Debre Berhan University

College of Social Science and Humanities

Department of Geography and Environmental Studies

Geography of Ethiopia and the Horn

CHAPTER TWO

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THE GEOLOGY OF ETHIOPIA AND THE HORN

By: Ayele Behaylu (Assistant Professor)

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2.1. Introduction

- Geology is an ***Earth science*** that studies the ***evolution of the earth***, the ***materials of which it is made of***, and the ***processes acting upon them***.
- Much of Geology is concerned with ***events that took place in the remote past*** when ***no one was around to witness them*** and with features which are ***far beneath the earth's surface*** where ***no one can see them***.
- A ***great deal of geological understanding*** must, therefore, be ***obtained by inference***, using clues ***from what can be seen*** and ***what can be measured***.

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- There are many such ***clues not only the rocks*** and ***landforms*** which can be observed and studied at the Earth's surface, but also those provided by ***indirect methods*** such as:

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- ***Geophysics*** (e.g. ***studying earthquake waves*** which can ***penetrate deep beneath the Earth's surface***),
- **Geochemistry** (analysis of the ***detailed composition*** of rocks which can give clues as to ***their origin***) and
- **Geochronology** (methods for ***finding the ages of rocks***, usually from the ***radioactive elements*** they contain).

The Theory of Earth's Evolution (Continental Drift Theory)

- ✓ About 400 years ago explorers were ***sailing the oceans and examining the coastlines***.
- ✓ These explorers brought back enough information for mapmakers to ***create reliable maps***.
- ✓ In ***1620***, ***Francis Bacon*** noticed that the ***shapes of some of the continents looked*** as ***if they could fit together.***
- ✓ He proposed that they ***once fit together*** but ***he didn't have a way to explain it***. Everyone rejected his idea!

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Francis Bacon

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- The earth's continents were once bunched up together in to a single huge continent called ***Pangaea***.
- The large super continent was then split into ***Gondwanaland*** where Africa is a part and ***Laurasia***; and later into smaller fragments over the last million years.
- These then drifted apart to form the present arrangement of continents.
- Australian Climatologist ***Alfred Wegener*** proposed the **hypothesis** that the ***continents were once assembled together as a supercontinent***, called the ***Continental drift Theory.***

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- In 1912, a German meteorologist came up with a theory that was similar to ***Francis Bacon's***.
- His name was ***Alfred Wegener***. He called his theory, the "***Theory of Continental Drift.***"
- **Continental Drift theory** is a theory that states the ***present continents*** *and* **other *major landforms*** *are* ***running one from*** **the *other*.**
- The continents gradually drifted apart to where they are today.

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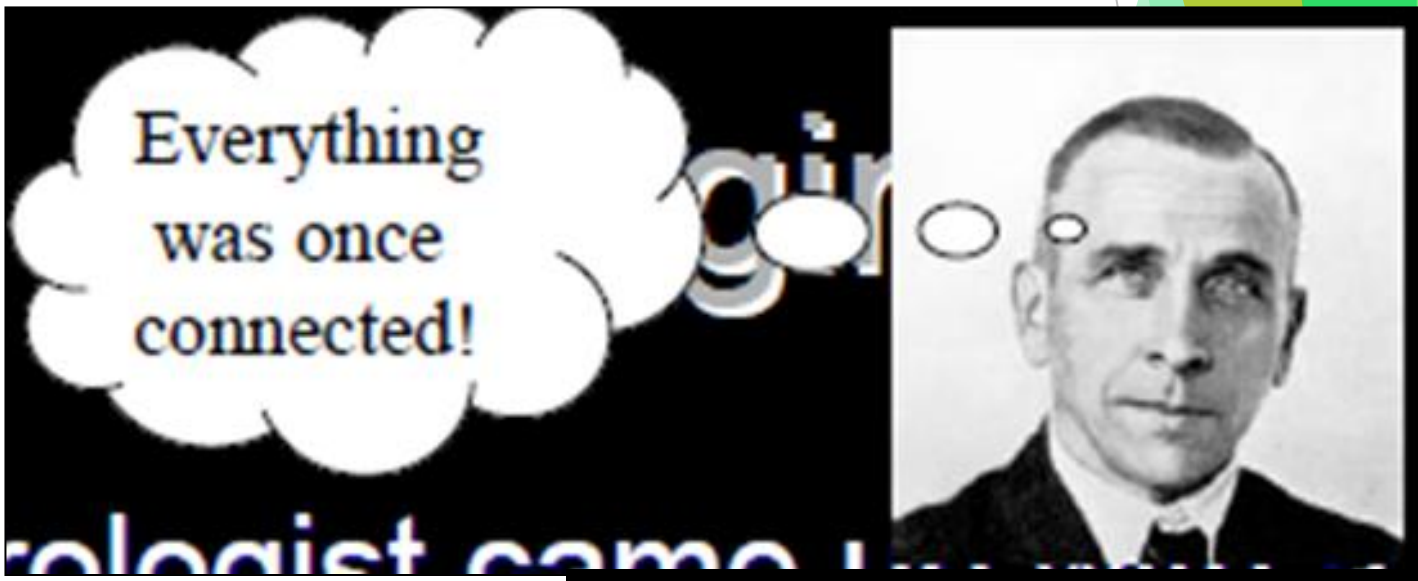

- In this theory, he said that not just ***Africa*** and ***South America*** were once connected but, ***all the continents were once connected and have since moved apart.***
- He called this ***giant land mass*** **(supercontinent)** ***PANGAEA*** *(250 million yrs ago)*. This word means "***All land.***"

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Pangaea approximately 250 million years ago looks



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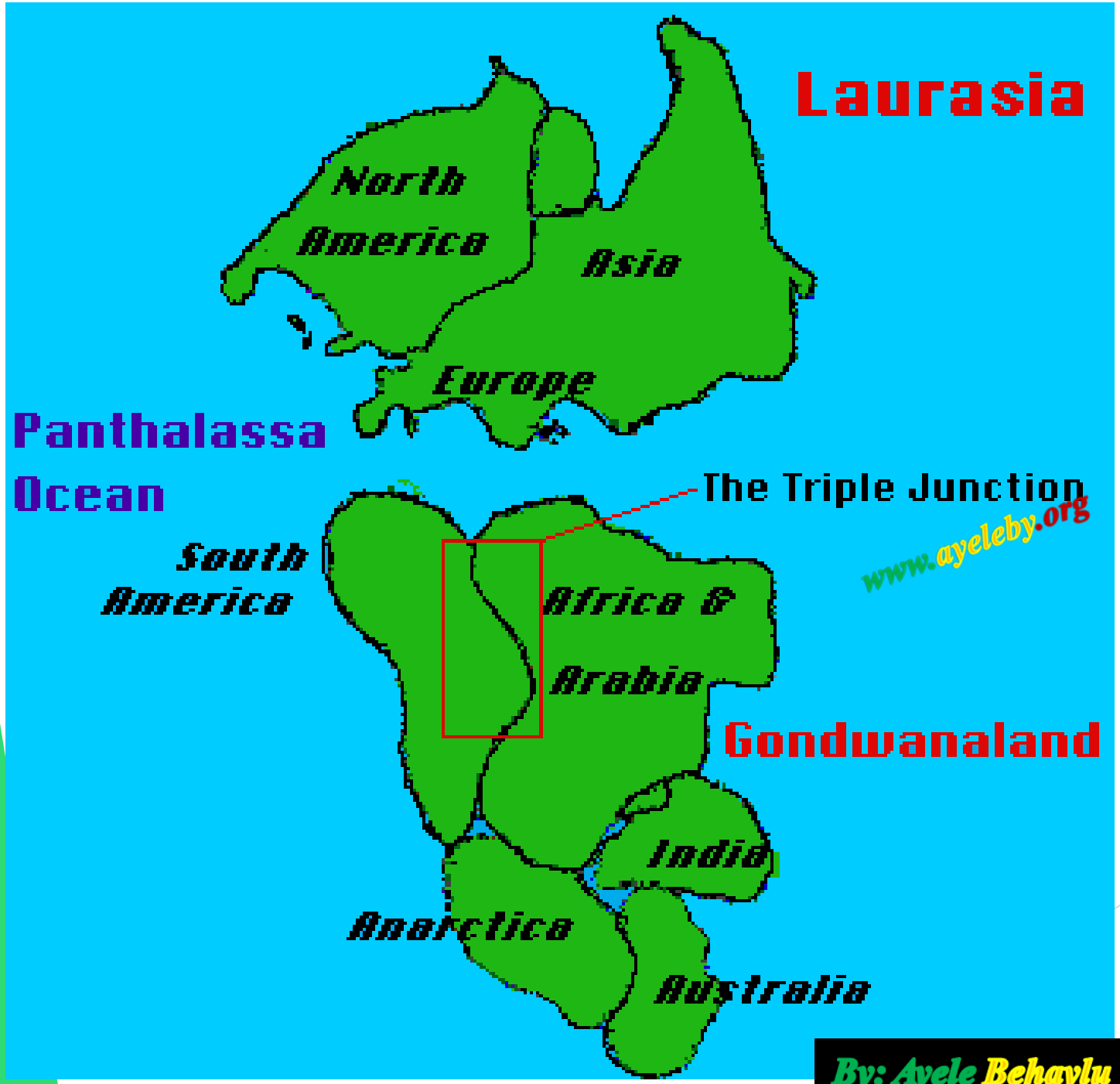
- According to Wegner around 180 million yrs ago ***Pangea*** was spilt in to two by the drifting process of continents.

The two supper continents are

- ***Laurasia*** **(**the Northern portion**)** and
- ***Gondwanaland*** (the Southern portion).





The gigantic mountains that were formed by the Precambrian orogeny were subjected to intense and prolonged denudation.

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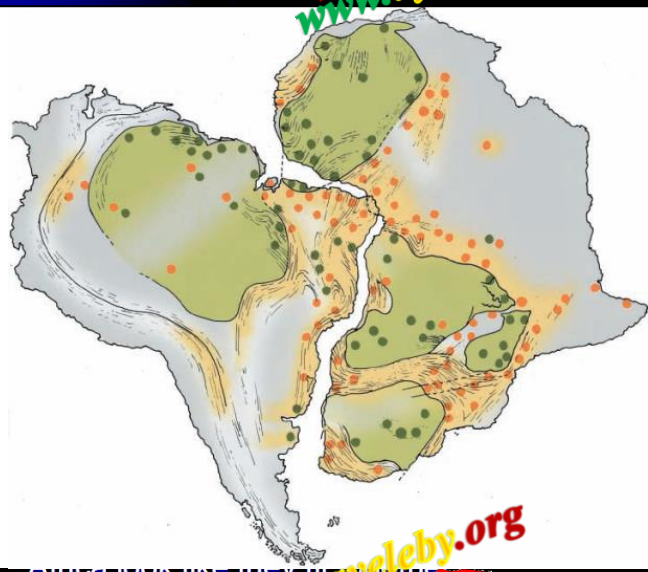
1. Structure *(The continents of South America and Africa look like they fit together)*



- Wegner argued that the ***fitting of continents*** prove that these continents were ***once together***.
- He then conclude that their present position is the outcome of drifting of these continents ***one from the other.***
- However, these coastal lines do not fit perfectly.
- This is due to ***erosional processes*** and ***continental displacement*** after the splitting modifies these shorelines.





2. Paleontological Evidence (*Fossils* of ***animals*** and ***plants*** were found on multiple continents.)

- Wegner knew that the Paleontologists have found the ***existence of identical fossils*** (remains of plants and animals of ***Paleozoic era***) on the ***widely separated landmass.***
- He at the same time knew that most of these scientists agree on the fact that ***occurrence of identical fossil*** is ***possible only*** if ***these continents*** were once joined.

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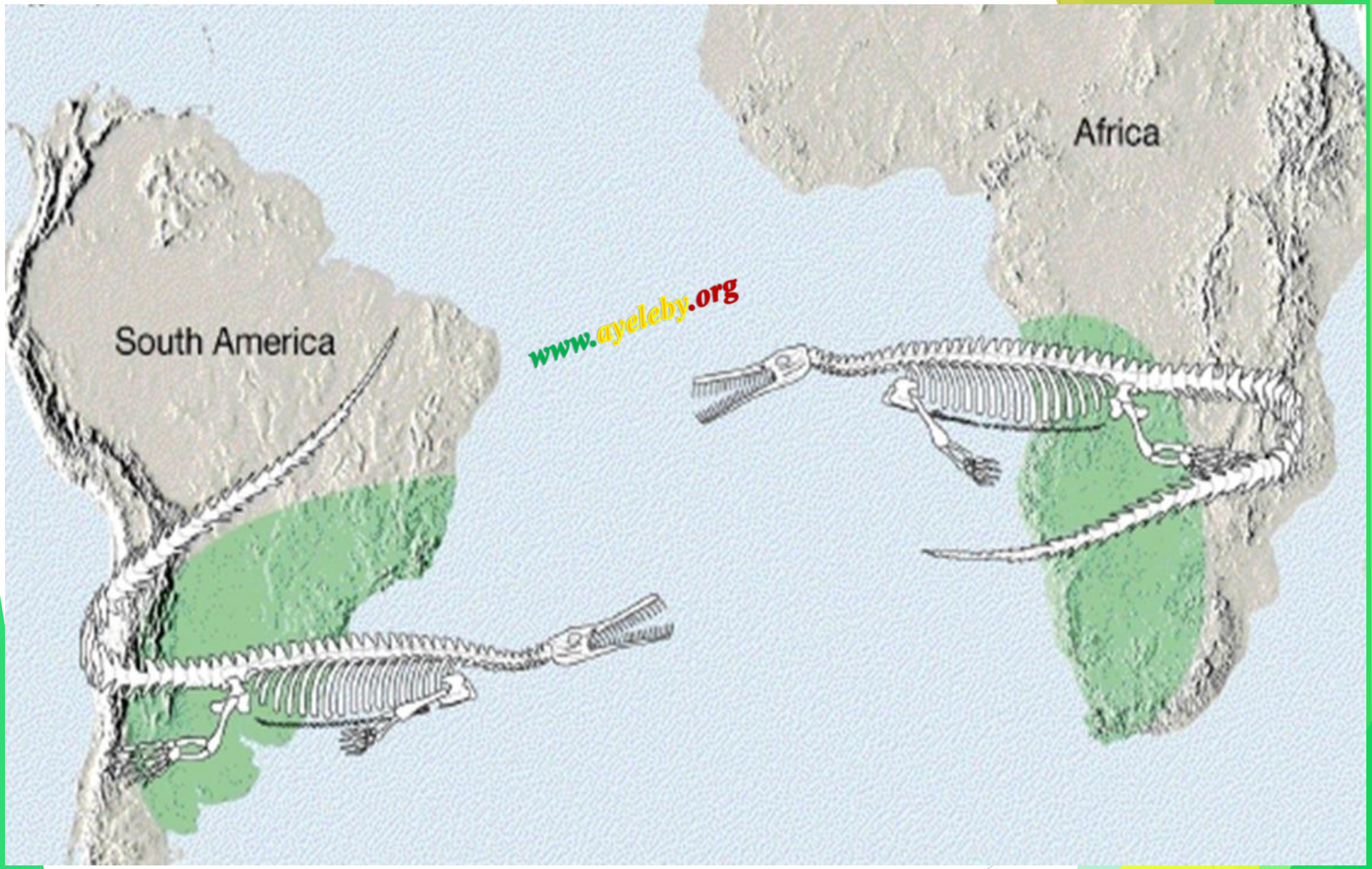

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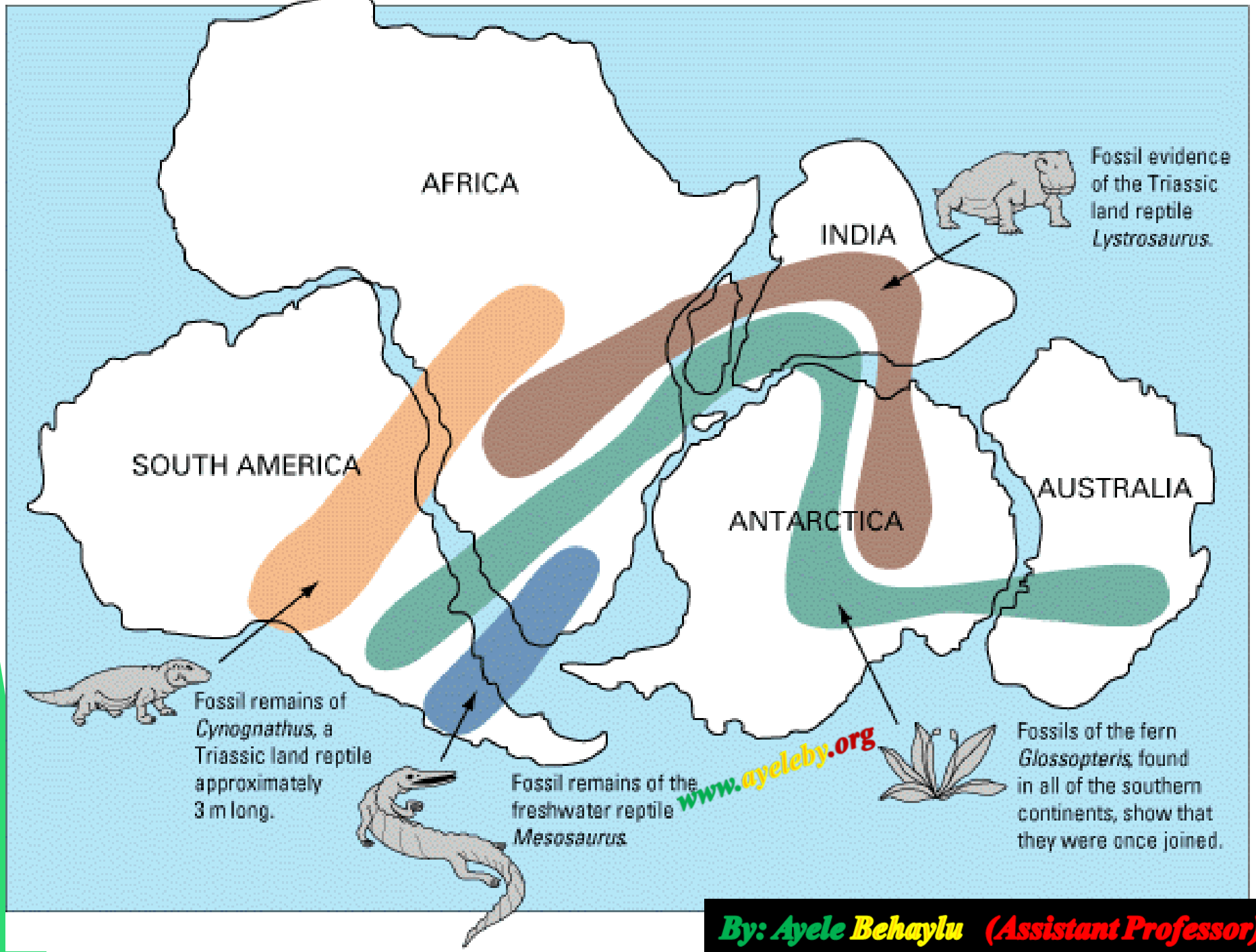

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3. Evidence from Rock Type and Structural Similarity

- ✓ The similarity of the ***rock type*** and ***structure of the land*** at expected matching position of continents is the third evidence forwarded by Wegner.
- ✓ Geological studies of the ***rock types*** of ***adjacent continents*** are found to be similar in ***age*** and ***type***. E.g. rocks in ***North West Africa*** are found to be matching to rocks found in ***Eastern Brazil***.
- ✓ ***Mountain ranges*** *"**matched up**" between different continents*
- ✓ The mountain ranges on the ***East Coast*** **of** ***North America*** and ***Northern Europe*** were made of the ***same rock*** and the ***rock*** was the ***same age.***
- ✓ ***Similar rock layers*** were found ***across multiple continents.***

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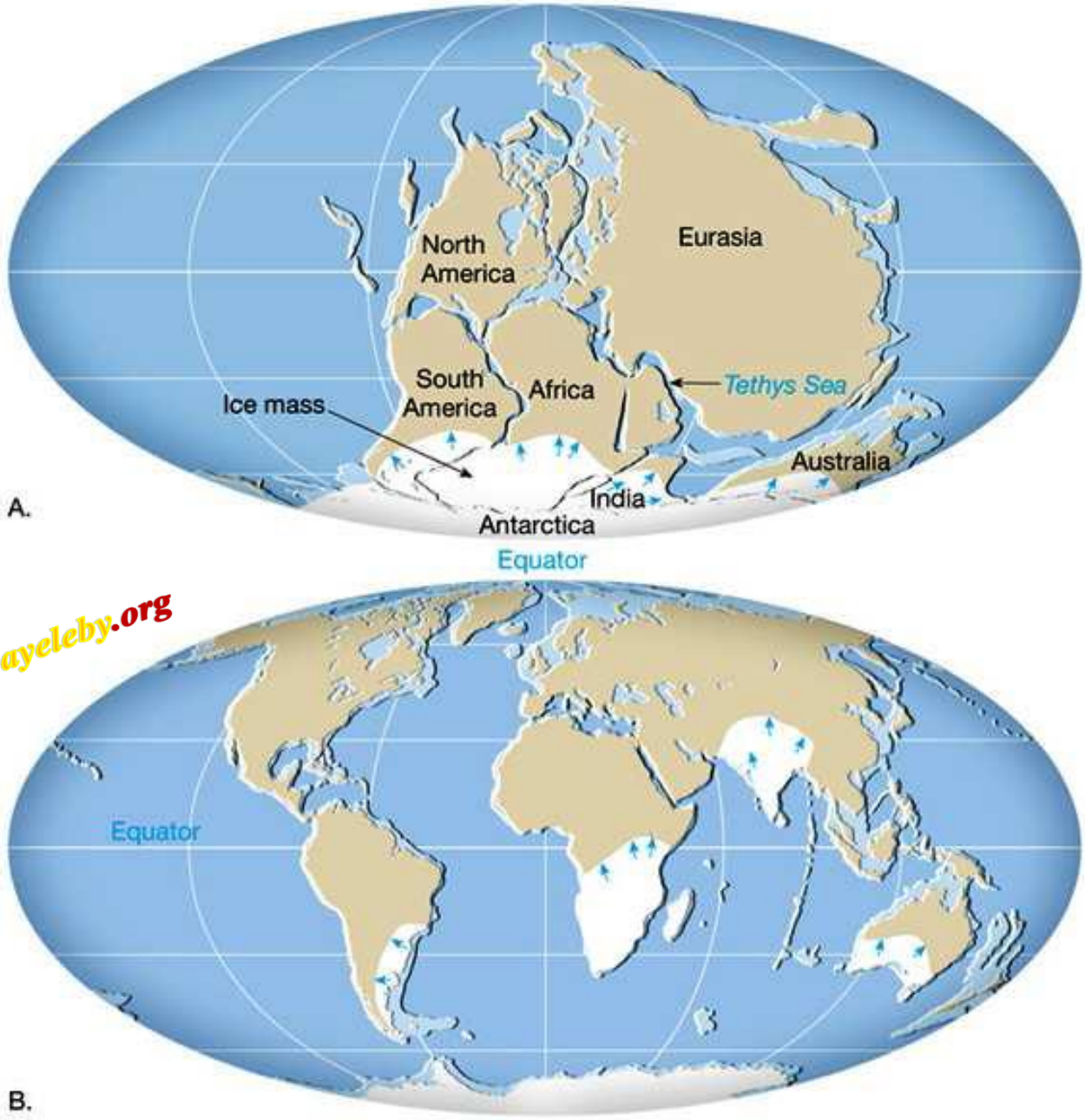
When the continents are put together to form ***Pangaea***, the remains of glacial materials fit together to form a pattern like the large ice sheets that cover our poles today.



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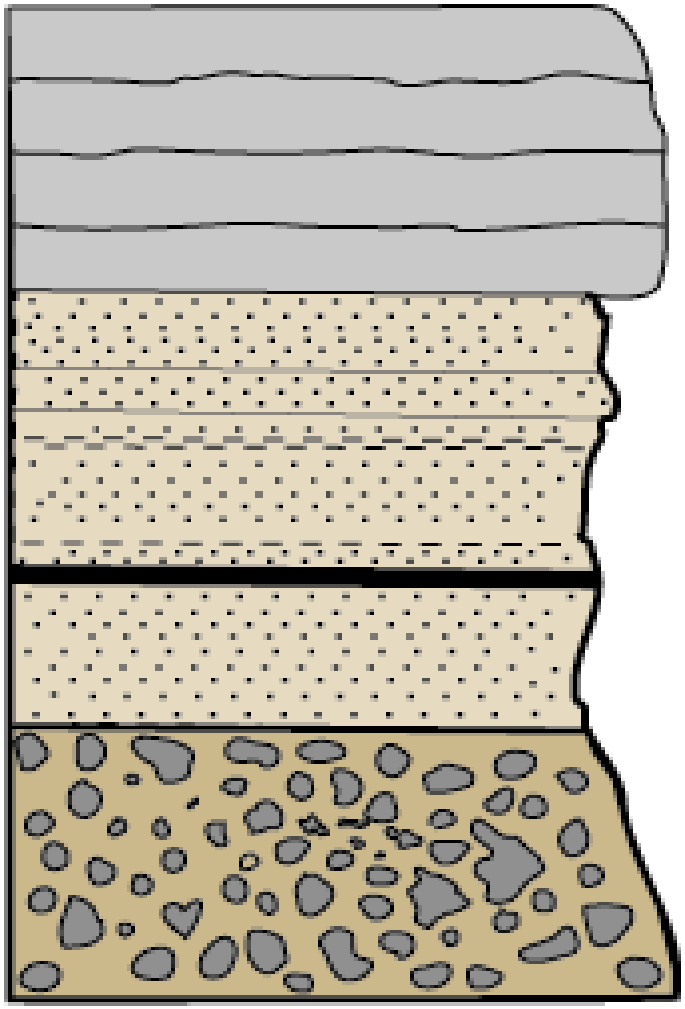

Similar layers of rock were formed in Antarctica, Australia, South America, Africa, and India before Pangea broke apart. Glossopteris fossils were found in the rocks on each continent.

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4. Paleo climatic (ancient climate) Records

- Other evidence of ***striking climatic changes*** recorded in the ***geologic record*** tends to ***support the drift theory***.
- Great ***coal deposits*** in ***Antarctica*** show that ***abundant plant life*** once ***flourished*** on that ***continent***, now covered with ***ice*** more than a kilometre thick.
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- On the other continents, thick deposits of ***salt***, formations of ***wind-blown sandstone*** and extensive ***fossil coral reefs*** provide additional clues that permit us to reconstruct the ***climatic zones*** of the past.
- The ***paleoclimatic patterns*** shown by these rocks are **baffling/mysterious** with the continents in their present positions, but if the continents are grouped together in their pre-drift positions, the patterns are easily explained.

- The evidence for the theory of continental drift was considered and debated for years.
- Wegener was criticized for ***failing to explain what forces would permit continents of granite to flow through oceans of rock.***
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- The idea of a moving lithosphere was yet to come.
- In the ***absence of a reasonable mechanism*** for drift, ***there was little further development of the theory*** until after World War II.
- An explosion of knowledge then provided renewed support for the drift hypothesis and also led to the discovery of a possible mechanism.

Wegener's principal observations were:

- **Fit of the continents**: The opposing coastlines of continents often fit together.
- **Match of mountain belts, rock types**: If the continents are reassembled as Pangaea, mountains in West Africa, North America, Greenland, and Western Europe match up.
- **Distribution of fossils:** The distribution of plants and animal fossils on separate continents forms definite linked patterns if the continents are reassembled.

- **Paleoclimates**: rocks formed 200 million years ago in India, Australia, South America, and southern Africa all ***exhibited evidence of continental glaciations.***



Plate Tectonics

Theory of Plate Tectonics is a theory that explains the ***lithosphere*** is broken in to several ***major*** and ***minor plates***.

- It is a theory that reveals the fact that almost ***all tectonic activities that affect the surface of our earth*** are located ***along*** the ***boundary of each plate***.

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- It had revealed the ***correct explanation*** for the ***dynamic nature of internal earth***, as it ***affects earth's surface***.
- It has correctly demonstrated the causes for instability within the earth.
- It explains **how**, **why** and **where** ***cracking***, ***faulting***, ***rifting***, ***warping***, ***folding volcanism*** and ***earth quake*** occur on our earth.

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- The theory was formulated by a Cambridge university scholar known as **Dan Mckenzie.**
- He developed the theory by uniting two theories. Viz: Theories of ***Continental drift*** and ***Sea floor spreading*.**
- *Sea floor spreading:* is a hypothesis that suggest ***seafloor along mid ocean ridge system*** move side way by convection current below the lithosphere due to ***tensional movement along mid ocean ridge***.
- According to this hypothesis as the lithosphere moves side wide a new magma replaced the one moved side way.

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- Why where the rocks younger in the ocean crust when compared to the continental crust?

- Write a hypothesis as to why the ocean crust is younger than the continental crust.
- In 1960, Dr. Harry Hess came up with some answers.
- A driving force, convection currents, moved the plates. The ocean floor, and the rock beneath it, are produced by magma that rises from deeper levels. The hot, less dense magma rises and cools, pushing the older crust out from the center.
- At the mid-ocean ridge, molten material rises from the mantle and erupts. The molten material spreads out, pushing older rock to both sides of the ridge.

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- This process that continually adds to the ocean floor is ***sea floor spreading***
- In the 1960s scientists found evidence that new material is erupting along the mid-ocean ridge.
- The presence of pillow shaped rocks has showed that molten material has erupted again and again.

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- What is the main difference b/n ***Sea floor spreading*** hypothesis and ***continental drift theory***?
- The main difference b/n Sea floor spreading hypothesis and continental drift theory is that the ***continental drift theory*** does not consider ***oceanic ridges*** as a ***starting position*** of the ***spread***.

Evidence for Sea-Floor Spreading

- Evidence in the rocks shows that Earth's magnetic poles have reversed.
- The iron particles lined up in the opposite direction.
- In the 1968, scientists aboard the Glomar Challenger gathered information about the Sea floor. They found rocks no older than 180 million years.
- Evidence from drilling into the sea floor shows evidence of the ages of rocks.
- The closer you get to the mid-ocean ridge the younger the rock. The farther you get, the older the rock.
- As one moves from the mid oceanic ridge, the age of the rocks become older and thicker.

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- ✓ The ***outer rigid*** part of the earth (***lithosphere***) consists of several segments called ***plates.***
- ✓ ***Plates*** are individual ***segments / land mass*** and they ***move*** in to d/t direction by ***internal forces***.
- ➢ The earth's crust is not all in one piece.
- ➢ It is divided in about a dozen major "plates" that ride on the earth's asthenosphere.

- Although the theory of continental drift was supported by some convincing evidence, the data on which it was originally based came only from the continents because, before the 1950s, there was no effective means of studying the ocean floor.
- Before 1950, therefore, geologists faced an almost total absence of data about the geology of three-fourths of Earth's surface; then, in the 1950s and 1960s, new technology resulted in a burst of new data and new ideas about the geology of the ***ocean floor*** and about ***paleomagnetism***.

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Plate boundaries

- All major interactions among individual plates occur along their boundaries
- Each plate is bounded by a combination of the ***three types*** of ***boundaries***
- New plate boundaries can be created in response to changes in the forces acting on these rigid slabs

Types of plate boundaries

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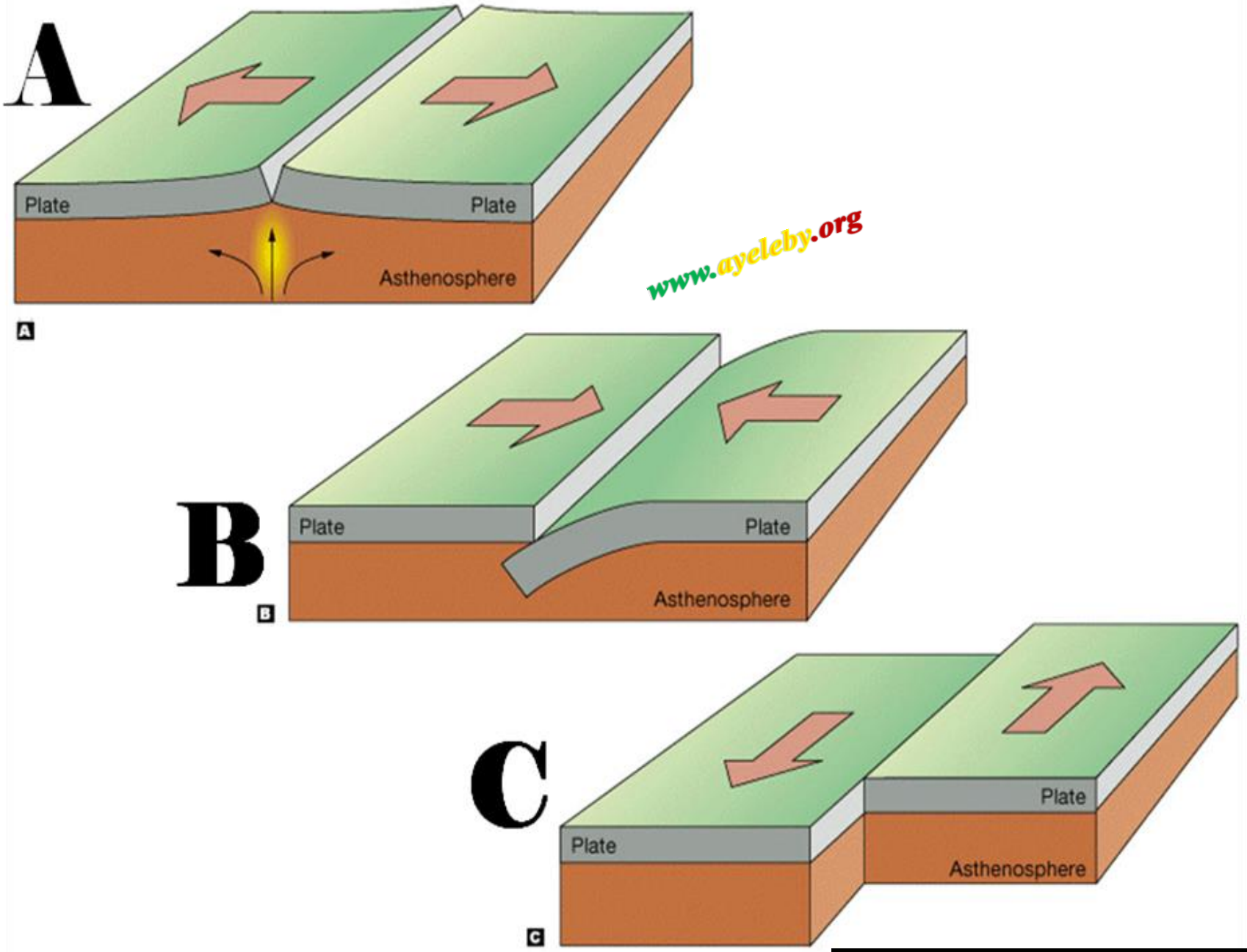
- ***Divergent plate boundaries*** (constructive margins)
- ***Convergent plate boundaries*** (destructive margins)
- ***Transform fault boundaries*** (conservative margins)



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Divergent Boundary

- Spreading or diverging of plates takes place along what is known as divergent **plate boundary.**
- Such interaction taken place when two plates ***move apart***, as a result of the up welling of materials from the ***upper mantle*** and ***side wide movement*** of the convection current in the ***asthenosphere*** (*See the figure above 'A'*)
- **Divergent boundaries** are characteristic of ***seafloor spreading centers***, where ***upwelling material*** from the ***mantle*** forms ***new seafloor***, and ***crustal plates*** are ***spread apart***.

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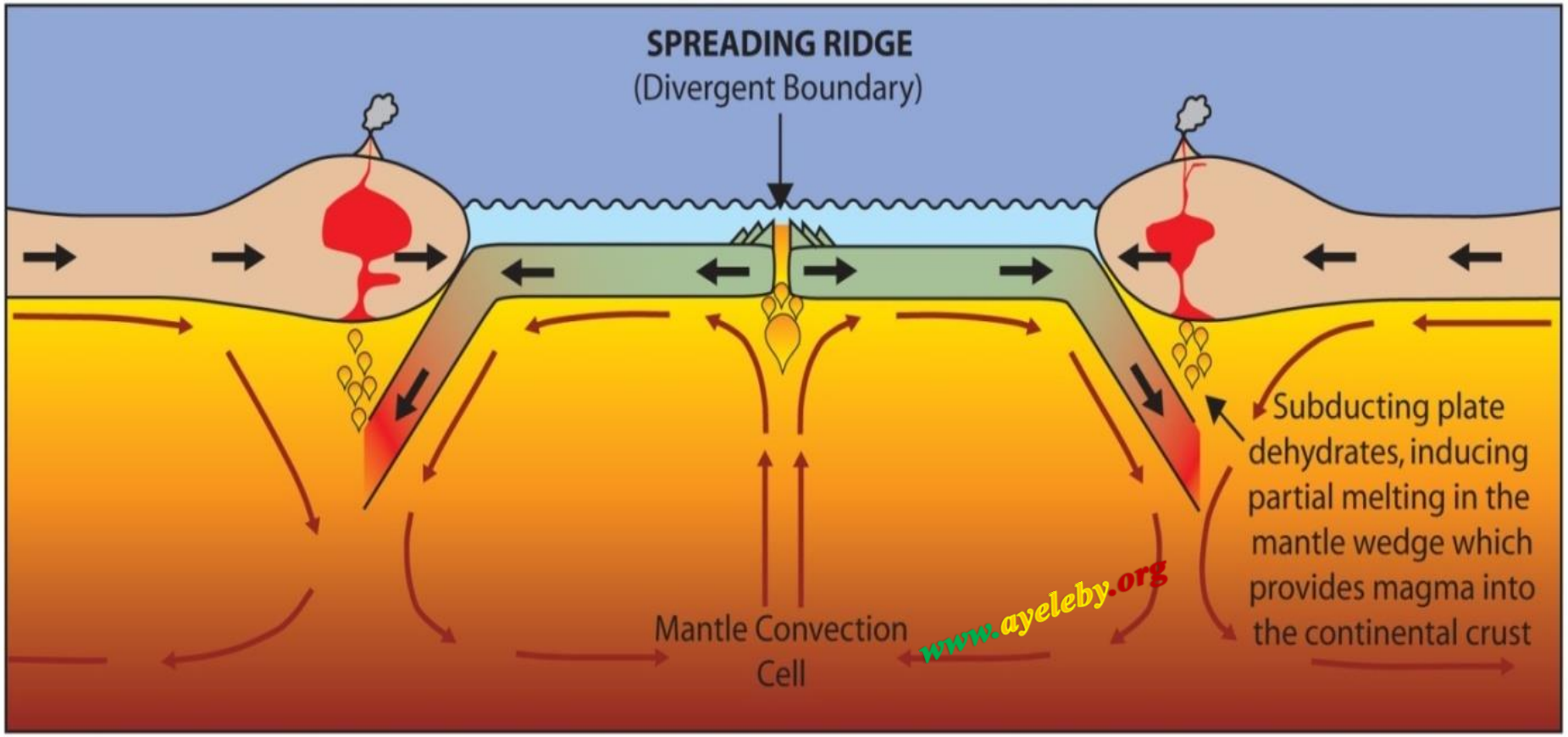

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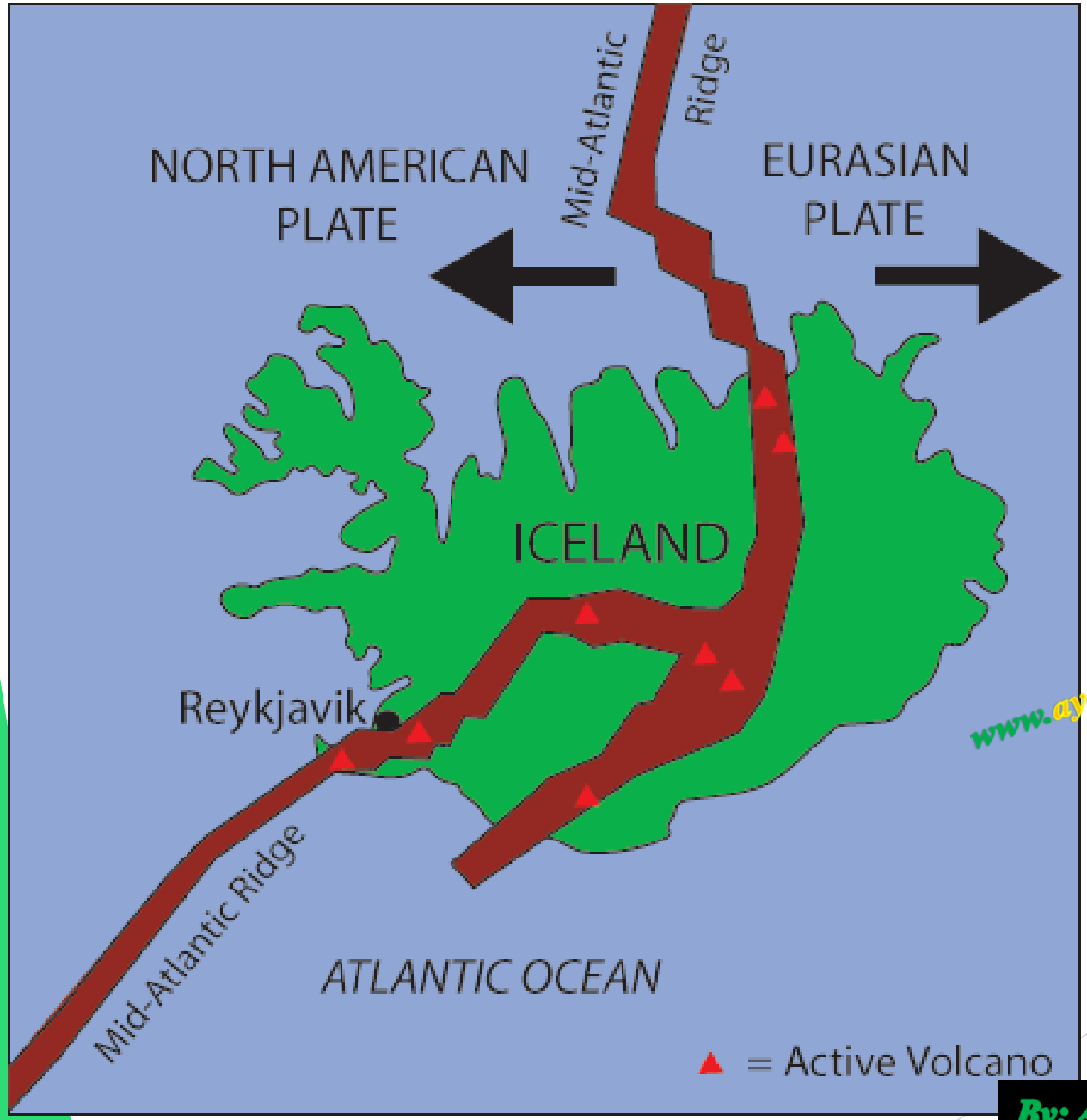
Iceland has a divergent plate boundary running through its middle.



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Convergent Boundaries

- **Convergent boundaries** are characteristic of ***collision zones***, where areas of ***continental*** and/or ***oceanic crust collide***. These are zones of compression.

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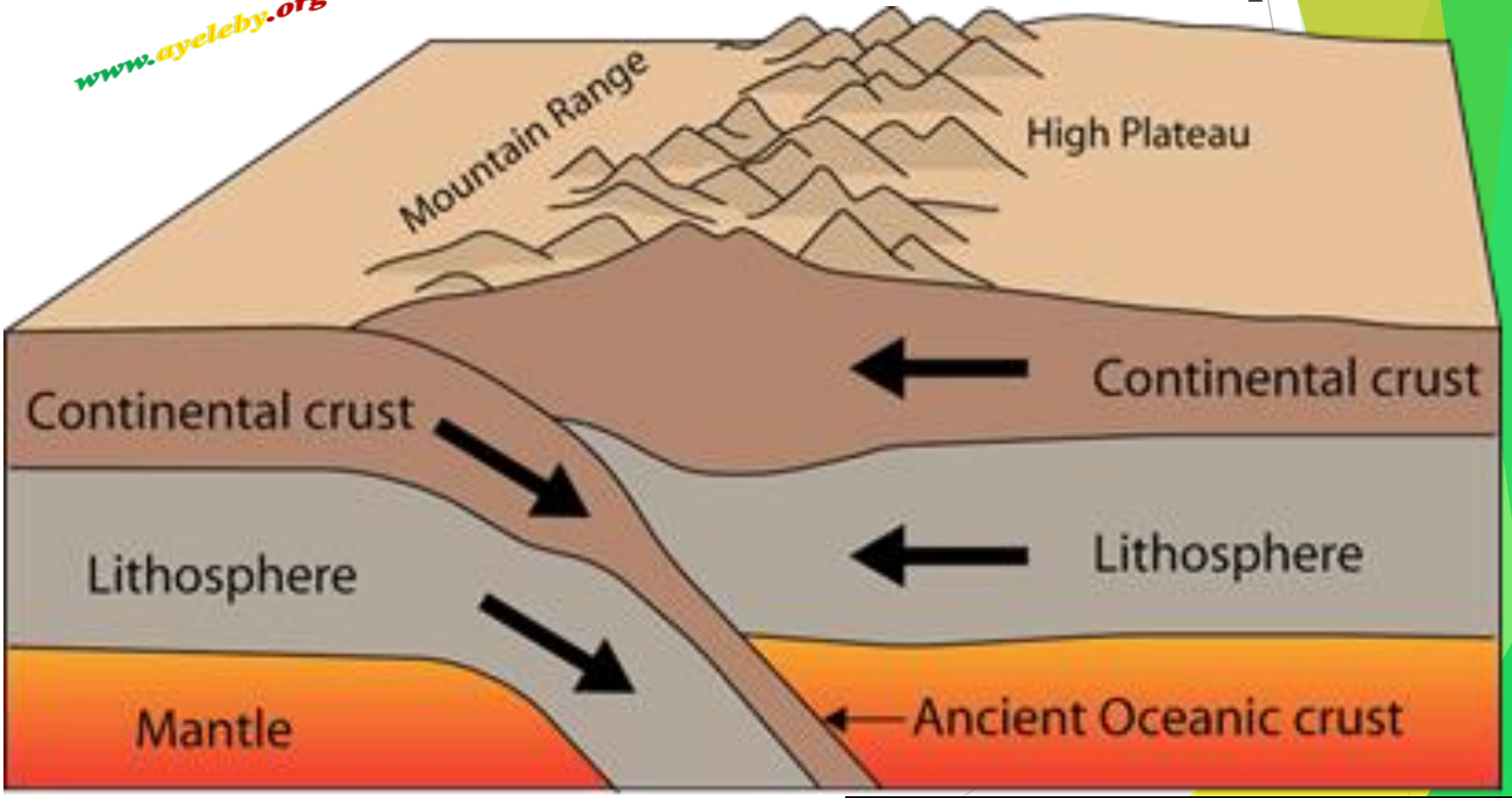

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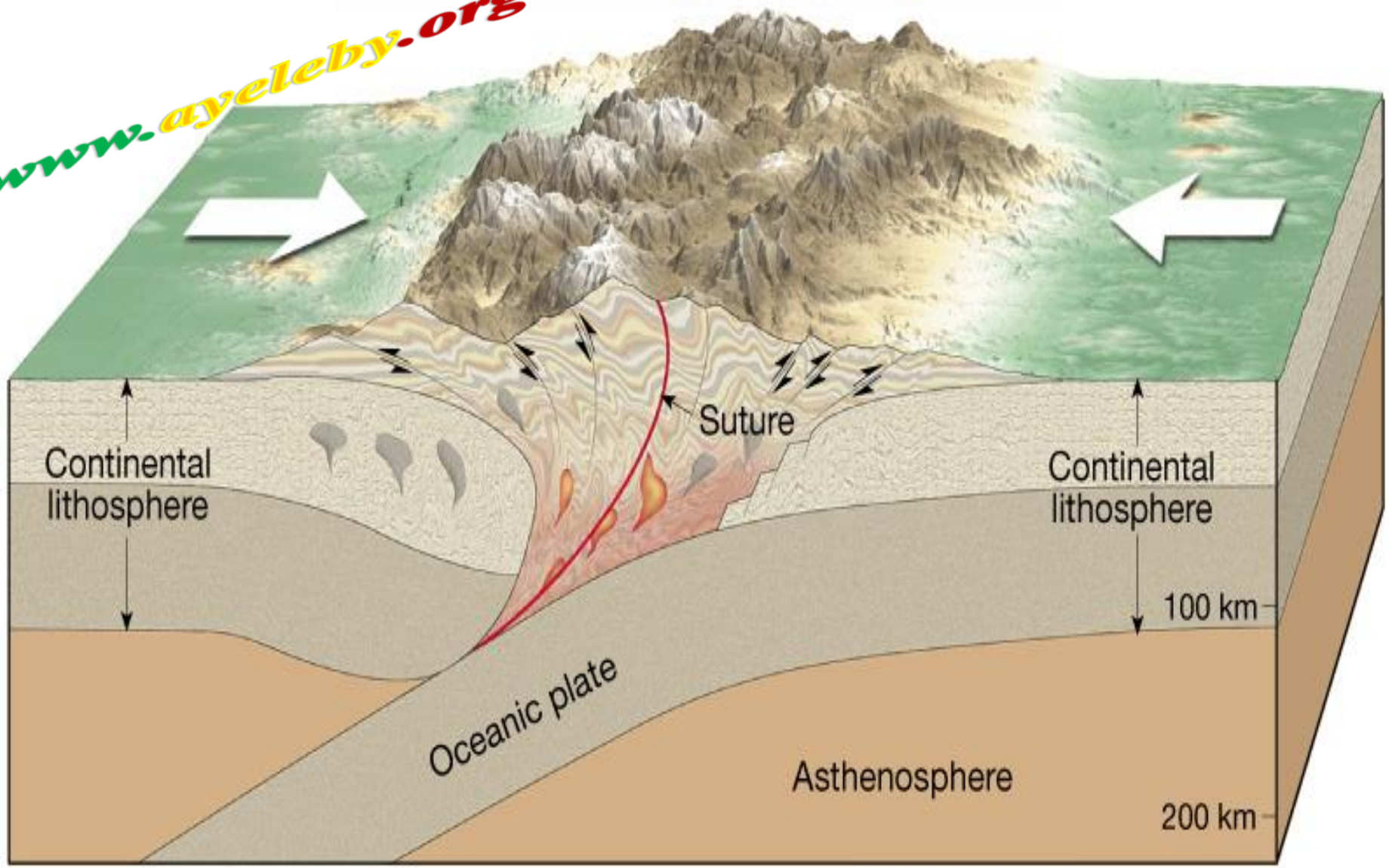

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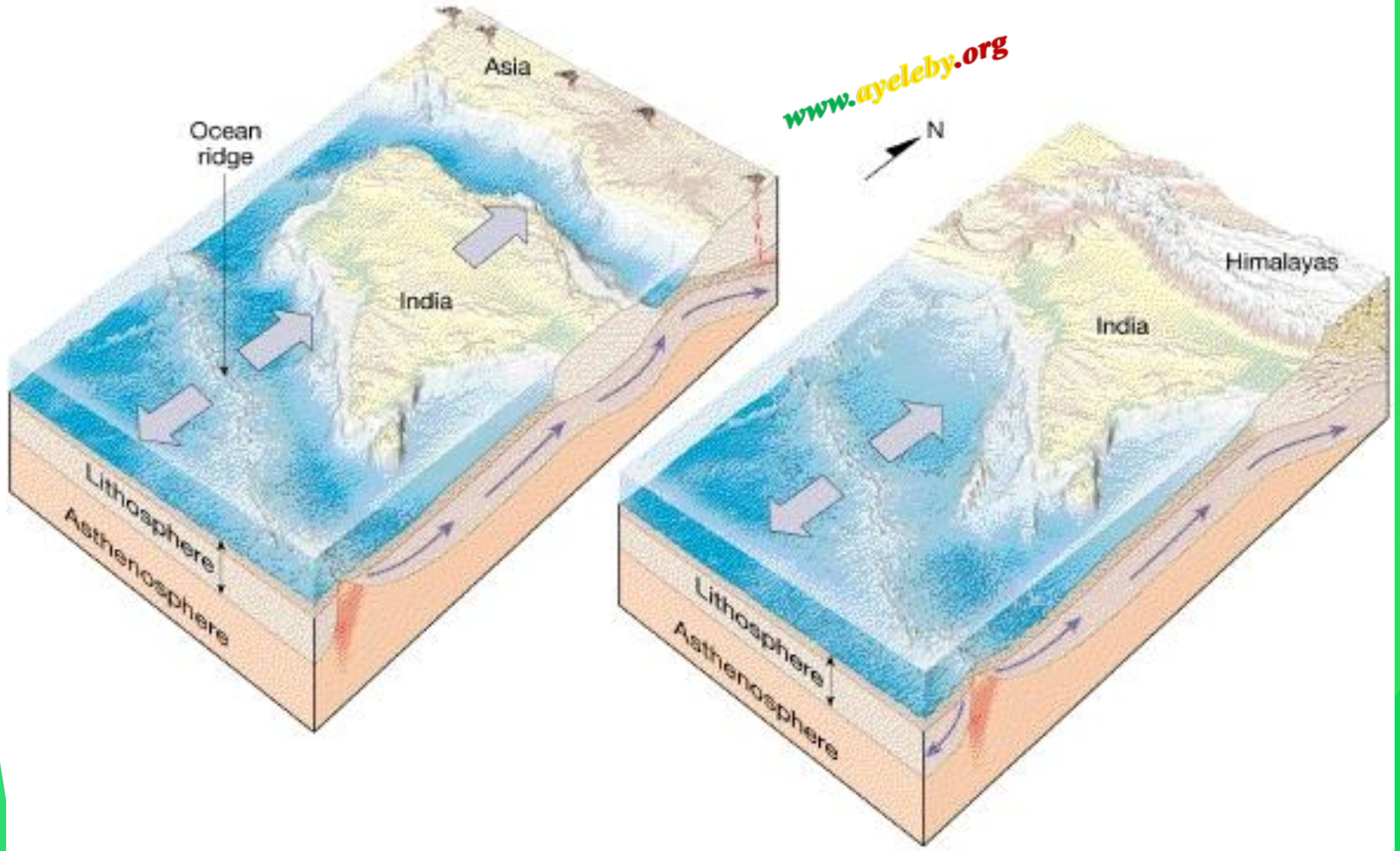
The collision of India and Asia produced the Himalayas



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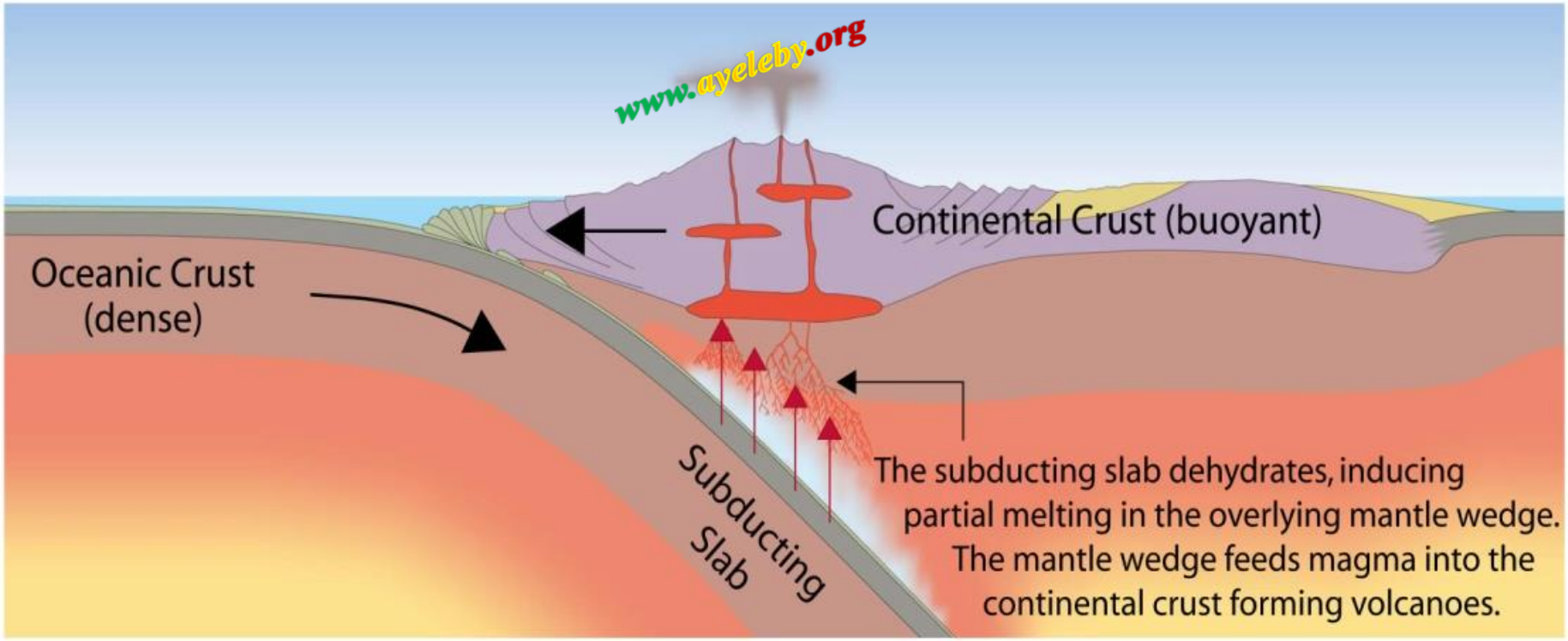
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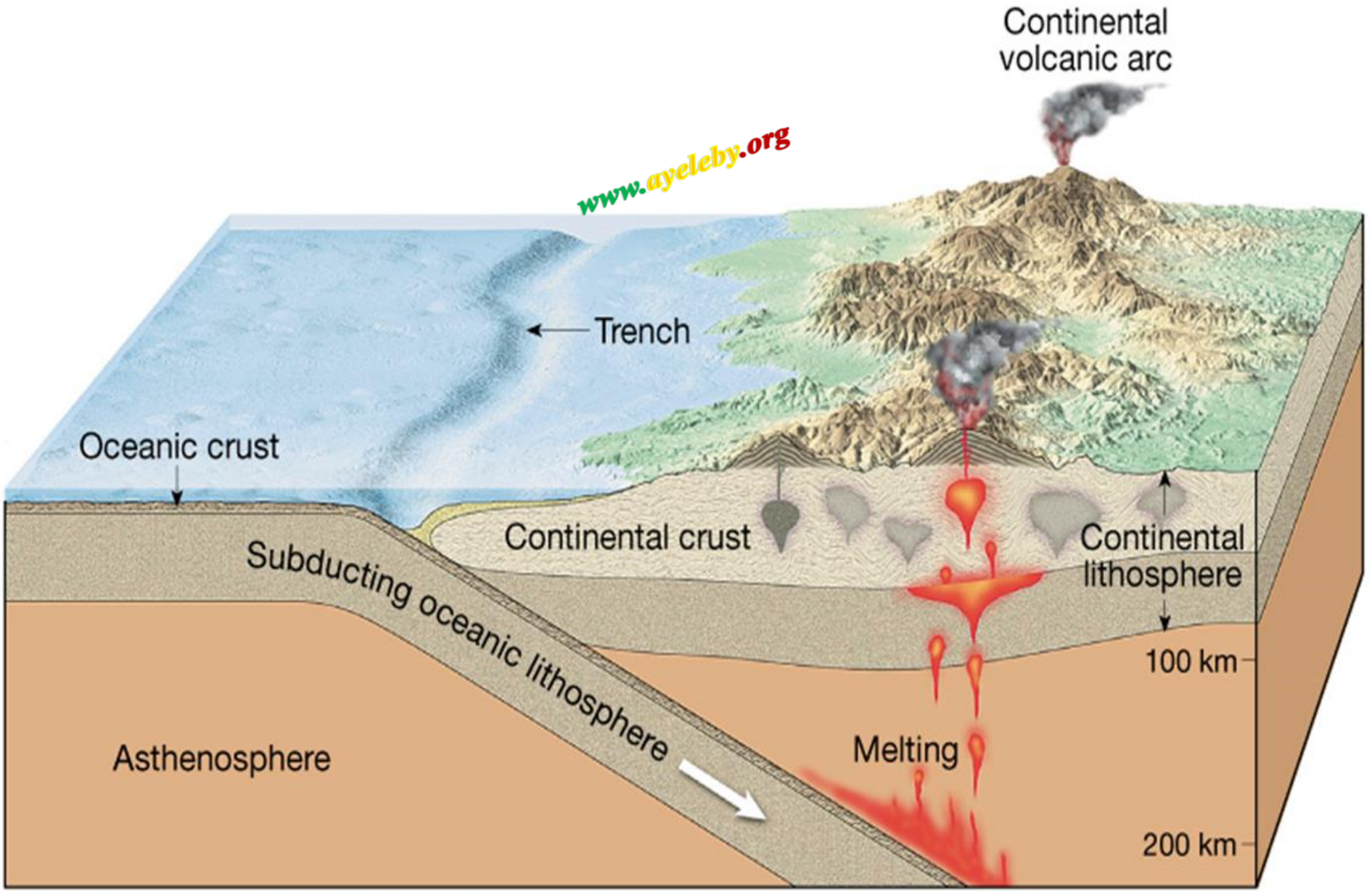
Continental Crust (buoyant)
Oceanic Crust
(dense)
Subducting
Slab
The subducting slab dehydrates, inducing
partial melting in the overlying mantle wedge.
The mantle wedge feeds magma into the
continental crust forming volcanoes.



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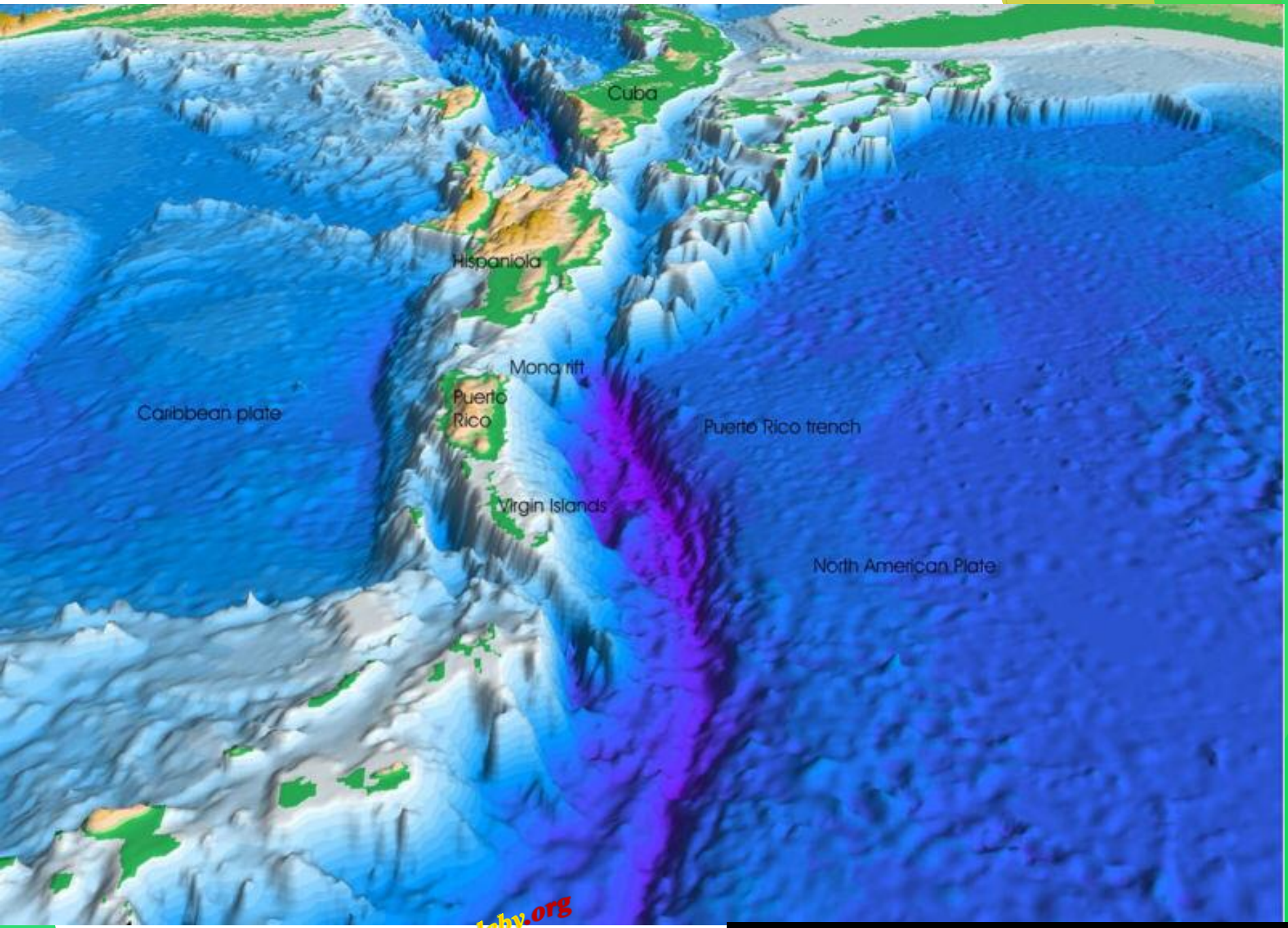

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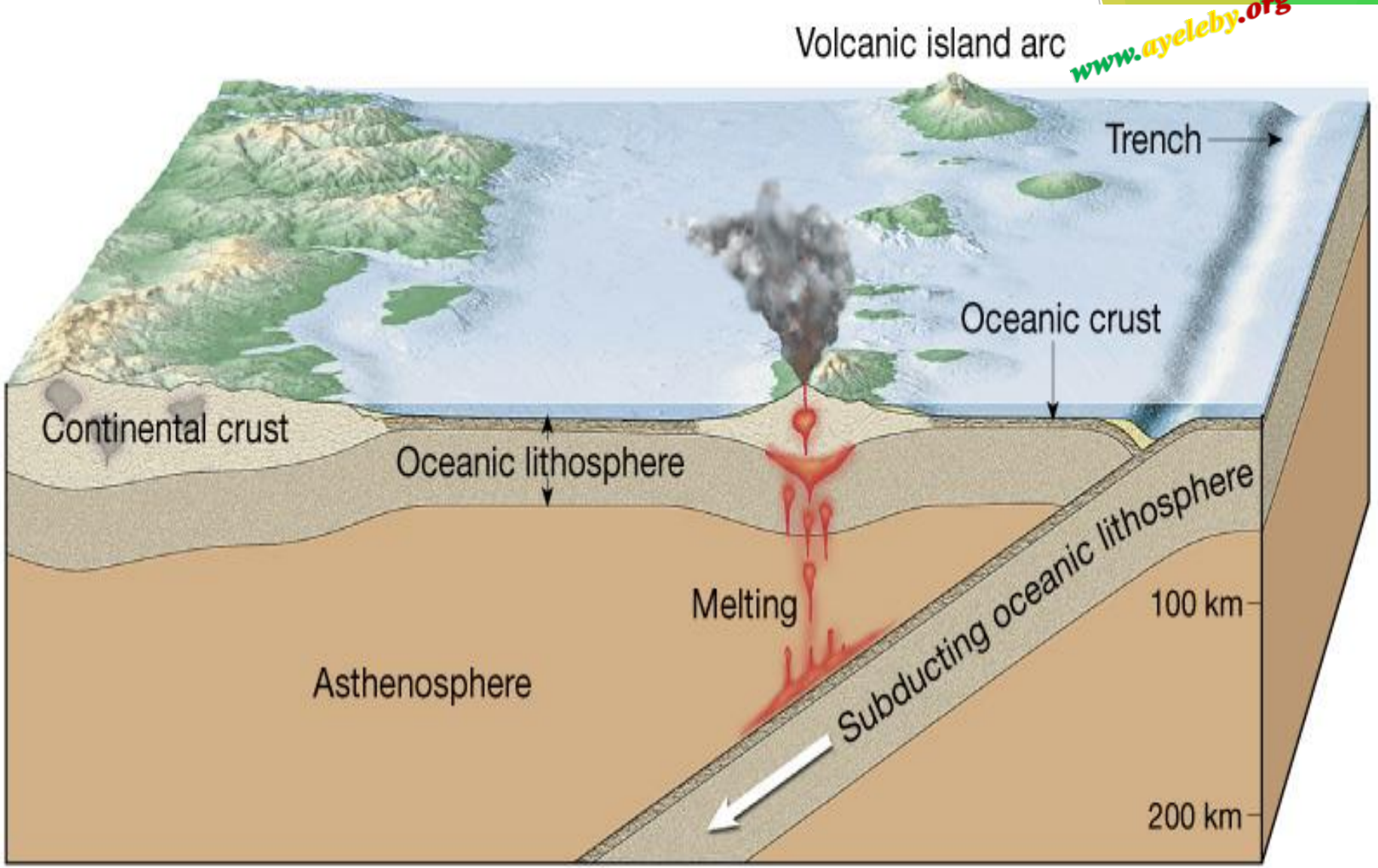

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Transform Boundaries

- **Transform boundaries** occur where ***plates slide laterally past one another*** at ***right angles*** to a sea-floor spreading centre, neither diverging nor converging, and usually with no volcanic eruptions.
- Plates slide past each other at transform boundaries; lithosphere is neither destroyed nor created.
- The ***San Andreas Fault,*** California is a ***transform boundary*** that separates the ***North American*** and ***Pacific*** Plates

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- ***Most join two segments of a mid-ocean ridge as parts of prominent linear breaks in the oceanic crust known as fracture zones***
- **A few (the San Andreas fault and the Alpine fault of New Zealand) cut through continental crust**



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