before the Trojan War.
- 1640 – Ussher calculated Earth was created in 4004 BC based on Biblical chronologies, astronomical records, & historical chronologies.



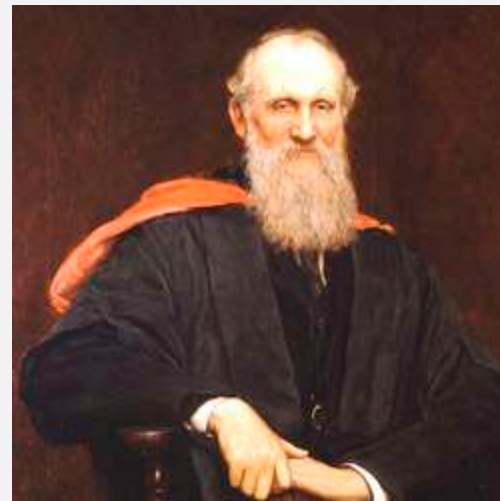
HOW OLD IS OUR EARTH?

- 1862 - Lord Kelvin – calculated how long Earth might have taken to cool from its original state. He concluded Earth was born 20-400 million years ago.



WHO WAS LORD KELVIN?

- Born William Thomson June 26, 1824 in Belfast
- Created 1st Physics laboratory in Britain
- Pioneer in Electromagnetism and Thermodynamics
- Theorized Absolute Zero (scale named after him)
- Knighted in 1866
- Given title of Baron Kelvin of Largs in 1892
- Died 1907



“The true measure of a man is what he would do if he knew he would never be caught”

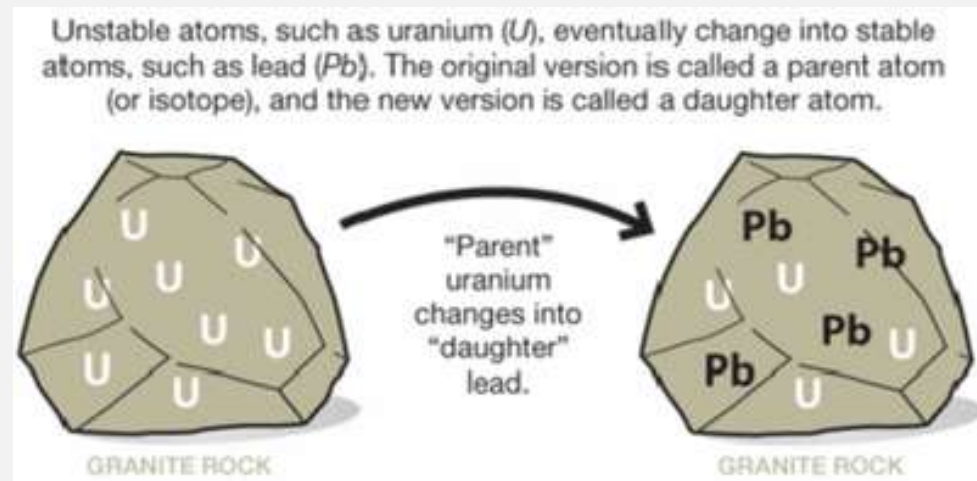
WARM UP

- What is Lord Kelvin known for?

HOW OLD IS OUR EARTH?

HS-ESS1-6

- 1940s-1950s – Radiometric dating methods came into prominence.



HOW OLD IS OUR EARTH

HS-ESS1-6

- Since 1950s- Many tens of thousands of radiometric age measurements have been done on various sorts of rock – both earthly and extraterrestrial – and averaged to determine an age of 4.5-4.6 billion years old.



HOW DO WE KNOW?? BOTTOM LINE...

HS-ESS1-6

Evidence: Radiometric Dating of:
lunar rocks, meteorites, oldest Earth rocks

RADIOMETRIC DATING REVIEW

HS-ESS1-6

- https://www.youtube.com/watch?v=Zo-_JkAkys8

OLDEST EARTH ROCKS DISCOVERED

HS-ESSI-6

- Tiny piece of zircon found in Western Australia.
- <http://www.smithsonianmag.com/smart-news/how-do-we-know-earth-46-billion-years-old-180951483/>

RADIOMETRIC DATING ACTIVITY

- You will be working with table partner and the partner either behind you or in front of you.
- Send one person up front for materials.

WARM UP

Discuss the results of the radiometric dating activity with your table partner and be ready to share.



EARLY HISTORY THAT “IMPACTED” THE FORMATION OF EARTH

HS-ESS1-6

EARTH'S FORMATION AND EARLY HISTORY (HS-ESS1-6)

Early in Earth's history it (along with the our moon and other terrestrial planets (mvm) experienced intense comet and asteroid bombardment.

LHB (Late Heavy Bombardment)

<https://www.youtube.com/watch?v=UIUFPNKLukk>

RALLY ROBIN-SHARE 2 THINGS YOU LEARNED FROM THE FILM

- Partner window side goes first



LATE HEAVY BOMBARDMENT (LHB)

HS-ESSI-6

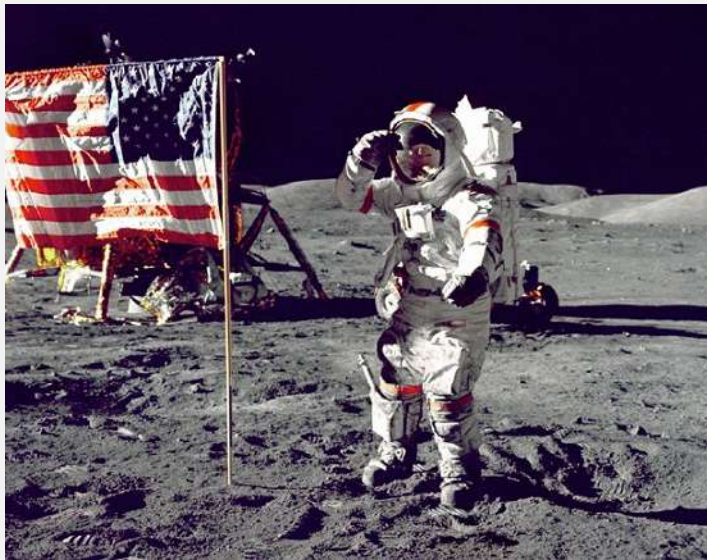
- 4.1 – 3.8 Billion years ago
- Also known as Lunar Cataclysm
- Some meteorites as big as 6 miles or more across for approx. 100 million years. (yikes!)
- No consensus on why the spike in impactors



WHAT EVIDENCE DO WE HAVE OF LHB

HS-ESSI-6

- Evidence derived from samples brought back by Apollo astronauts (1969-1972)
- Radiometric dating of moon rocks (researchers examined about 50 different melted rock samples)



WHAT EVIDENCE DO WE HAVE OF LHB

HS-ESS1-6

- Many of the samples displayed different chemical “fingerprints” – suggesting they were formed from different meteorites and lunar rocks.



TIMED-PAIR-SHARE
DISCUSS THE SIGNIFICANCE OF
HARVESTING THESE LUNAR ROCKS

- **1 person stand facing the back of the room and 1 person facing the front of the room**
- **Person facing the back goes first**
- **Talk for 15 sec then switch**

WHY GET EVIDENCE FROM THE MOON?

HS-ESS1-6

- All you have to do is look at the moon to see its been hit hard!!
- Craters are a record of past impact.
- Moon has no air to weather craters and little internal activity like volcanoes or Earthquakes.



Any impact that affected the moon probably affected Earth.

LHB: IMPLICATIONS FOR LIFE

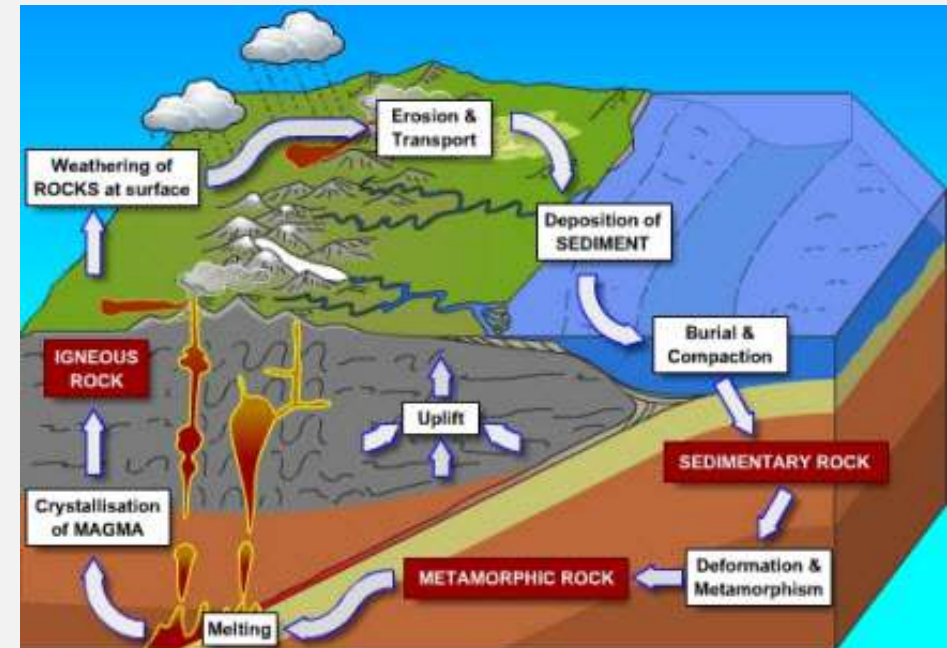
HS-ESS1-6

- Important implications for life on Earth
 - Coincides with when first primitive bacteria appeared on planet
 - Any life present before/during would have been in constant peril.
 - If life occurred before it may have taken refuge in cracks or crevices.
 - Another idea: meteorites may have carried life (or precursors = molecules) to Earth.

EARTH'S FORMATION AND EARLY HISTORY

(HS-ESS1-6)

- It has been very difficult to determine the age of Earth in part due to the constant changes in the crust.



WHY IS THERE SO LITTLE EVIDENCE OF LHB ON EARTH?

HS-ESS1-6

- Erosion, Volcanism and Plate Tectonics on Earth have destroyed much of the evidence of bombardment (explaining the relative scarcity compared with other solar system objects).
- (Our focus= Plate Tectonics)



PLATE TECTONICS – BOZEMAN

HS-ESS1-6

- <https://www.youtube.com/watch?v=JmC-vjQGSNM>

THINK-WRITE-PAIR-SHARE

- 2 min Free Write
- 20 sec to share out with each other

PLATE TECTONICS

HS-ESS1-6

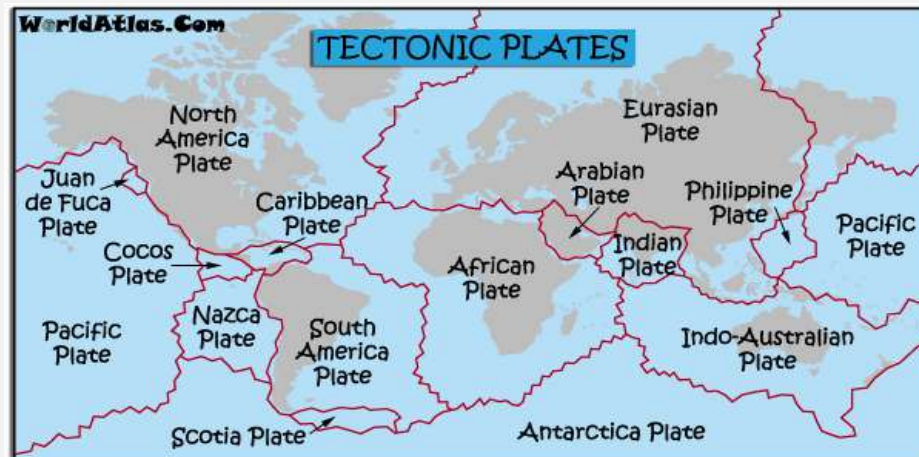
- 1905 – Alfred Wagner (German Scientist)
- Observed continents seemed like pieces of a puzzle
- Claimed continents were actually moving by some force of the ocean not motionless pieces of land.
- Claimed a super continent known as Pangaea once existed.
- This is known as “Continental Drift”

FACT OR FAKE?

- At the times Wegner's theory was not accepted by fellow scientists.
- They recognized Wegner's proof as being the effect of "polar wandering", not moving continents.
- Later in the 1940's and '50's, Wegner's enhanced technology lead to the theory of sea floor spreading and convection currents; all of which ended up leading to the tectonic plate theory.

PLATE TECTONIC THEORY

- According to the plate-tectonics theory, Earth's surface is broken into a number of shifting plates.
- Why does this happen?



CONVECTION!
(DRIVES OUR DYNAMIC PLANET)

- Convection is the process by which less dense material rises and more dense material sinks.
- In Earth's mantle hot rock rises and slightly cooler rock sinks.
- Mantle convectively flows at rates of several cm/year

WHERE DOES THE HEAT THAT DRIVES
THE MANTLE CONVECTION COME
FROM?

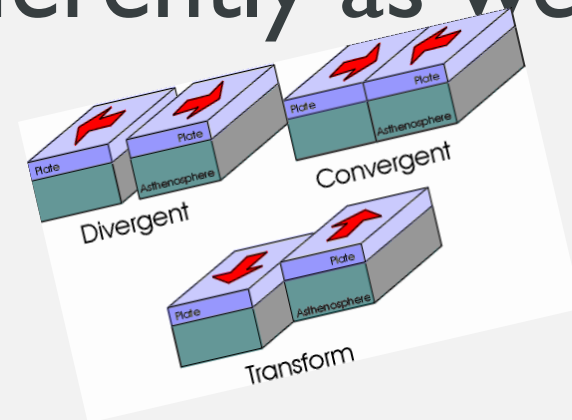
- Primordial heat left over from formation of Core
- Heat due to decay of radioactive isotopes
- Tidal friction from the Moon's pull on the Earth
- (mantle convection is how this heat escapes from the interior of the Earth)

CONVECTION = PLATE TECTONICS

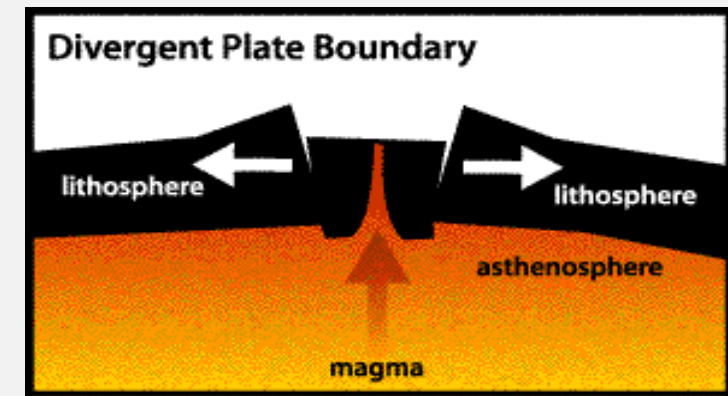
- Mantle's convection (upwelling) motion breaks crust into plates and moves them around the surface of the planet.

DIFFERENT BOUNDARIES, DIFFERENT ACTIONS

- There are three types of boundaries that occur at tectonic plate fault lines depending on what is happening with mantle convection.
- These boundaries include divergent, convergent, and transform.
- Each of these boundaries move differently as well as cause diverse events.

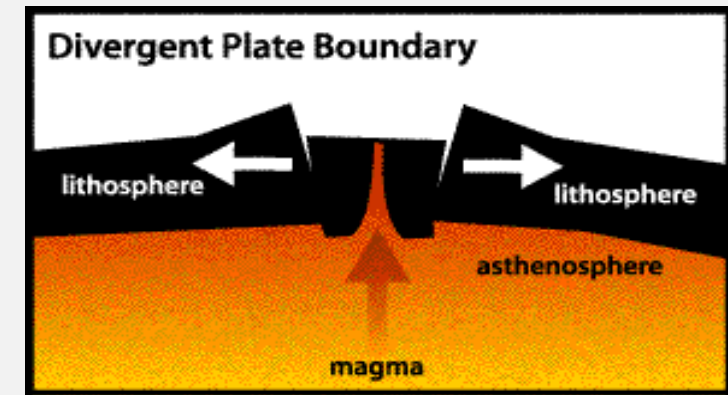


DIVERGENT BOUNDARY: MANTLE BENEATH IS UPWELLING



- Places where plates are coming apart are called divergent boundaries.
- When Earth's lithosphere is pulled apart, it usually breaks along parallel faults that tilt away from each other.

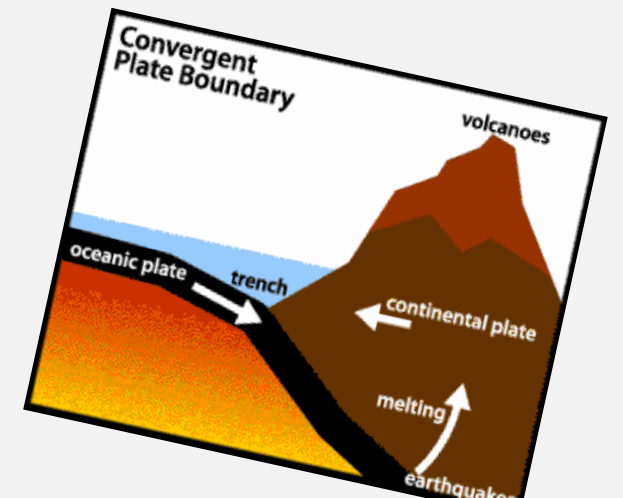
DIVERGENT BOUNDARY



- As the plates separate, the block between faults cracks and drops down into the asthenosphere. The sinking of the block forms a central valley called a rift.
- Magma seeps upward to fill the cracks. In this way, new crust is formed along the boundary.
- Earthquakes occur along the faults, and volcanoes form where the magma reaches the surface.

CONVERGENT BOUNDARY (MANTLE IS DOWNWELLING)

- Places where plates collide are called convergent boundaries.
- Collisions are very slow and last millions of years.
- There are three kinds of convergent boundaries: continental-oceanic, oceanic-oceanic, and continental-continental.



CONVERGENT BOUNDARY

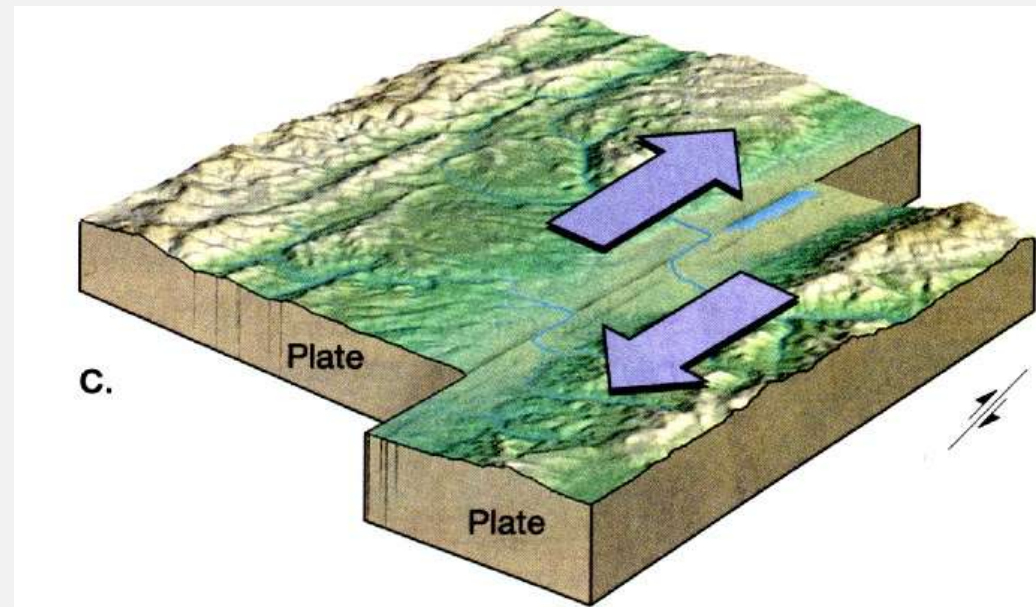
- Continental-oceanic boundaries are when a land plate and an ocean plate converge. These boundaries cause trenches and earthquakes to form.
- In continental-oceanic boundaries, the oceanic plate subducts under the continental plate, causing trenches to form.

CONVERGENT BOUNDARY (CONT'D)

- Continental-continental boundaries are when two land plates converge. These boundaries cause mountains to form.
- Oceanic-oceanic boundaries are when two oceanic plates converge. These boundaries cause trenches as well as undersea volcanoes.

TRANSFORM BOUNDARY

- Places where plates slide past each other are called transform boundaries.
- This causes earthquakes and valleys to form.



WARM UP

[HTTPS://YOUTU.BE/KWFNGATXUJI](https://youtu.be/kwfngatxuji)

What causes continents to “drift”?

PLATE TECTONICS ACTIVITY

- Door Side:
 - Place 2 “fresh” pieces of cardboard so that they are barely touching.
 - Light the candle and do NOT touch the lighter again unless the candle blows out.
 - Answer questions in packet.

PLATE TECTONICS ACTIVITY

- Window Side:
 - Add materials when simmering and **THEN** bring to a boil
 - Make observations after boiling is reached.
 - Complete packet.

SAFETY – PLATE TECTONICS

- Wear Goggles at all times.
- Place goggles away correctly when finished.

WARM UP

What evidence do we have for
Plate Tectonics?

PLATE TECTONICS: EVIDENCE

- Evidence for theory:
 - Fossil locations
 - Earth's convection currents
 - Land masses converging to form mountains
 - Aging of crustal rocks (this will be our focus!!)

HOW CAN THE THEORY OF PLATE TECTONICS BE PROVEN WITH THE AGING OF CRUSTAL ROCKS? HS-ESSI-5

- First, what are crustal rocks??



CRUSTAL ROCKS

HS-ESS1-5



- 2 types of crusts on Earth
 - Continental: large land masses known as the continents such as Asia, North America, etc...
 - Oceanic: Under the ocean, makes up 70% of our Earth's surface.

CRUSTAL ROCKS: CONTINENTAL

HS-ESS1-5

Continental Crust is made up of 3 different types of rocks:

Visual Example of the three types of crustal rocks found on the earth's continental crust:



[Igneous Rocks]



[Sedimentary Rocks]



[Metamorphic Crust]



Prezi

CRUSTAL ROCKS: OCEANIC CRUST

HS-ESS1-5

- Thinner but more dense than continental crust
- Consists of Mafic rocks, examples: basalt and gabbro
- Most of these rocks consist of mainly iron and magnesium (which is what makes them so dense!)

CRUSTAL ROCKS: OCEANIC CRUST

HS-ESS1-5

Oceanic Crustal Rocks Visual Examples:



[Basalt Rocks]

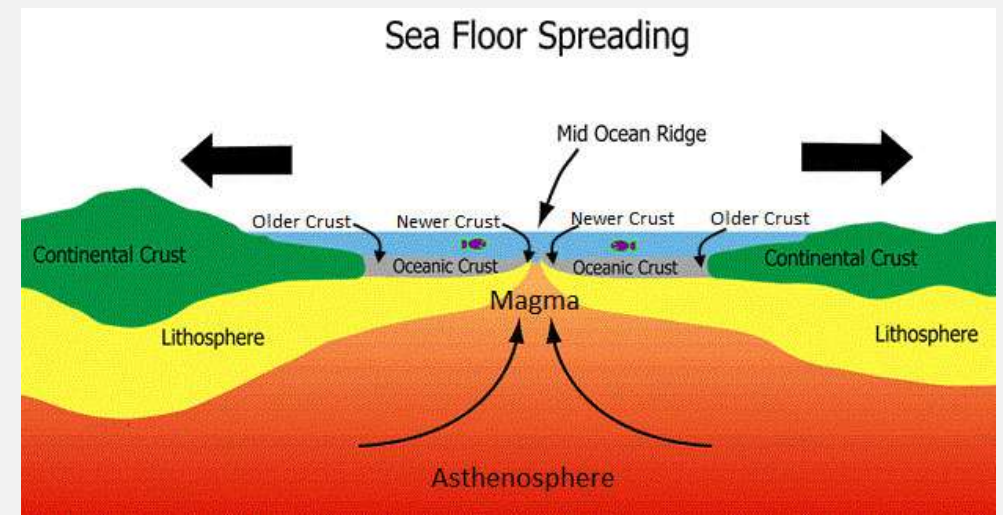
[Gabbro Rocks]



NOW THAT WE KNOW ABOUT CRUSTAL ROCKS, HOW
CAN AGING THEM PROVE PLATE TECTONICS?

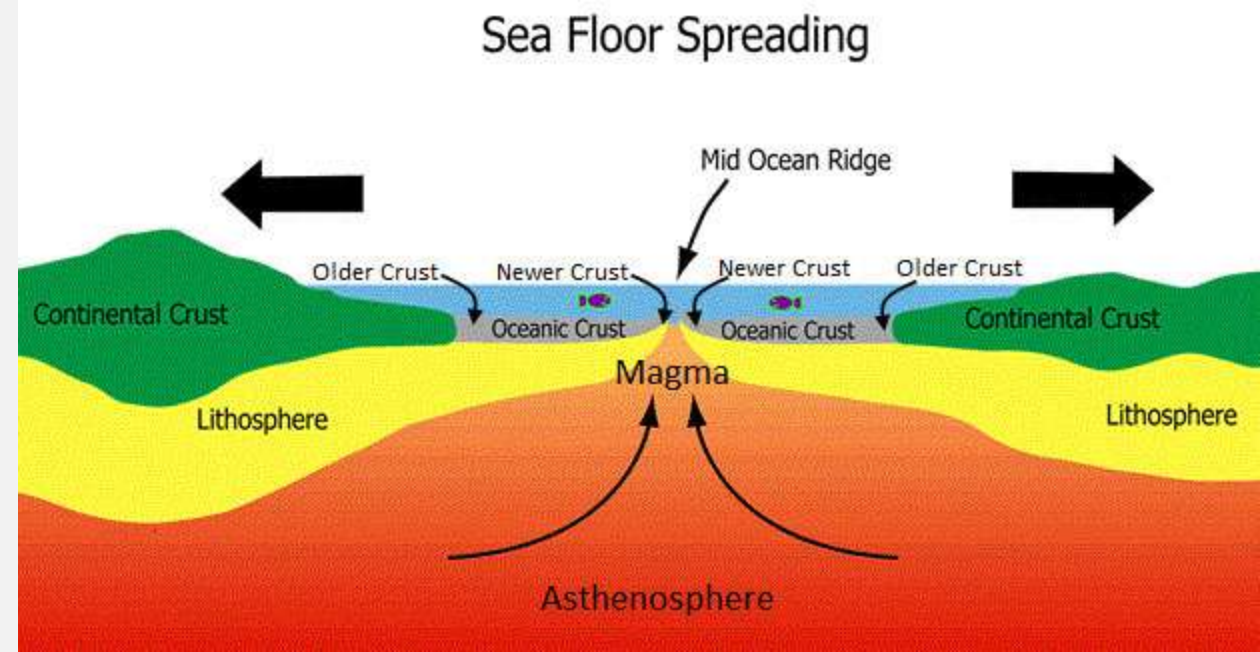
HS-ESS1-5

- Answer: a process called Sea Floor Spreading
- Causes divergent boundaries (plates that move apart from one another.)



HOW DOES SEAFLOOR SPREADING WORK?

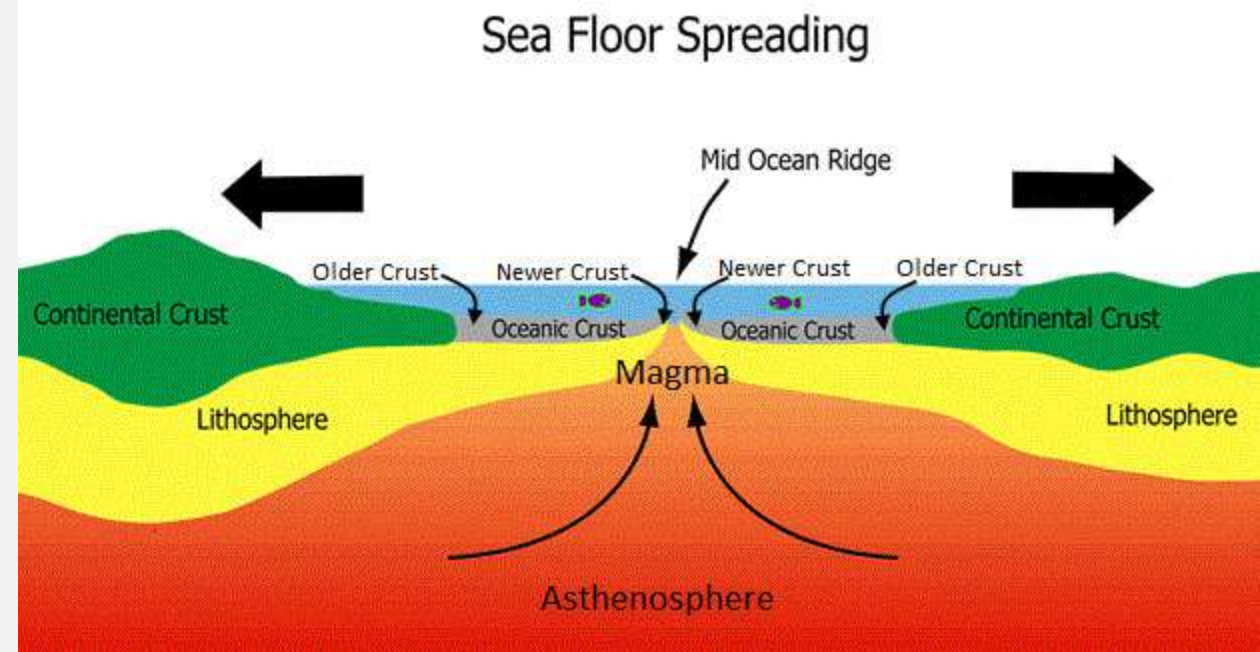
HS-ESS1-5



- Plates move apart from each other
- This repeatedly splits the ocean floor
- To make up for this loss of oceanic crust, molten from inside the Earth comes to the surface and cools with water to form new crust.

HOW DOES SEAFLOOR SPREADING WORK?

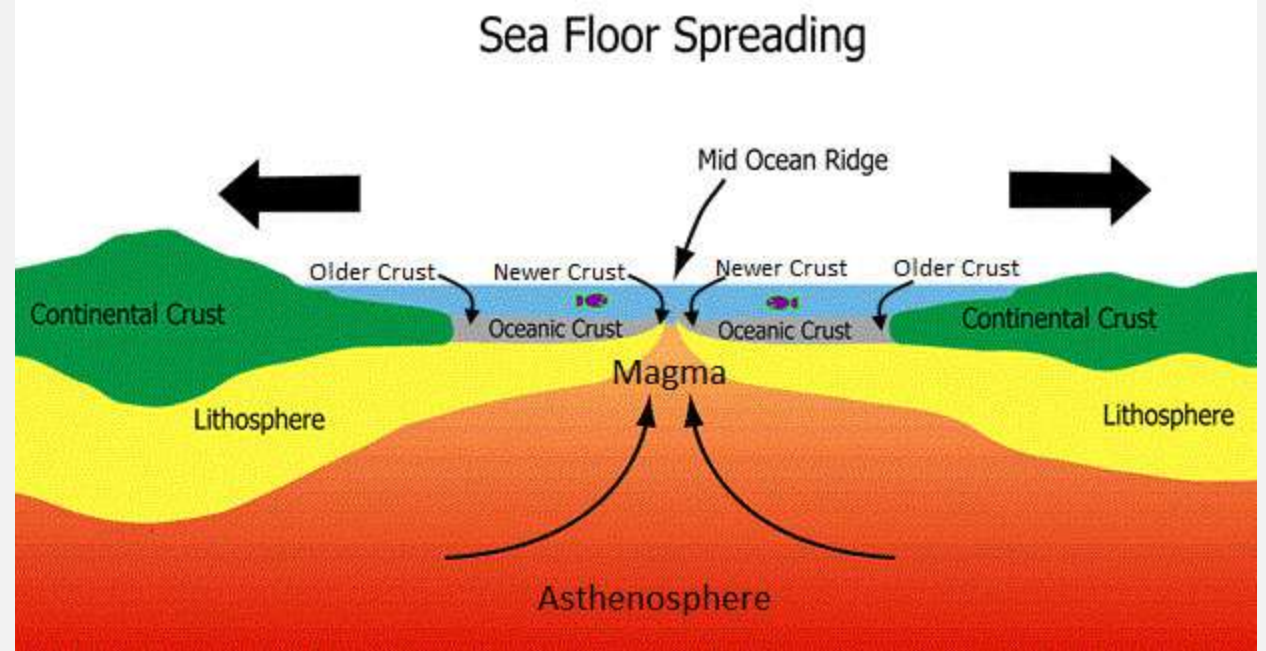
HS-ESS1-5



- As this happens, the older crust spreads apart and the oceanic crust is spread far enough till subduction happens.
- Subduction is when the oceanic crust goes under the continental crust. This causes continental crust to be pushed by the oceanic crust... contributing to Plate Tectonics

SO AGE OF CRUSTAL
ROCKS IS EVIDENCE OF
PLATE TECTONICS...

HS-ESS1-5



Drilling into the sea floor shows the following about the ages of rocks:

Older Crust is further away from the ridge

Young Crust is at the ridge

This shows seafloor spreading in an area, concludes that tectonic plates are diverging or coming apart in that area