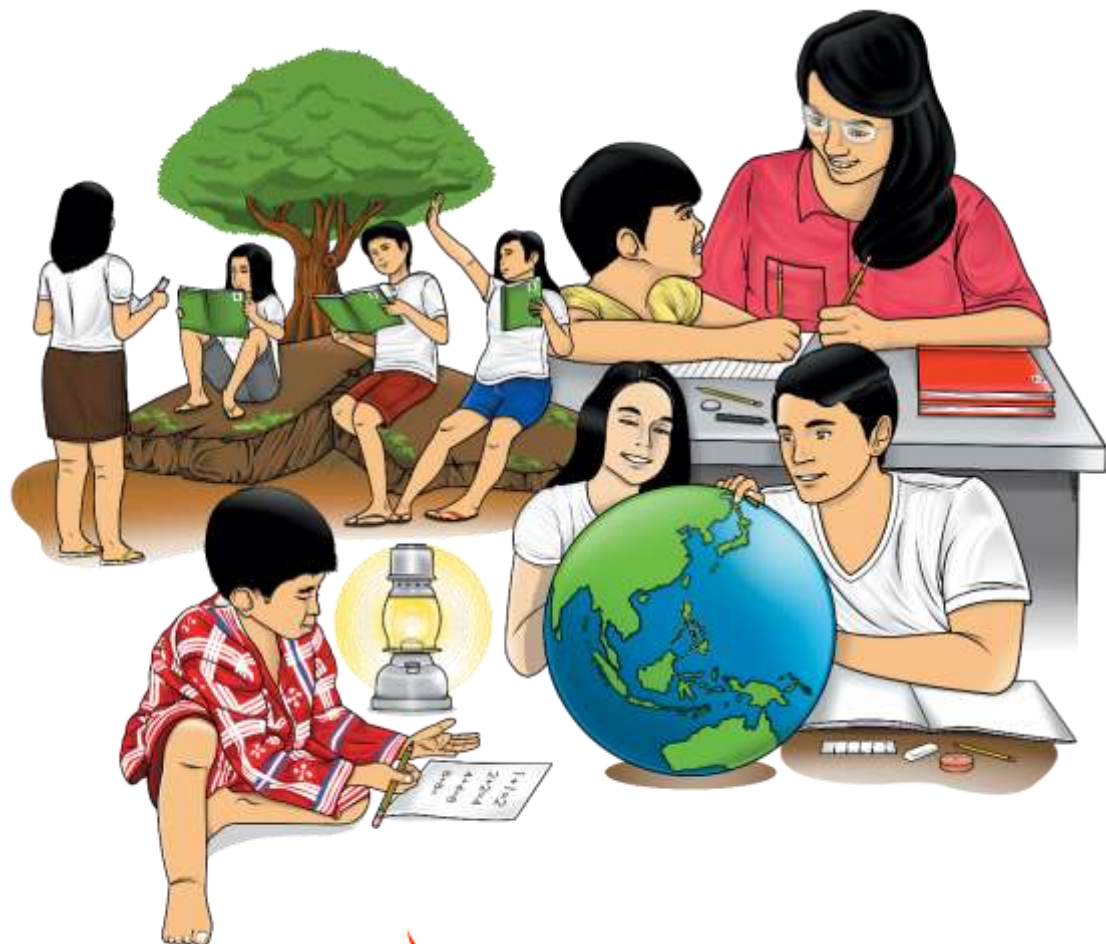


# Science

## Quarter 1 – Module 5: Evidences of Plate Movements



**Science – Grade 10**  
**Alternative Delivery Mode**  
**Quarter 1 – Module 5: Evidences of Plate Movements**  
**First Edition, 2020**

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# 10

## **Science**

### **Quarter 1 – Module 5: Evidences of Plate Movements**

# Introductory Message

For the facilitator:

Welcome to the **Science 10 Alternative Delivery Mode (ADM) Module 5 on Evidences of Plate Movements!**

This module was collaboratively designed, developed, and reviewed by educators both from public and private institutions to assist you, the teacher or facilitator in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners in guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21<sup>st</sup>-century skills while taking into consideration their needs and circumstances.

As a facilitator, you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their own learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to the **Science 10 Alternative Delivery Mode (ADM) Module 5 on Evidence of Plate Movements!**

The hand is one of the most symbolized parts of the human body. It is often used to depict skill, action, and purpose. Through our hands, we may learn, create, and accomplish. Hence, the hand in this learning resource signifies that you, as a learner, is capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be enabled to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:



***What I Need to Know***

This will give you an idea of the skills or competencies you are expected to learn in the module.



***What I Know***

This part includes an activity that aims to check what you already know about the lesson to take. If you get all the answers correct (100%), you may decide to skip this module.



***What's In***

This is a brief drill or review to help you link the current lesson with the previous one.



### ***What's New***

In this portion, the new lesson will be introduced to you in various ways, such as a story, a song, a poem, a problem opener, an activity, or a situation.



### ***What is It***

This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.



### ***What's More***

This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.



### ***What I Have Learned***

This includes questions or blank sentences/paragraphs to be filled in to process what you learned from the lesson.



### ***What I Can Do***

This section provides an activity that will help you transfer your new knowledge or skill into real-life situations or concerns.



### ***Assessment***

This is a task which aims to evaluate your level of mastery in achieving the learning competency.



### ***Additional Activities***

In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned. This also tends to the retention of learned concepts.



### ***Answer Key***

This contains answers to all activities in the module.

At the end of this module, you will also find:

### ***References***

This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next.

6. Return this module to your teacher/facilitator once you are through with it.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain an in-depth understanding of the relevant competencies. You can do it!



## ***What I Need to Know***

You have learned from your previous lessons that lithospheric plates or the solid part of the Earth are gradually moving to form different geologic events such as earthquakes, mountain buildings, and volcanoes. But what causes these plates to move? What is the evidence that the Earth's Plates are moving? These questions ignited our scientists' curiosity to look for answers and lead to the development of the following ideas: Continental Drift Theory, Seafloor Spreading, and Earth's Magnetic Reversal.

After going through this module, you are expected to enumerate the lines of evidence that support the plate movement (*S9ES -Ia-j-36.6*).

Specifically, you will learn to:

- ✓ investigate the pieces of evidence of the Continental Drift Theory;
- ✓ demonstrate the evolution of the oceanic crust through Sea Floor Spreading; and
- ✓ realize the importance of the seafloor spreading process relative to the Continental Drift Theory.



## ***What I Know***

Before you start in this module, kindly assess your understanding of the lesson by answering the Pretest.

**Directions:** Choose the best letter answer in each item. Write your answer in your answer sheet.

1. What evidences do scientists use to support the Continental Drift Theory?  
A. rocks, fossils, air  
B. rocks, water, ice  
C. rocks, fossils, climate  
D. rocks, fossils, human beings
2. The youngest crust is found \_\_\_\_\_ the mid-ocean ridge.  
A. far  
B. near  
C. beside  
D. away
3. If you are a cartographer, what would give you an idea that the continents were once joined?  
A. ocean depth  
B. shape of the continents  
C. position of the South Pole  
D. size of the Atlantic Ocean

4. What discovery provided strong support for Continental Drift Theory?
- |                    |                     |
|--------------------|---------------------|
| A. Geology         | C. Electromagnetism |
| B. Fossil evidence | D. Paleomagnetism   |
5. Which is **not** evidence of seafloor spreading?
- |                                     |                     |
|-------------------------------------|---------------------|
| A. molten magma constantly erupting | C. fossil evidence  |
| B. drilling samples of rock         | D. magnetic stripes |
6. The magnets point north when Earth's magnetic field has \_\_\_\_\_.
- |                      |                    |
|----------------------|--------------------|
| A. magnetic reversal | C. mid-ocean ridge |
| B. reversed polarity | D. normal polarity |
7. Why was Alfred Wegener's Continental Drift Theory not accepted immediately by the people during his time?
- He cannot explain what causes the continents to drift.
  - He explains that South America and Africa fit together like a puzzle.
  - He described that the rocks and mountains at the edges of the continents were similar.
  - He explains that fossils of ancient plants such as "Glossopteris" can be found in almost all continents.
8. Why were magnetic patterns found on the ocean floor puzzling?
- They did not show alternating bands of normal and reversed polarity.
  - They showed alternating bands of normal and reversed polarity.
  - No rocks were magnetic.
  - All rocks were magnetic.
9. What do you call the process that forms and moves new oceanic crust?
- |                       |               |
|-----------------------|---------------|
| A. magnetic reversal  | C. convection |
| B. seafloor spreading | D. trenching  |
10. What do you call the supercontinent landmass formed million years ago?
- |                |            |
|----------------|------------|
| A. Pangaea     | C. Asia    |
| B. Panthalassa | D. Eurasia |
11. If Australia is moving about 2cm/ year and was drifted from the ridge by 1000km, how long ago was it when Australia was near the ridge?
- |                     |                        |
|---------------------|------------------------|
| A. 50 million years | C. 500 million years   |
| B. 10 million years | D. cannot be predicted |
12. Which one among the continental drift pieces of evidence mainly proves that the Cape Mountains of South America and Africa line up perfectly before?
- There's an equal amount of coal deposits in each continent and fossils.
  - The evidence from the rock layers in different continents exactly matched.
  - The remains of the ancient plant called Glossopteris can be found on both continents.
  - The climate of the two continents is almost the same and with the same ancient organisms.



13. What information can be derived about Antarctica having fossils of ancient plants and animals?
- A. Antarctica drifted to the Southern hemisphere because of the melting of glaciers that traps the plants and animals.
  - B. Antarctica has a very nice climate that caused these organisms to migrate and stay.
  - C. It has a tropical climate today that provides a good environment for complex life forms.
  - D. Antarctica had once located near the equator.
14. He is a German Scientist who hypothesized in 1912 that continents were once a giant landmass called Pangaea.
- A. Harry Hammond Hess
  - B. Robert Dietz
  - C. Alfred Lothar Wegener
  - D. Charles Darwin
15. What did Harry Hammond Hess realize in the 1950s when his team continued exploring the ocean floor and discovered the Mid-Atlantic Ridge?
- A. He realized that the oceanic crust is older than the continental crust.
  - B. He realized that Alfred Wegener's Continental Drift Theory is not true.
  - C. He realized that the oceanic crusts near the Mid-Atlantic Ridge are thicker and less dense.
  - D. He realized that the Earth's crust had been moving away on each side of oceanic ridges, down the Atlantic and Pacific Oceans.

How was your performance in the pretest? If you got a perfect score, you may skip this lesson or still continue to further enrich your understanding about of the evidence and theories that support the Earth's plate movements.

## Lesson

# 1

## Evidence of Plate Movements: Continental Drift Theory



### *What's In*

You have learned so far that Earth has distinct mechanical and compositional layers. This knowledge about the Earth's internal structure came from the indirect observation of our scientists through seismic activities. Scientists learned that as continental and oceanic crusts move, they can form geologic events such as earthquakes, volcanoes, and mountain ranges.



### *What's New*

### **Continental Drift Theory**

Have you seen a world map before? Definitely, yes, you have seen one! Did you notice that the eastern border of South America and the Western part of Africa seem to fit together like a big jigsaw puzzle?



*Figure: Public Domain Clip Art Image: Blue World Map*

If you said yes, then you are thinking like **Alfred Lothar Wegener** (1880-1930), who was a German polar researcher, geophysicist, and meteorologist.

He is remembered as the originator of the **Continental Drift Theory** by hypothesizing in 1912 that the continents are slowly drifting around the Earth and is once a large landmass called **Pangaea**, a Greek word which means "**All Earth.**"



Alfred Lothar Wegener

The figure below shows the evolution of the supercontinent Pangaea to the present-day distribution of continents. Can you say that continents are drifting?

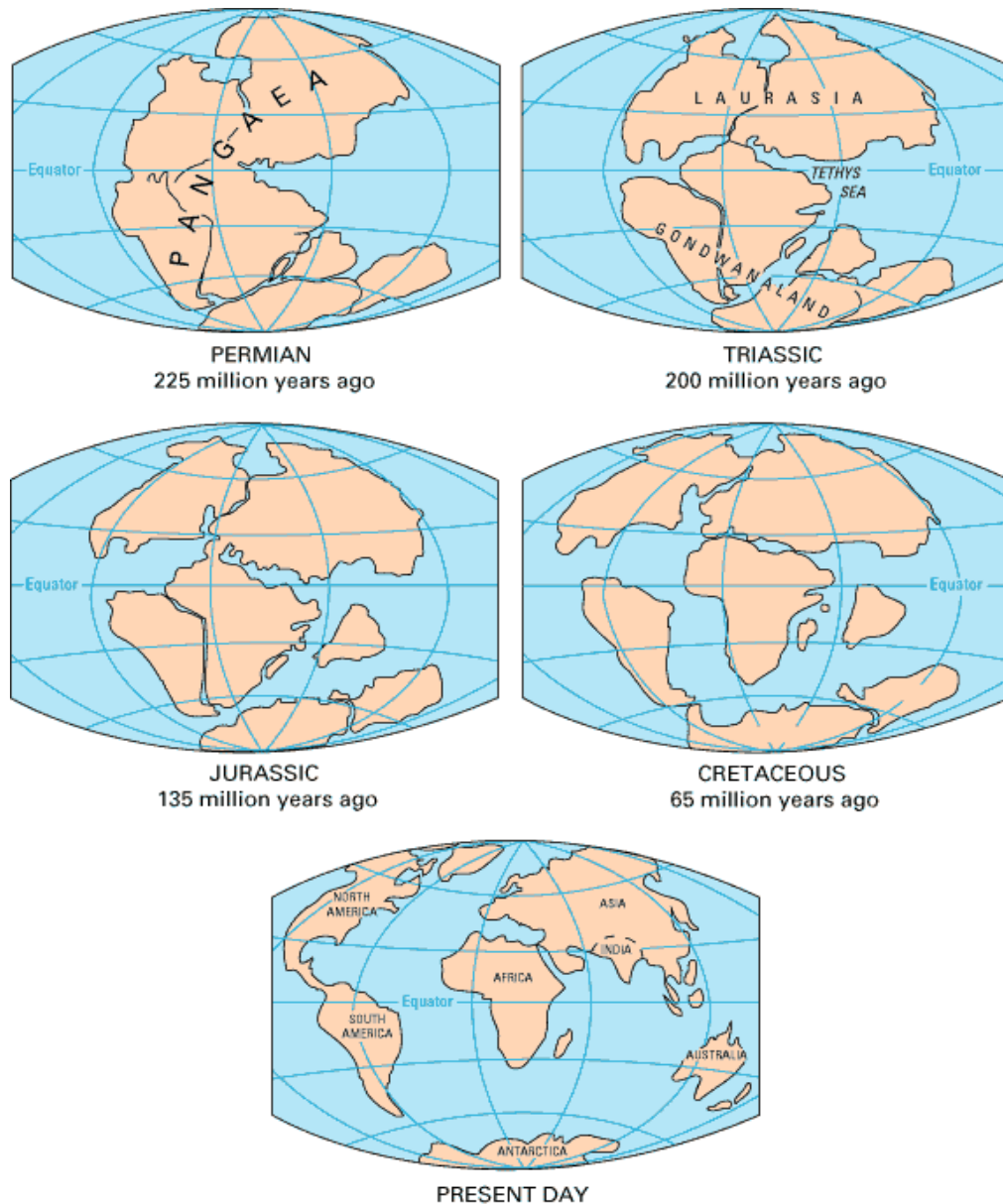


Figure 1. The Evolution of Pangaea from [pubs.usgs.gov](http://pubs.usgs.gov)

Wegener's curiosity about the idea of drifting continents started when he noticed the edges of South America and Africa in a World Map could be fitted like a jigsaw puzzle.

Would fitting edges of continents be enough proof that the continents are drifting? What are the other pieces of evidence gathered by Wegener to support his Continental Drift Theory?

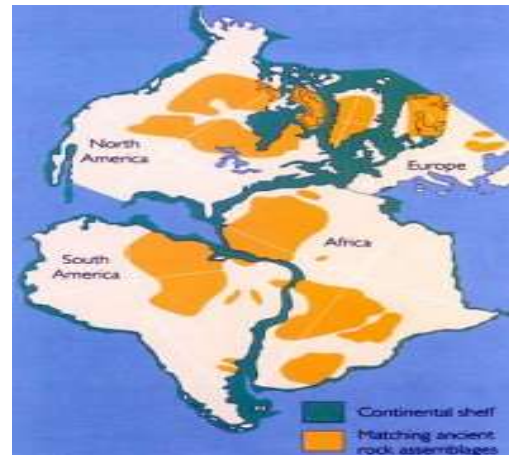


## ***What is It***

### **Evidence**

Alfred Wegener collected diverse pieces of evidence to support his theory, including **geological "fit"** and **fossil evidence**. It is important to know that the following specific fossil evidence was not brought up by Wegener to support his theory.

Wegener did not collect the fossils, but he called attention to the idea of using these scientific documents stating there were fossils of species present in separate continents in order to support his claim.

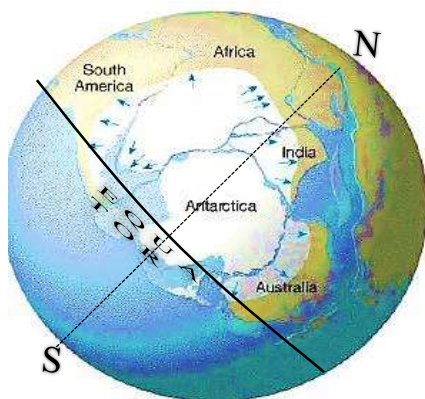


*Illustration showing similar rock assemblages across different continents.*

**Geological "fit" evidence** is the matching of large-scale geological features on different continents. It has been noted that the coastlines of South America and West Africa seem to match up, however more particularly, the **rock terrains** of separate continents confirm as well.

Examples include the Appalachian Mountains of eastern North America linked with the Scottish Highlands, the familiar rock strata of the Karroo system of South Africa matched correctly with the Santa Catarina system in Brazil, and Brazil and Ghana mountain ranges agreeing over the Atlantic Ocean.

**Glaciers** carve rocks and leave marks as they move. In this evidence, scientists can determine the direction of movement of each continent.



In addition, the existence of **coal deposits** in Antarctica suggested that it was once located near the region of the Earth where the climate is enough to support complex life forms such as plants and tall trees.

See the figure on the right, notice the direction of the movement of the continents indicated by the arrows during Pangaea time.

Look at the map below. It shows how Alfred Wegener mapped-out the distributions of the four Permian and Triassic fossil groups and used it as biogeographic evidence for continental drift and land bridging.

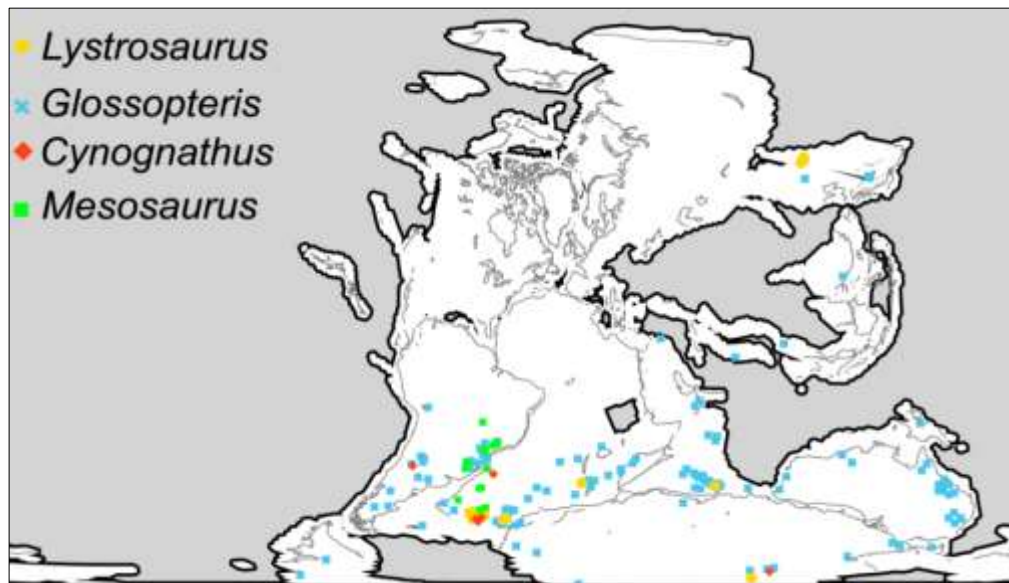


Figure 2: Wegener fossils-mapped.png  
Illustration showing similar rock continents.

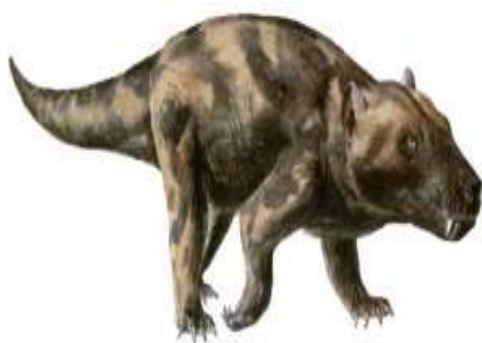
**assemblages across different**

The **Mesosaurus** is known to have been a type of reptile, similar to the modern crocodile, which propelled itself through the water with its long hind legs and limber tail. It lived during the early Permian period (286 to 258 million years ago), and its remains are found solely in South Africa and Eastern South America.

Now, if the continents were still in their present positions, there is no possibility that the Mesosaurus would have the capability to swim across such a large body of ocean like the Atlantic because it was a coastal animal.



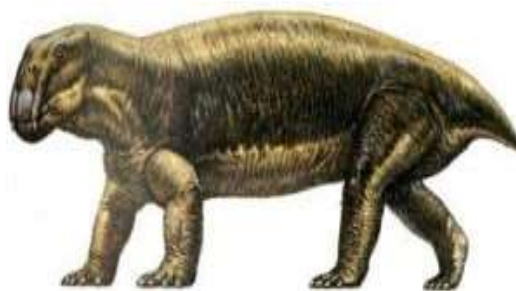
*Modern-day representation of the Mesosaurus.*



*Modern-day representation of the Cynognathus.*

The now extinct **Cynognathus** was a mammal-like reptile. Roaming the terrains during the Triassic period (250 to 240 million years ago), the Cynognathus was as large as a modern wolf. Its fossils are found only in South Africa and South America. As a dominant land species, the Cynognathus would not have been capable of migrating across the Atlantic.

The **Lystrosaurus**, which translates to "shovel reptile," is thought to have been a herbivore with a stout built like a pig. Lystrosaurus fossils are only found in Antarctica, India, and South Africa. Similar to the land-dwelling Cynognathus, the Lystrosaurus would not have had the swimming capability to traverse any ocean.



Modern-day representation of the Lystrosaurus.

Possibly the most important fossil evidence found in the plant, **Glossopteris**. The Glossopteris fossil is found in Australia, Antarctica, India, South Africa, and South America—all the southern continents.

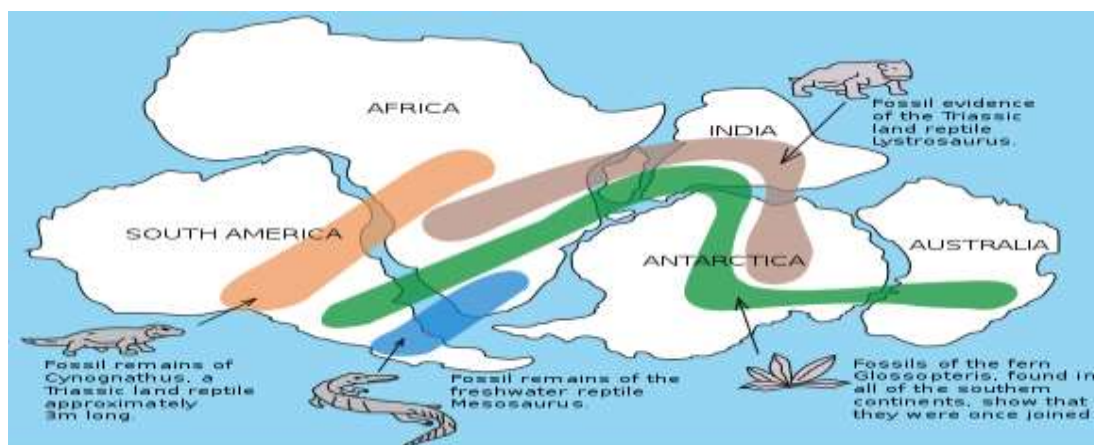


Modern-day representation of the Glossopteris.

Glossopteris seed is known to be large and bulky and possibly could not have drifted or flown across the oceans to a separate continent. Therefore, the continents must have been joined at least one point in time in order to maintain the Glossopteris' wide range across the southern continents.



260 million years old fossilized leaves of glossopteris



Description showing the fossil locations of the Mesosaurus, Cynognathus, Lystrosaurus, and Glossopteris spread across different continents.



## ***What's More***

To further understand the idea of Alfred Wegener, perform the activity below to learn about the other evidence of Continental Drift Theory.

### **Activity 1: A Journey From The Past To the Future!**

**Let's find out:** What is the evidence of the Continental Drift Theory?

**Let's use these materials:** photocopy of the seven continents, blank globe map, pair of scissors, and world map.

**Let's do it this way:**

1. Use a separate clean paper to write your answers and observation in this activity.
2. Look carefully at the continents on a globe or a world map.
3. Cut out carefully the picture of the landmasses. These cutout-landmasses represent the continents and some of the large islands of the Earth a hundred million years ago.

*(Note: Before forming "Pangaea," try to place each landmass cut out on top of the present-day World Map to familiarize yourself about the name of each continent and imagine how it drifted to its present location.)*

4. In the drawn circle in a separate sheet, construct the supercontinent using the legends as your basis.

*(Note: Consider the possible location and position of each continent based on the legends before pasting it in the blank globe map.)*

5. Answer the following questions:

Q1. Do the Glossopteris fossils tell us all landmasses were once joined together?

Q2. If Glossopteris fossils were found in Antarctica, what was the climate of this continent before?

Q3. If the climate and the position of a place were relative to each other, where then was the initial location of Antarctica 250 million years ago?

Q4. Is the presence of animal fossils tells that South America, Africa, and Antarctica were once connected?

6. Examine the giant landmass "Pangaea" and answer the questions below:

Q5. What clues are useful in reconstructing Pangaea?

Q6. Which continents were obviously neighbors before?

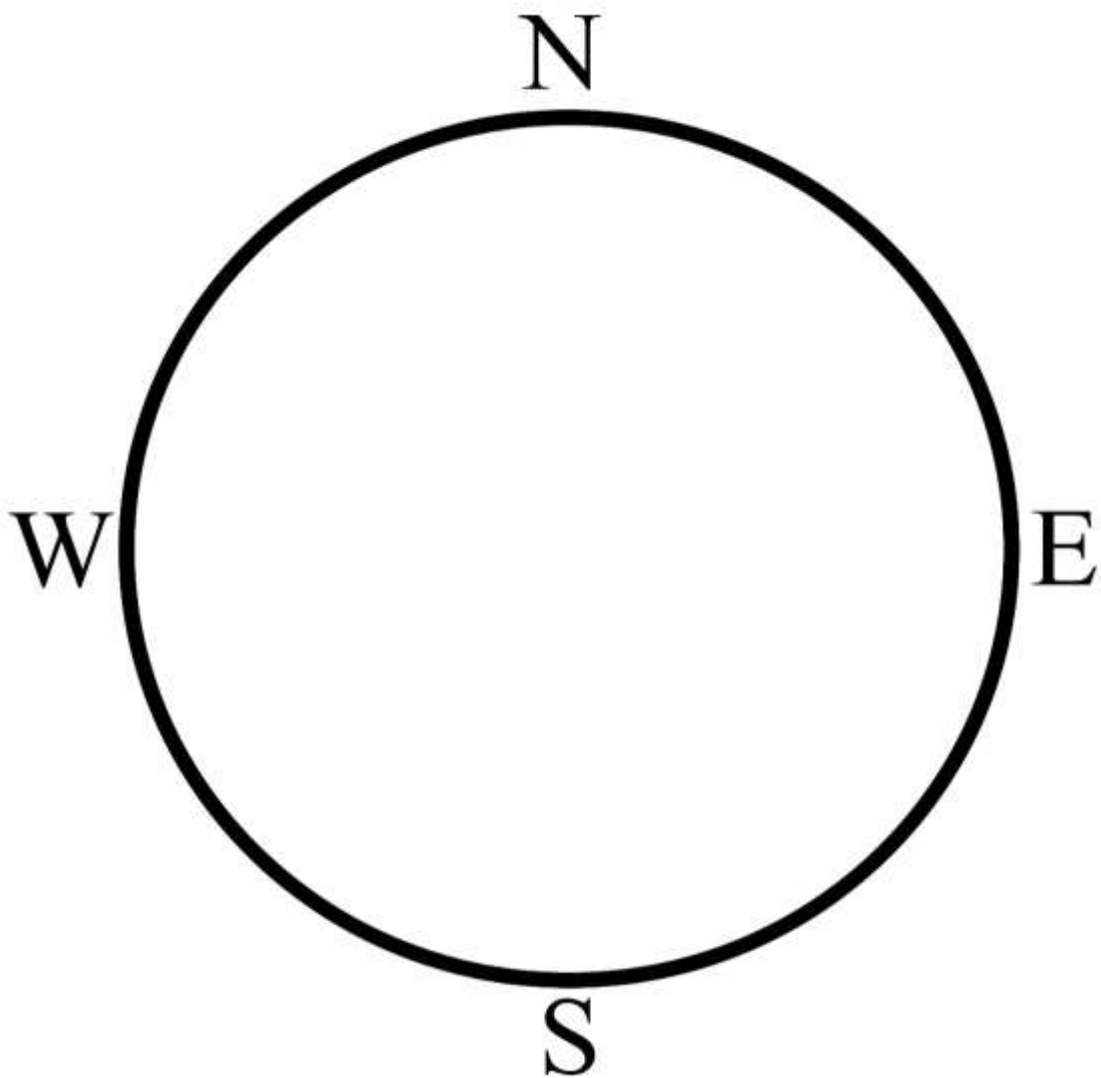
Q7. Where do you think was the location of the Philippines in Pangaea during the time when it existed? *(Note: Recall the lesson on Convergent Plate Boundaries: Oceanic vs. Oceanic Crust)*

7. Now move one continent relative to its current location. Observe the direction of its motion carefully as it assumes its current location and position. Do the same procedure to the other continents.

Q8. If the continents will continue to move, try to predict the Philippines' location 25 million years from now.

Adapted from <https://studylib.net/doc/7058676/continental-drift-lab---cms15-16>

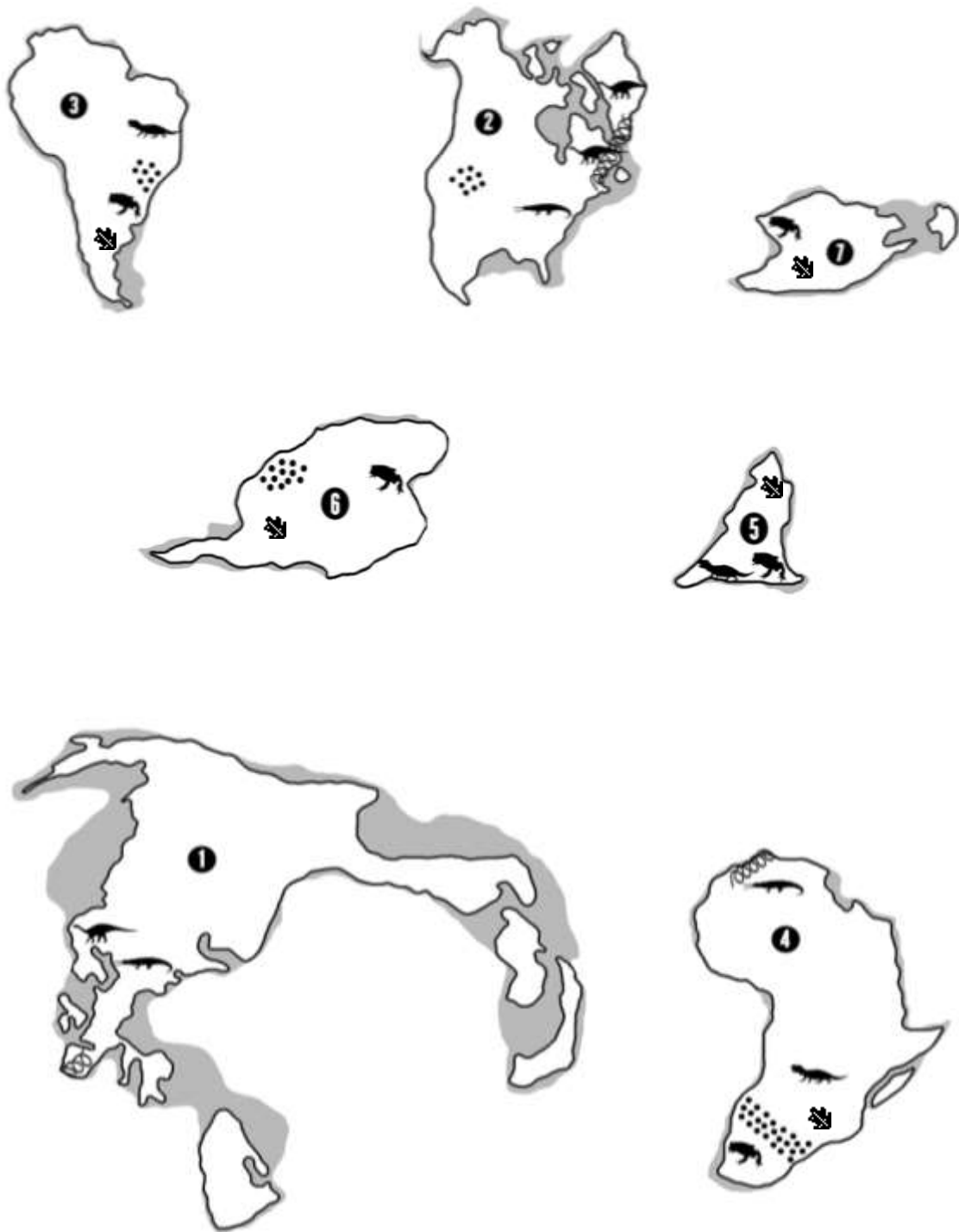
① Europe and Asia	⑤ India	 landmasses ABOVE sea level	 Amphibian
② North America	⑥ Antarctica	 Glossopteris	 Plateosaurus
③ South America	⑦ Australia	 basalt	 Phytosaur
④ Africa	 landmasses BELOW sea level	 desert	 Rhynchosaur





*\*Note: This activity sheet must be photocopied*

*Landmasses/ Continents*



*\*Note: This activity sheet must be photocopied and cut-out the printed picture of the continents.*



## ***What I Have Learned***

You have learned that Alfred Lothar Wegener's curiosity drives him to look for evidence that supports his Continental Drift Theory that continents were once connected as a big landmass called "Pangaea."

The Continental Drift Theory is being supported by the following evidence: continental fit, matching of rocks, fossils of ancient organisms, coal deposits in Antarctica, ancient climates, and glaciers carvings.

Despite Wegener's gathered evidence supporting his idea about drifting continents during his time, the scientific community rejected him for some problems: Wegener was not a geophysicist, he estimated the speed of continental motion, 250 cm/year, was unbelievably high, and he cannot explain what causes the continents to move.

Nevertheless, Alfred Wegener didn't give up and continued his expedition to search for more evidence but later on died. It took many years before his Theory of Continental Drift was accepted. What causes the continents to move to? What can other missing indications be used to support such a claim? Let's find out in the next theory!

*Let us see if you have understood the essence of the first enrichment activity. Please answer the assessment below.*



## ***Assessment 1***

**Directions:** Use a separate sheet for your answers. Write only the letter of the correct answer.

1. He was credited for the idea of Continental Drift Theory?  
A. Alfred Lothar Wegener  
B. Charles Darwin  
C. Harry Hammond Hess  
D. Robert Dietz
2. All continents were once joined together forming a supercontinent called\_\_\_\_\_.  
A. Panthalassa  
B. Laurasia  
C. Gondwanaland  
D. Pangaea
3. It is possibly the most important fossil plant evidence that continents are drifting.  
A. Glossopteris  
B. Lystrosaurus  
C. Mesosaurus  
D. Cynognathus
4. What are the evidence gathered by Alfred Wegener to support his Continental Drift Theory?  
A. continental fit, rocks, fossils, coal deposits, ancient climate, and glaciers scars  
B. the ancient climate of Antarctica and Africa  
C. remains of dead plants and animals  
D. observing the map
5. What two specific continents fit together most noticeably?  
A. Africa and North America  
B. South America and Africa  
C. South America and Europe  
D. Antarctica and Africa

## Lesson 2

# Evidence of Plate Movements: Seafloor Spreading Theory



### *What's In*

You learned from Lesson 1 about the Continental Drift Theory that all continents were once connected into a big landmass called Pangaea, and this was supported by the pieces of evidence gathered by Alfred Lothar Wegener; however, questions such as what causes the continents to move was not logically answered by the theory.

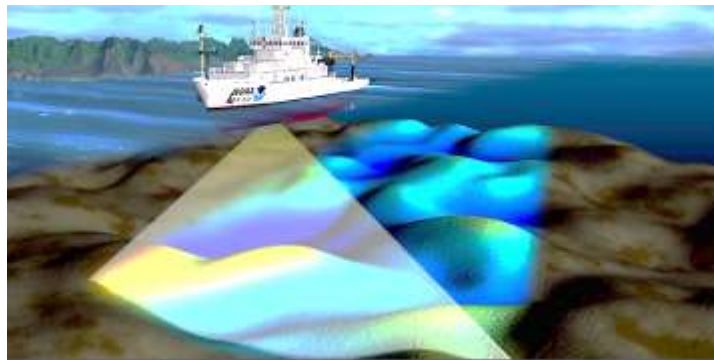
In this lesson, you will learn about the Seafloor Spreading Theory that will strongly support the idea that continents are drifting and find out the site of origin of plate movements.



### *What's New*

#### **Seafloor Spreading and Magnetic Reversal**

The idea of continental drift circulated in scientific circles until World War II, when sounding gear called **SONAR** produced new evidence of what the seafloor looked like. The gear, developed in the 1930s, bounced sound waves off the seafloor to determine its depth and features.



*SONAR beam to navigate and map out the seafloor*

It happened that the command of one attack transport ship, the USS Cape Johnson, was given to **Harry Hammond Hess**, a geologist from Princeton University.

Hess, then in his late thirties, wanted to continue his scientific investigations even while at war. So he left his ship's sounding gear all of the time, not just when approaching port or navigating a difficult landing. What Hess discovered was a big surprise.



*Harry Hess, courtesy of Princeton University Archives*

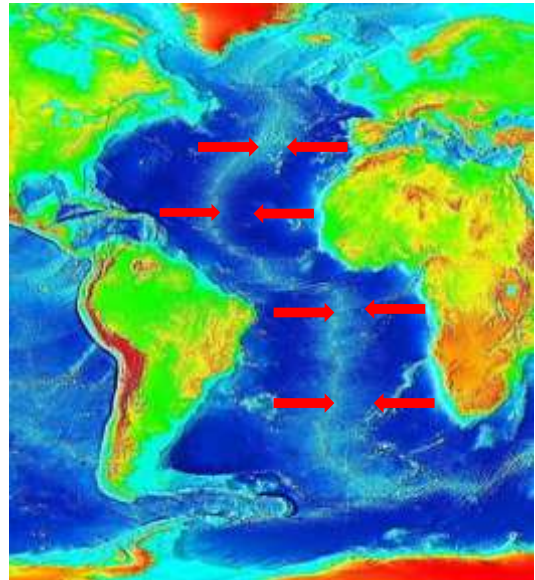
What did Harry Hess and his men accidentally discover when they explored the oceanic floor? Were they able to locate the start of all the movements on the Earth's surface? Moreover, did the Harry Hess team gather much strong evidence to support the claim that continents are drifting?



## ***What is It***

Ocean floor exploration continued, and by the 1950s, other researchers had found that a huge rift ran along the top of the Mid-Atlantic Ridge. That enabled Hess to understand his ocean floor profiles in the Pacific. He discovered that the bottom of the sea was not as smooth as expected, but full of canyons, trenches, and volcanic sea mountains. He realized that the Earth's crust had been moving away on each side of oceanic ridges, down the Atlantic and Pacific oceans, long and volcanically active.

Harry Hess observed that the rate of formation of new seafloor at the mid-ocean ridge is not always as fast as the destruction of the old seafloor at the **subduction zone**. This explains why the Pacific Ocean is getting smaller and why the Atlantic Ocean is getting wider. If the subduction zone is faster than the seafloor spreading, the ocean shrinks. He published his theory in *History of Ocean Basins* (1962), and it came to be called "**seafloor spreading**."



*Red arrows pointing the Mid-Atlantic Ridge*

In the early 1960s, dating of ocean-core samples showed that the **ocean floor was younger at the Mid-Atlantic Ridge but progressively older in either direction**, confirming the reality of seafloor spreading.



## What's More

Perform the next activity to understand further what Harry Hess and his men discover.

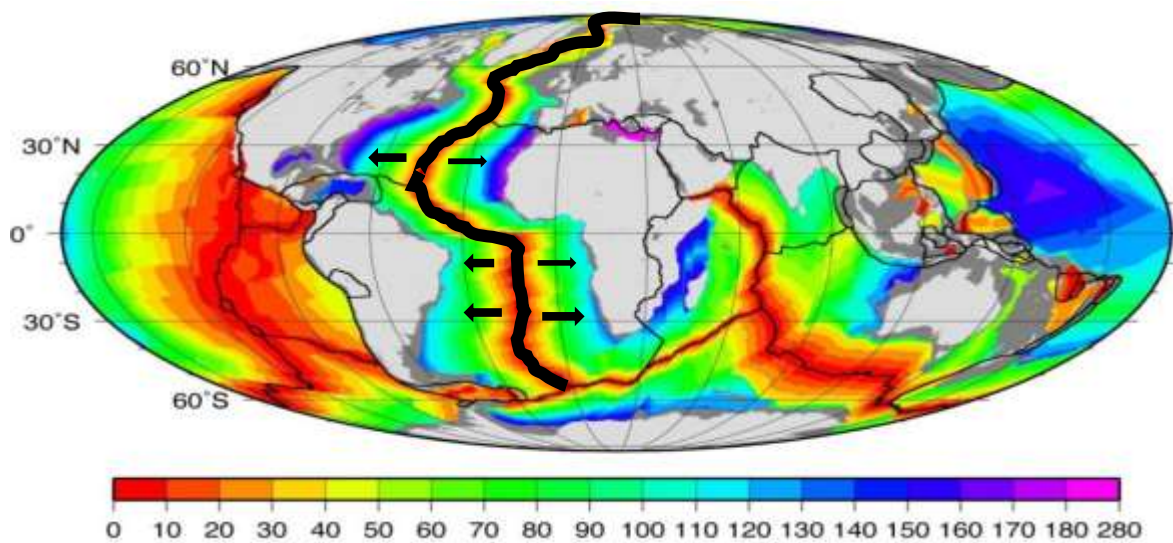
### Activity 2: Where It All Begins?

**Let's find out:** What is seafloor spreading?

**Let's use these materials:** Ages of Oceanic Lithosphere map and diagram of the Mid-Atlantic Ridge and Oceanic Crust

#### Let's do it this way:

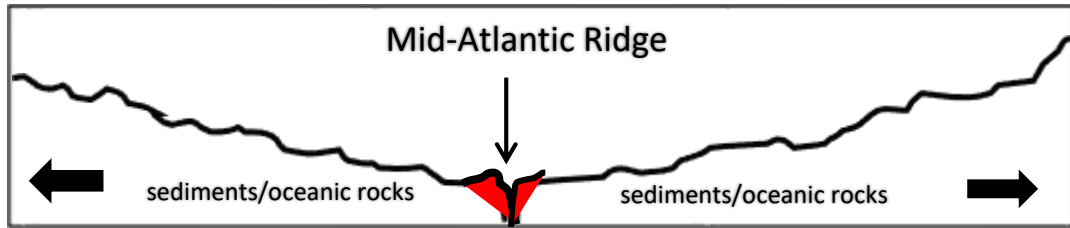
1. Get a clean sheet of paper to write down your answers and observation.
2. Examine the thick line in the map below that crosses from Northern to Southern hemispheres. The line represents the **Mid-Atlantic Ridge**, which is the longest and the most extensive chain of underwater mountains on Earth.



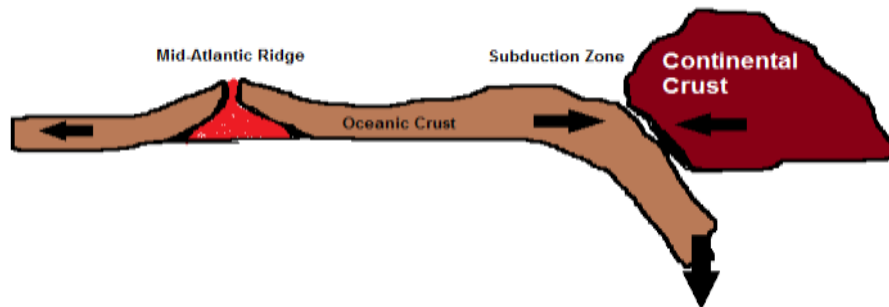
**Ages of Oceanic Lithosphere in million years**

The colors in the map indicate the ages of the oceanic rocks per million years.

3. Answer the following questions:
  - Q1. What type of plate movement or boundary is happening in the Mid-Atlantic Ridge?  
*Choose your answer from these types of plate boundaries:*  
*convergent                  divergent                  transform fault*
  - Q2. Before Q1, what molten material will come out from the ridge?
  - Q3. What can you say about the ages of the oceanic rocks **near** the Mid-Atlantic Ridge?
  - Q4. What can you say about the ages of the oceanic rocks **far** from the Mid-Atlantic Ridge?
4. The figure below shows the cross-section of the Mid-Atlantic Ridge and the Oceanic Crust.



5. Answer the following questions:
- Q5. What can you say about the thickness of the sediments **near** the ridge?  
*Choose your answer: thicker or thinner*
- Q6. Before Q5, what can you say about the density of rocks **near** the ridge?  
*Choose your answer: denser or less dense*
- Q7. What can you say about the thickness of the sediments **far** from the ridge?  
*Choose your answer: thicker or thinner*
- Q8. Prior to Q8, what can you say about the density of rocks **far** from the ridge?  
*Choose your answer: denser or less dense*
6. The diagram below shows the movement of oceanic crust in the Mid-Atlantic Ridge and the different geologic processes involved.



7. Answer the following question:
- Q9. If new ocean floor is being formed near the ridge, what will happen to the old oceanic crust materials? *Note: recall lesson on types of plate boundaries.* \_\_\_\_\_
- Q10. What is the importance of Seafloor Spreading in understanding the origin of the plate movement? \_\_\_\_\_
- Q11. Based on your understanding about seafloor spreading theory, is earth getting larger and wider when plates drift away from each other? \_\_\_\_\_  
*Choose your answer: Yes, the Earth gets larger and wider as plates drift. No, the Earth doesn't get larger and wider as plates drift.*



## Assessment 2

**Directions:** Use a separate sheet for your answers. Write the best letter answer in each item.

1. What can you say about the ages of oceanic crust near and far from the mid-oceanic ridge?
  - A. Oceanic crust is younger near the ridge but older far from it.
  - B. Oceanic crust is older near the ridge but younger far from it.
  - C. Oceanic crust materials have the same ages.
  - D. The Oceanic crust does not age.
2. During World War II, he discovered and proposed that the origin of the plate would be at the mid-oceanic ridge.
  - A. Alfred Wegener
  - B. Harry Hess
  - C. Charles Darwin
  - D. Albert Einstein
3. Describe the thickness of sediments near and far from the mid-oceanic ridge:
  - A. The sediments are thinner near the ridge but thicker as you go far from it.
  - B. The sediments are thicker near the ridge but thinner as you go far from it.
  - C. The thickness of the oceanic sediments near and far from the ridge is the same.
  - D. The sediments are unevenly distributed.
4. What type of plate boundary is occurring in the Mid-Atlantic Ridge?
  - A. Convergent Plate Boundary
  - B. Transform Fault Plate Boundary
  - C. Divergent Plate Boundary
  - D. Destructive Boundary
5. Why is the Earth not getting bigger despite the fact that molten materials are gradually coming out from the mid-oceanic ridge?
  - A. Because everything is being consumed in the subduction zone.
  - B. Because of the faster rate of movement of materials from the ridge.
  - C. Because older oceanic materials are pushed away and slowly consumed in the subduction zone.
  - D. Because the rate of coming out of new oceanic materials and destruction of older oceanic crust are the same.

## Lesson

# 3

## Evidence of Plate Movements: Magnetic Reversal



### *What's In*

The Seafloor Spreading Theory contradicts a part of the Continental Drift Theory. The Seafloor Spreading Theory strongly supports that the actual site of plate movements would be in the mid-oceanic ridge.



### *What's New*

### **Magnetic Reversal**

Further evidence came along by 1963, as geophysicists realized that **Earth's magnetic field had reversed polarity many times**, with each reversal lasting less than 200,000 years. Rocks of the same age in the seafloor crust would have taken on the magnetic polarity at the time that part of the crust formed.

Sure enough, surveys of either side of the Mid-Atlantic Ridge showed a symmetrical pattern of alternating polarity stripes.

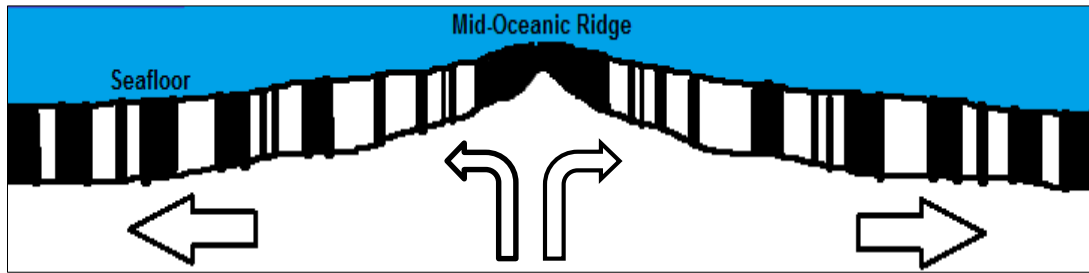
A magnetic compass can tell direction. The needle of a magnetic compass usually points to the North Pole of the Earth, which is actually the South Magnetic Pole at present. The crystalized irons in rocks found in the seafloor act as a magnetic compass that can tell the Earth's magnetic field direction. So, what is magnetic reversal? How can magnetic reversal be used as evidence of the Seafloor Spreading Theory?



### *What is It*

Seafloor spreading was strengthened with the discovery of the magnetic rocks near the ridge following a pattern aside from the fact that the rocks near the ridge are younger than those farther from the ridge.





*Symmetrical patterns on each side of the mid-oceanic ridge*

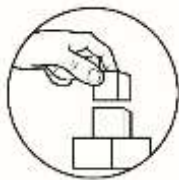
Magnetic reversal happened many times in the past. The occurrence of the magnetic reversal can be explained through the magnetic patterns in the magnetic rocks. These magnetic patterns allow our scientists to understand the ages and rate of movement of the materials from the mid-oceanic ridge.

The magnetic reversal, also called the "**magnetic flip**" of the Earth, happens when the North Pole is transformed into the South Pole, and the South Pole becomes the North Pole. This event happens because of the changing direction of the flow of materials in the Earth's liquid outer core.

Over the last 10 million years, there had been an average of 4 to 5 reversals per million years. New rocks are added to the ocean floor at the ridge with approximately equal amounts on both sides of the oceanic ridge.

By the 1970s, geologists had agreed to use the term "**plate tectonics**" for what had become the core paradigm of their discipline. They used the term "plates" because they had found evidence that not just continents move, but so do whole plates of the Earth's crust.

A plate might include a continent, parts of a continent, and or undersea portions of the crust. Alfred Wegener's idea of continental drift had been developed and refined together with the Seafloor Spreading of Harry Hess.



## ***What's More***

To understand further how Earth's magnetic reversal strengthens the Seafloor Spreading Theory, explore the last activity in this module to understand what happens deep under the ocean at the Mid-Atlantic Ridge.

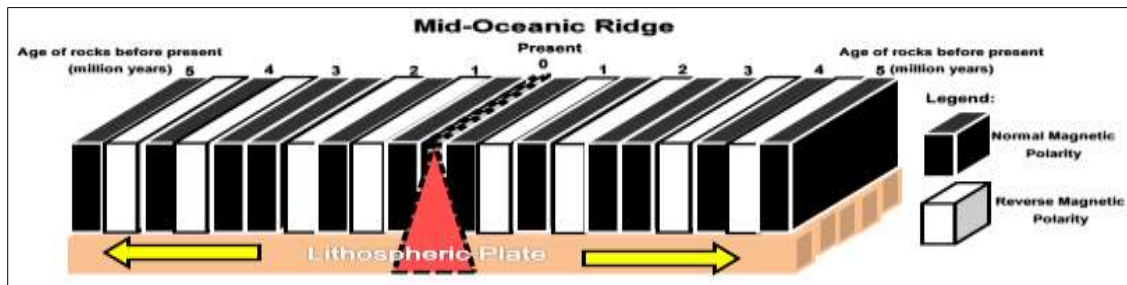
### **Activity 3: The enigmatic Magnetic Reversal**

**Let's find out:** What is magnetic reversal?

**Let's use these materials:** Diagram of the Earth's Magnetic Polarity

### Let's do it this way:

1. Use a clean sheet of paper to write your answer and observation in this activity.
2. Analyze the diagram that shows the Earth's magnetic polarity. The numbers indicate the ages of the oceanic rocks in a million years, while the legend represents the normal-reverse polarity.



3. Answer the following questions:

Q1. If magnetic reversals are recorded in the seafloor, what kind of rock is the seafloor made?

*Note: Materials rise and flow from the mid-oceanic ridge. The material that makes up the seafloor contains magnetic materials such as **iron**. These solidified irons in the seafloor can act like a **little compass needle** and follow the Earth's magnetic field.*

Q2. What does the magnetic stripes pattern represent?

*Note: Remember that solidified irons in the oceanic rocks can give information about the direction of the Earth's magnetic field.*

Q3. Is the magnetic stripe pattern on each side of the Oceanic Ridge equal?

Q4. Are the ages of rocks on each side of the ridge the same?

*Let us see if you have understood the purpose of the activity. Please answer the following assessment.*



## What I Have Learned

Let's find out what you have learned from our lesson on Sea Floor Spreading and Magnetic Reversal. Can you answer the following questions?

- ↪ What geologic feature was discovered by Harry Hess and his team in the oceanic crust that stretches from Northern to Southern region?
- ↪ What can you say about the ages of the oceanic rocks near the Mid-Atlantic Ridge? Do the ages of oceanic rocks get older as you move away from the ridge?
- ↪ How can Earth's magnetic reversal be used to support Sea floor spreading theory?
- ↪ What are the lines of evidence that support the plate movement?



## ***What I Can Do***

Most of the changes on the Earth's surface take place so slowly that they are not immediately noticeable by humans. The idea that the Earth's landmasses have broken apart rejoined and moved to other parts of the world forms part of the Plate Tectonic Theory, which you will be exploring in the next module.

Since there are strong evidence that continents are drifting as supported by the Continental Drift Theory, Seafloor Spreading, and Magnetic Reversal, can you predict the next movement and locations of the continents 100 million years from now? Is there a possibility that another supercontinent might be formed?

**Activity: Pangaea Ultima** (*The Last Supercontinent*)

**Let's find out:** How does climate change related to the movement of continents?

**Let's use these materials:** coloring materials (pencil and crayons), short bond paper and a world map showing the present location of the continents and their movement

**Let's do it this way:**

1. Examine the map on the next page. It shows the present location of each continent. The arrows indicate the direction of each plate boundary/ continent.

If you can speed up the time 100 million years from now, predict what will be the location of the continents? Will they merge into one supercontinent?

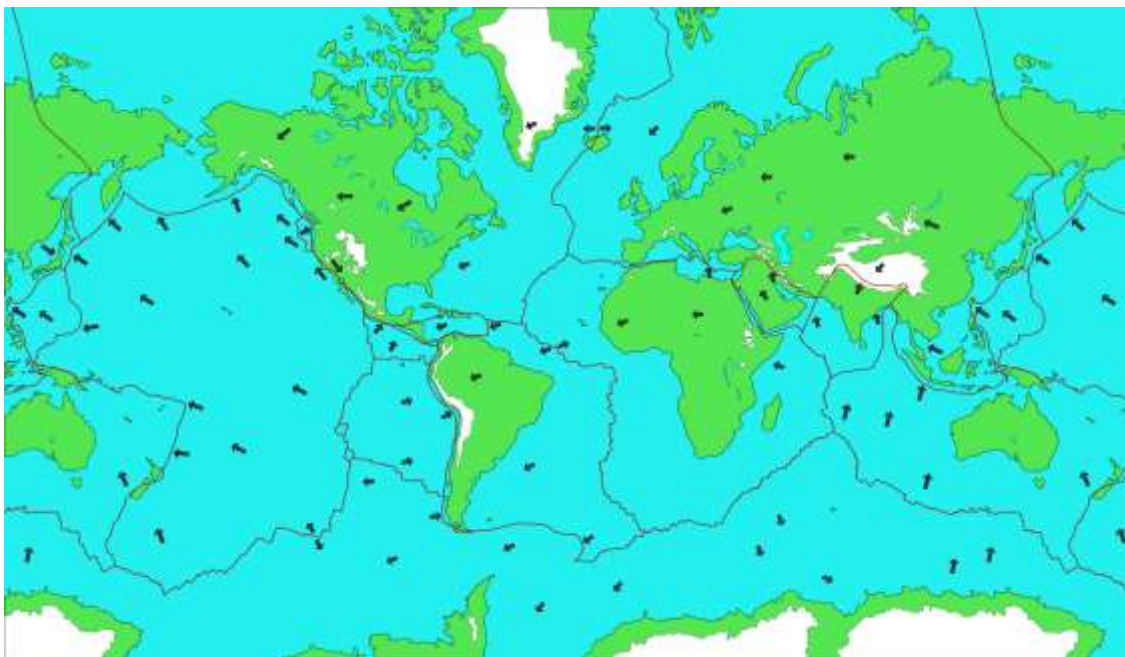


Plate Tectonic Process from <https://www.astronomynotes.com/solarsys/s8c.htm#>

2. Draw your prediction in a separate bond paper.

*Note: You might want to check this video simulation "How Earth will look in 250 Million Years?" Youtube link:  
<https://tinyurl.com/howearthwilllook250millionyear>*

*Remember also that your output in this activity will be rated by your teacher according to the following criteria:*

Accuracy of Details and Information (similar to the shapes of each continent)	5 pts
Techniques (appropriate colors, lines, shapes)	5 pts
Neatness of Work	5 pts
<b>Total</b>	<b>15pts</b>

3. Answer the following questions:

- Q1. What can you say about the climate of this "Super Continent"?
- Q2. Do movements of continents play an important factor in the so called "Climate Change"?
- Q3. Will this new supercontinent be inhabitable for mankind?
- Q4. Just for fun, if you can name this Super Continent, what will it be? Why

Great job for finishing this module on Evidence of Plate Movements! You are now ready to move forward to the next module! But before that, let's evaluate what you have learned so far from our lessons.



### **Assessment 3**

**Directions:** Use a separate sheet for your answers. Write **TRUE** if the statement is correct and **FALSE** if the statement is incorrect.

1. The iron materials found in the seafloor can give information about the Earth's magnetic field direction.
2. The age of rocks that comes out and flow from each side of the oceanic ridge is equal.
3. The magnetic polarity of the Earth remains normal and does not reverse or change.
4. The average distance traveled by the materials from each side of the ridge is the same.
5. A magnetic reversal happens many times in the past.



## Assessment

**Directions:** Choose the best letter answer in each item. Write your answer in a separate paper.

1. The idea proposed by Alfred Wegener to explain the continental shapes and positions is known as \_\_\_\_.

A. Pangaea  
B. Continental drift  
C. Plate tectonics  
D. Seafloor spreading

2. Examine the figure on the right, which two are the best examples of different continental positions in the past?

A. North America – South America  
B. North America – Africa  
C. South America – Asia  
D. South America – Africa



*Pangaea from Wikimedia Commons*

3. In the Mid-1900s, scientists mapped mid-ocean ridges using what?  
A. Satellites      B. Moons      C. Stars      D. Sonars
3. Early observers thought continents might have been joined based on what observation?  
A. rocks and fossils      C. magnetism  
B. earthquakes      D. coastline
4. Wegener suggested that coal beds discovered in Antarctica indicated that this continent was  
A. once underwater.      C. always frozen.  
B. once near the equator.      D. part of Africa
5. In the figure above, what is the age of the seafloor off of the Bahamas?  
A. younger than 9.6 million years      C. 33.0 – 83.0 million years  
B. 9.6 – 33.0 million years      D. 83.0 – 141.9 million year

*Study the Mid-Atlantic figure to answer items 6-7*

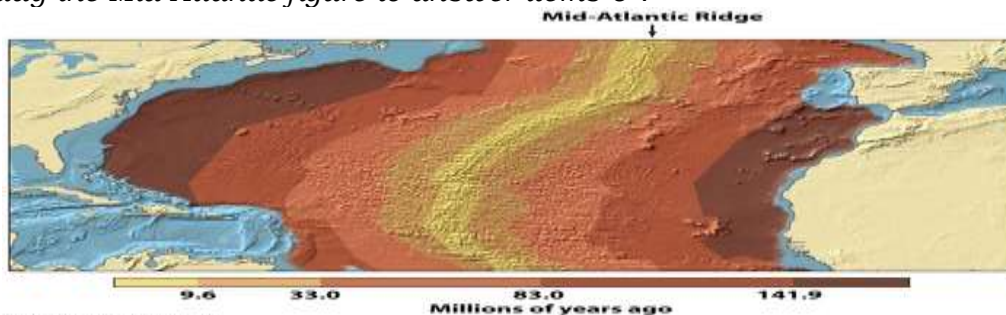


Figure 4.8. Visualizing Seafloor Age  
© 2008 John Wiley & Sons

6. In the figure above, what is the approximate age of the seafloor off the **north coast** of Spain?  
A. younger than 9.6 million years      C. 33.0 – 83.0 million years  
B. 9.6 – 33.0 million years      D. 83.0 – 141.9 million years

7. Peer scientists reviewing Wegener's hypothesis of continental drift rejected his notion because \_\_\_\_\_.
  - A. his evidence was too few to make a valid conclusion.
  - B. he did not explain how continents move and what moves them.
  - C. his evidence was not clear in showing how continents were joined.
  - D. he lied by including false evidence.
8. \_\_\_\_\_ help explain why Earth is not getting any larger even though the tectonic plates are always moving.
  - A. Earthquakes
  - B. Fossils
  - C. Subduction zones
  - D. Volcanoes
9. If there are **MORE** mid-ocean ridges than subduction zones, what happens to the ocean?
  - A. It gets larger.
  - B. It sinks.
  - C. It gets smaller.
  - D. Nothing will change.
10. What do ancient glacier scars found in rock surfaces in Africa tells about its climate in the past?
  - A. The continents have not moved.
  - B. Africa has always been near the equator.
  - C. Africa was once in an area of the Earth that had a very cold climate.
  - D. Africa was once covered with ice sheets but did not move ever since.
11. Which of the following increases with distance from the mid-oceanic ridge?
  - A. The age of oceanic lithosphere.
  - B. The density of oceanic lithosphere.
  - C. The thickness of the lithosphere.
  - D. All (A, B, & C)
12. The Seafloor Spreading Theory states that \_\_\_\_\_.
  - A. all continents are drifting.
  - B. ages of rocks near a ridge are older than the ones far from it.
  - C. fossils of plants and animals are found in almost all continents.
  - D. hot and less dense material from below the Earth's crust rises towards the surface at the mid-oceanic ridge.
13. What can you say about the rate of movement of materials coming out from the mid-oceanic ridge and the materials sinking in the subduction zone?
  - A. The rising of the materials from the ridge is slower than in the subduction zone.
  - B. The movement of the materials in both ridge and subduction zone is the same.
  - C. The rising of the materials from the ridge is faster than in the subduction zone.
  - D. There is no much movement of materials happening in both the ridge and subduction zone.
14. What strong evidence discovered by our scientist that Earth's magnetic reversal had been happening in the past?
  - A. The magnetic reversal occurrence is supported by magnetic patterns in magnetic rocks found on the ocean floor.
  - B. The ages of the rocks on the ocean floor are constantly changing.
  - C. The magnetic field of the Earth becomes weaker.
  - D. The Earth's magnetic field is fluctuating.



## Additional Activities

*Note: This is an optional activity. You may ask your teacher for help in accessing the video links.*

To remember more about Alfred Wegener and Harry Hess works, you might want to sing the song "**Wegener was his name**" by Mr. Parr to the tune of the song "One-call away" from Youtube.com. Here is the link to that song: <https://tinyurl.com/wegenerwashisname>

Wait, there's more! You might want to sing this song too "**Pangaea's Moving Farther Apart Again Song**," link: <https://tinyurl.com/pangaeamovingpartagain>

Have fun, and enjoy singing!

### **How I Rate My Self...**

*Before you return this module to your teacher, kindly copy and fill out the Self-rating table adapted from Valdoz (2017).*

<b>How much did this module help you...</b>	<b>Fair (5pts)</b>	<b>Good (8 pts)</b>	<b>Excellent (10 pts)</b>
Explain the Continental Drift Theory?			
Identify the pieces of evidence of Continental Drift Theory?			
Explain the Seafloor Spreading Theory?			
Identify the pieces of evidence of Seafloor Spreading Theory?			
Explain magnetic reversal?			
Predict the next movement of the continents?			



# Answer Key

## Activity 1: A journey from the past to future!

### Assessment 1

- 1. A
- 2. D
- 3. A
- 4. A
- 5. B

- Q1. Yes
- Q2. Temperate
- Q3. Near equator
- Q4. Yes
- Q5. Shapes, fossils, rocks (basalt), sand
- Q6. Africa and South America
- Q7. Philippines did not exist during the time of Pangaea (recall oceanic vs. oceanic convergent boundary)
- Q8. Philippines might be moving eastward

## Activity 2: Where it all begin?

### Assessment 2

- 1. A
- 2. B
- 3. A
- 4. C
- 5. C

- Q1. Divergent boundary
- Q2. Magma or lava
- Q3. Younger oceanic rocks
- Q4. Older oceanic rocks
- Q5. Thinner sediments near the ridge
- Q6. Less dense oceanic rocks
- Q7. Thicker sediments far from the ridge
- Q8. Denser oceanic rocks
- Q9. It will be pushed away and destroyed at the subduction zone (recall convergent plate boundary)

### Assessment 3

- 1. True
- 2. True
- 3. False
- 4. True
- 5. True

- Q10. Seafloor Spreading is a process that occurs at mid-ocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.
- Q11. No, earth doesn't get larger and wider as plates drift.

## Activity 3: The enigmatic Magnetic Reversal

- Q1. Magnetite / Magnetic rocks / rocks containing irons
- Q2. Magnetic stripes patterns represent the direction of the earth's magnetic polarity.
- Q3. Yes
- Q4. Yes

### Pre-assessment

- 1. C
- 2. B
- 3. B
- 4. B
- 5. C
- 6. D
- 7. A
- 8. B
- 9. B
- 10. A
- 11. A
- 12. B
- 13. D
- 14. C
- 15. D

### Post-Assessment

- 1. B
- 2. D
- 3. D
- 4. D
- 5. B
- 6. D
- 7. D
- 8. B
- 9. C
- 10. A
- 11. C
- 12. D
- 13. D
- 14. C
- 15. A



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Alfred Wegener from  
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Alfred Wegener: Building a Case for Continental Drift from  
<http://publish.illinois.edu/alfredwegener/evidence/> publish.illinois.edu © 2019  
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Collecting Multibeam Sonar Data by National Ocean Service from flickr.com  
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Diagram Earth's Magnetic Polarity by Marianne Soriano

Diagram Mid-Atlantic Ridge and Sediments/Rocks by Marianne Soriano  
Diagram Mid-Atlantic Ridge and Subduction Zone by Marianne Soriano  
Diagram Symmetrical Pattern by Marianne Soriano  
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File: East Pacific Rise seafloor magnetic profile - observed vs. calculated.png from  
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Fossilized Leaves of Glossopteris from  
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Pangaea's Moving Farther Apart Again Song by Mr. Parr from

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Wegener was his name by Mr Parr from

<https://www.youtube.com/watch?v=ME4B9aMLcZ0>

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