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General Knowledge

CSS-PMS

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(GK Expert)

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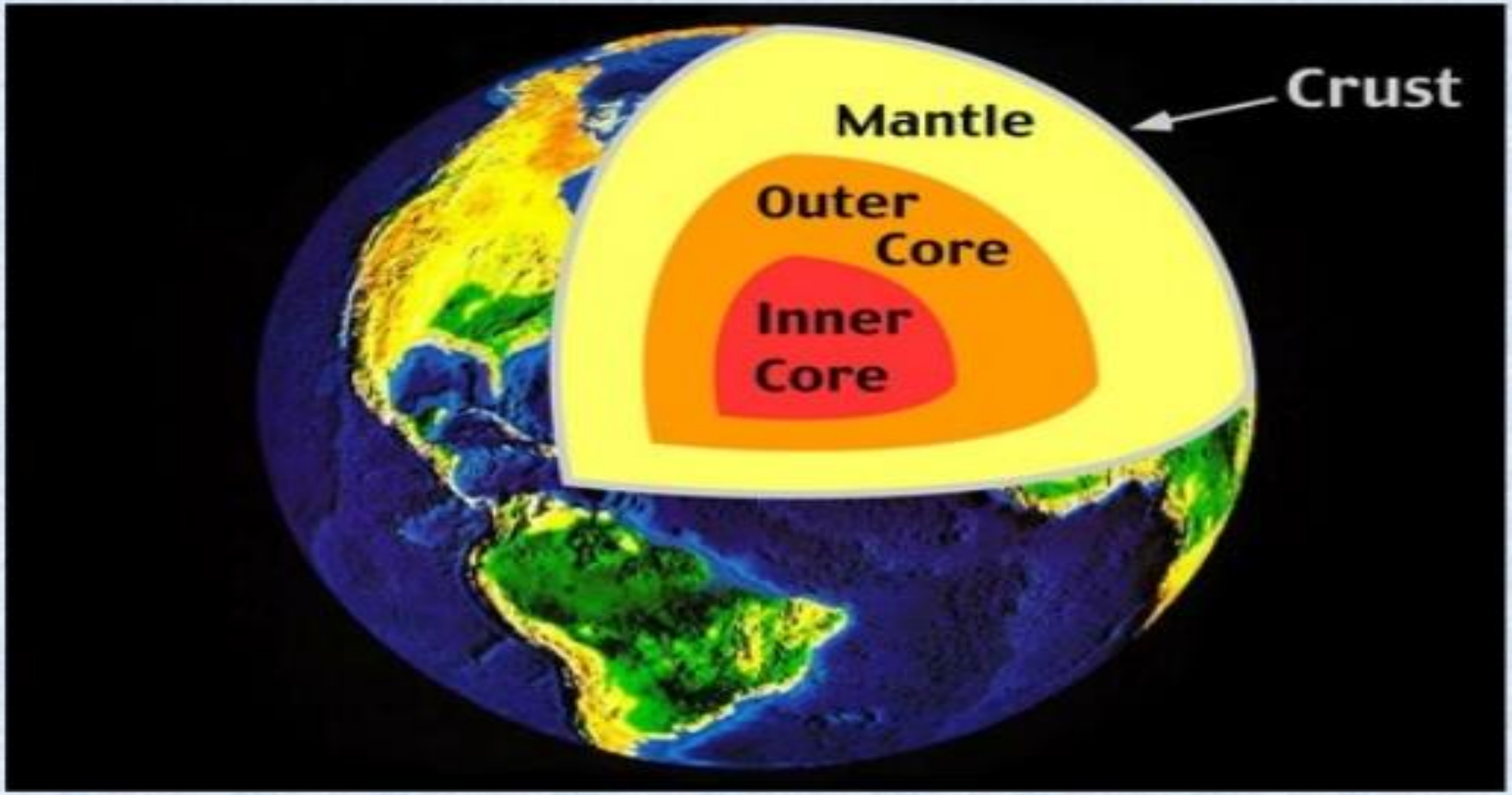
Earth Structure

Section 1.1

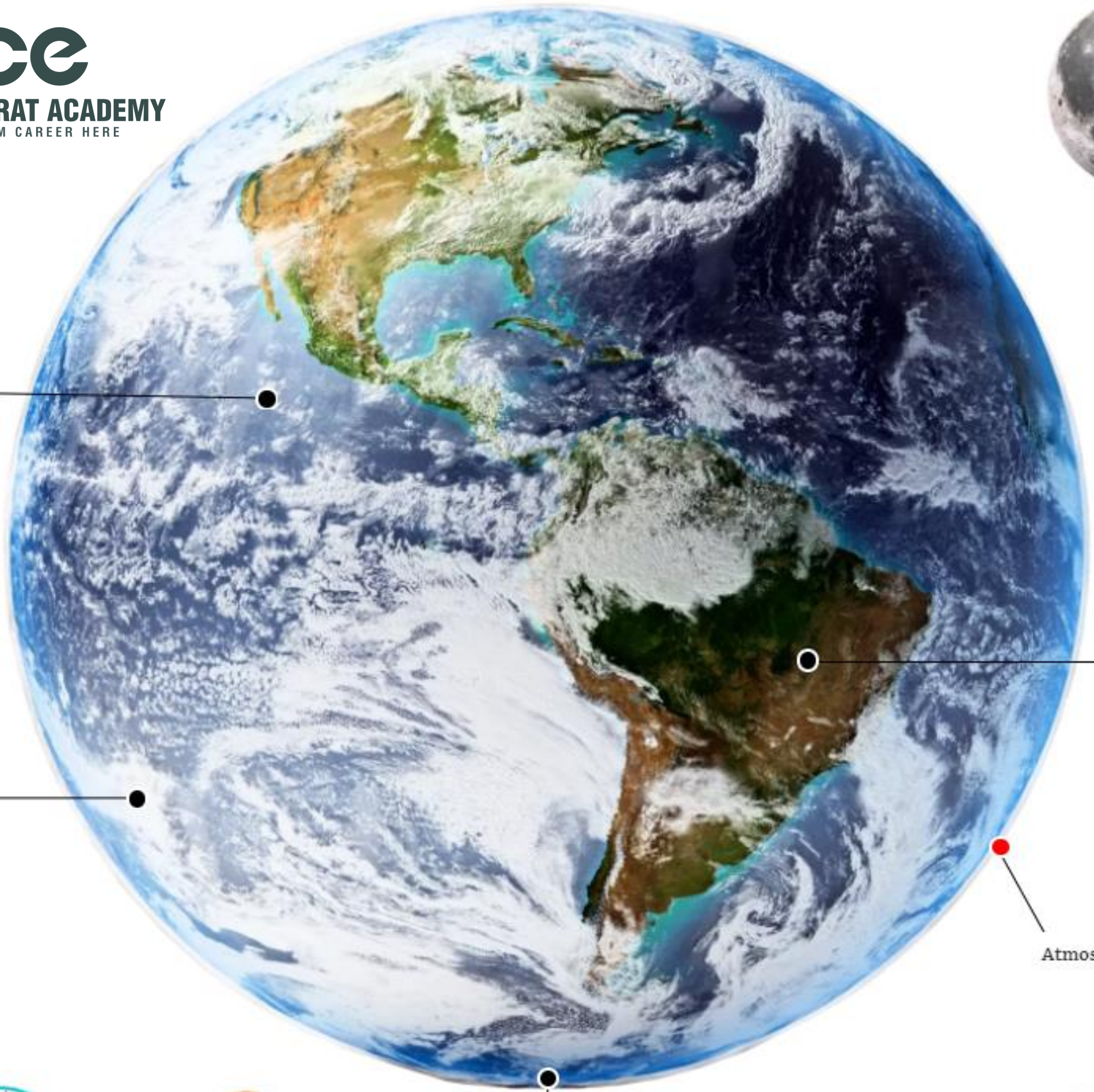
Earth Has Several Layers

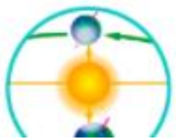


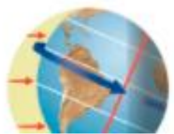
Earth

The third planet from the Sun, Earth is the only planet in the universe known to support life. It has two things that are vital for living creatures: an atmosphere rich in oxygen, and a large supply of liquid water on its surface. Earth sits at an ideal distance from the Sun—if it were any closer, it would be so hot that water would boil away. If it were any further away, its surface would be cold and frozen, like the planet Mars.

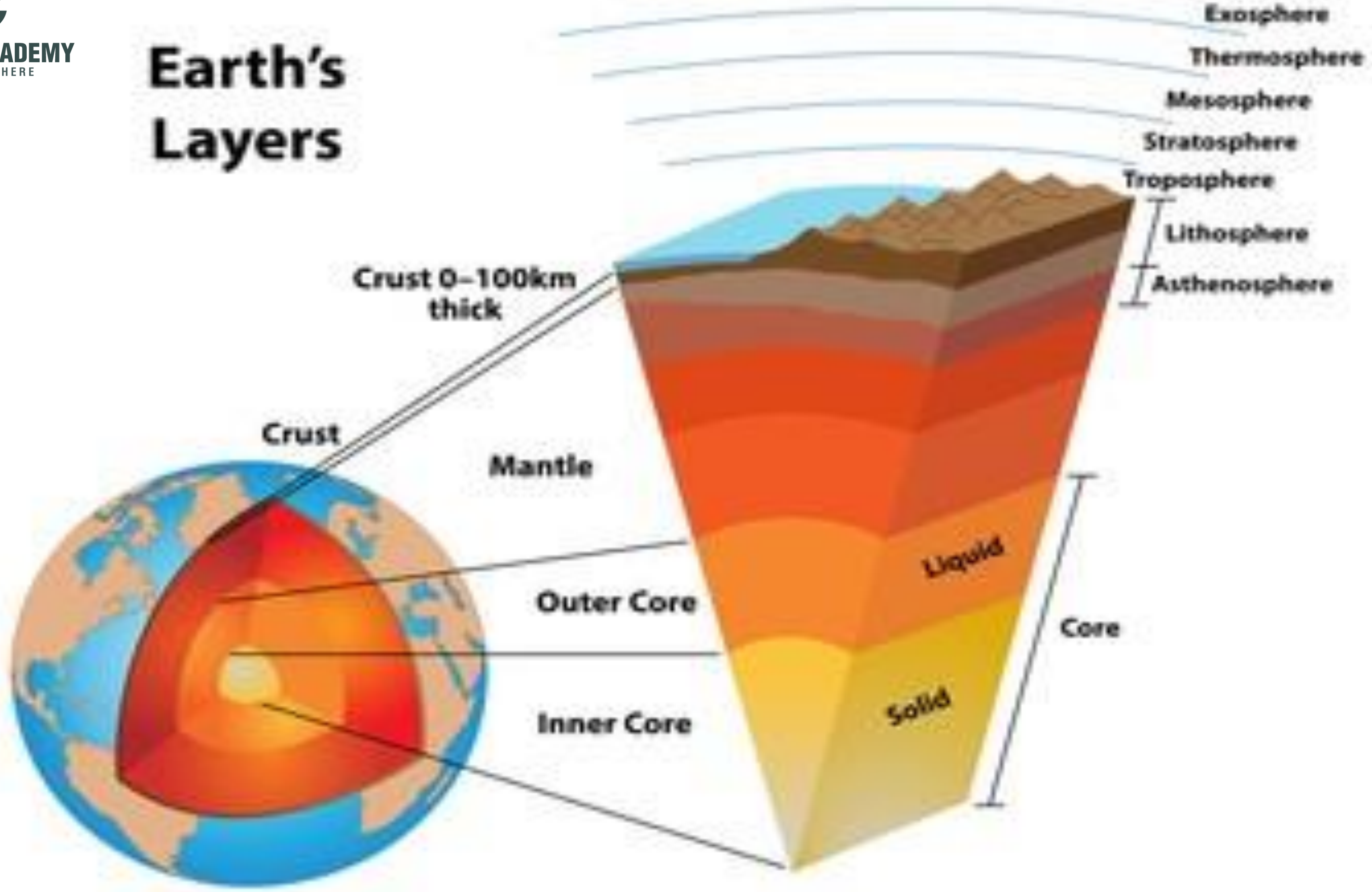
Almost three-quarters of Earth's surface is covered in water.







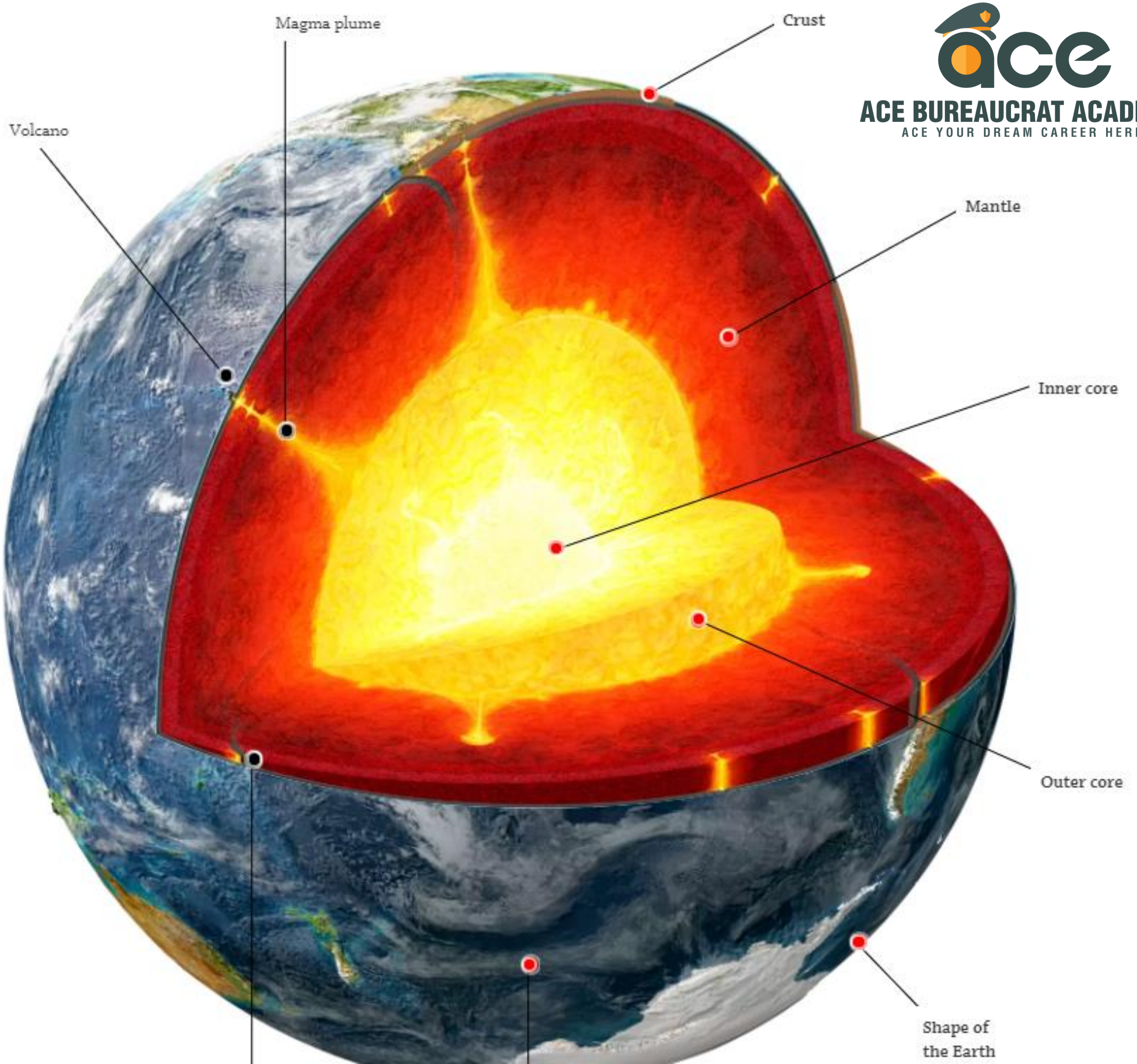
Earth's Layers



Structure of the Earth

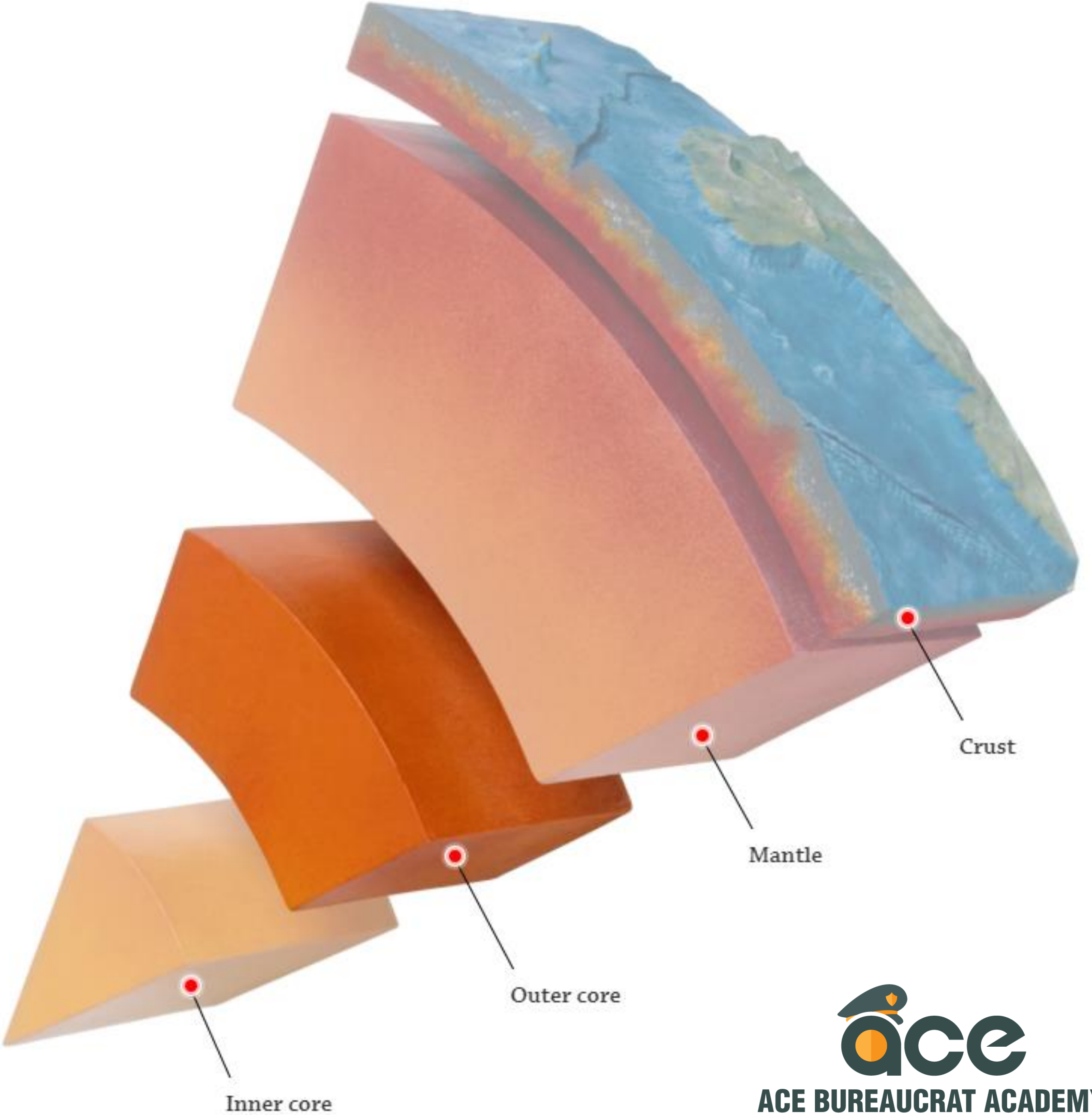
The Earth is made up of many rocky layers. The solid, outer layer is called the crust. Below the crust lies a layer of very hot, almost solid rock called the mantle. Beneath the mantle lies the core. The outer core is a liquid mix of iron and nickel, but the inner core is solid metal. Sometimes, hot molten rock, called magma, bursts through Earth's surface in the form of a volcano.

Earth's inner core is as hot as the surface of the sun—about 10,000°F (5,500°C).



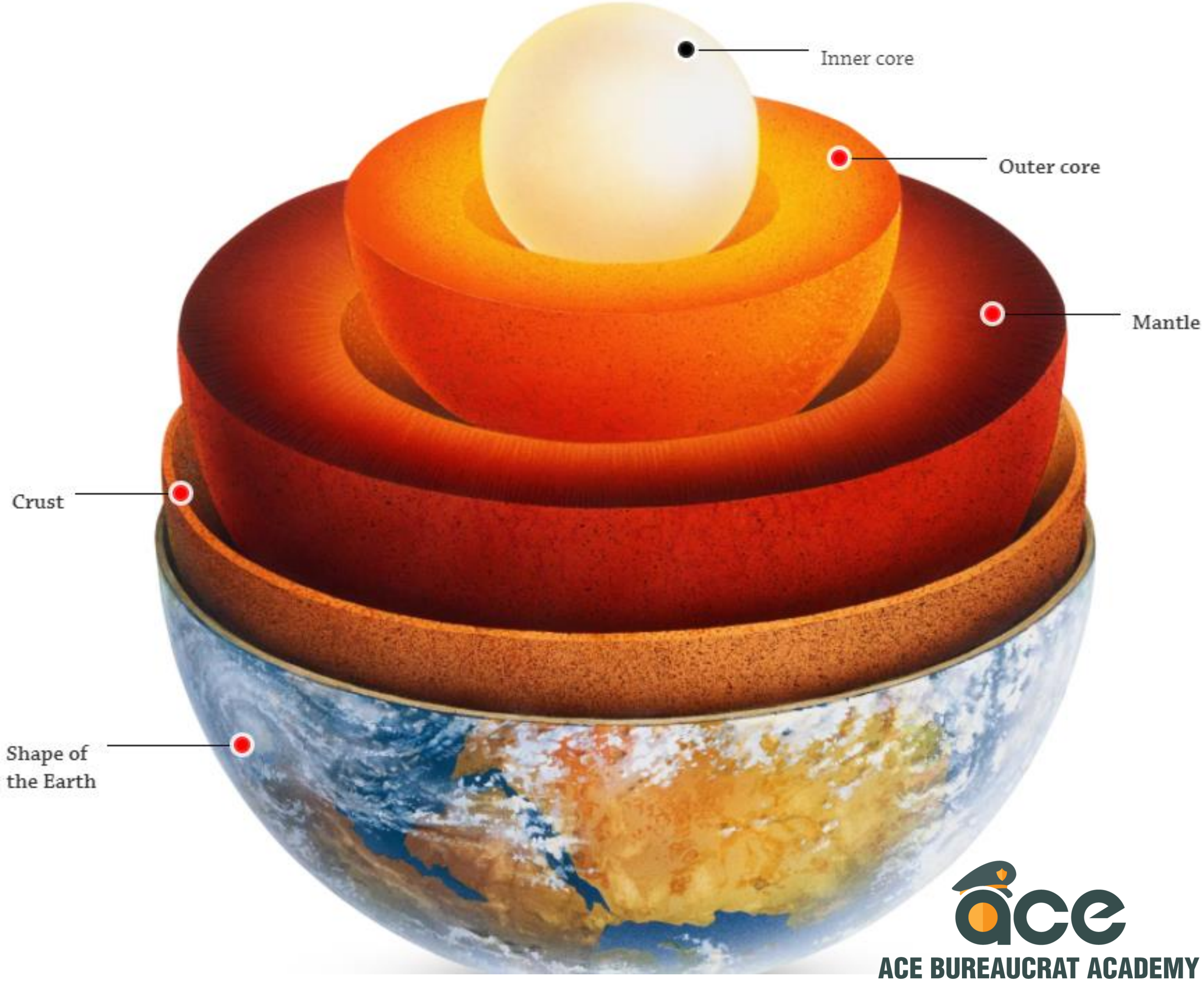
Outer core

The center of the Earth is made up of two layers, the outer core and the inner core. The outer core is the third layer of the Earth. It is the only liquid layer, and is mainly made up of the metals iron and nickel, as well as small amounts of other substances. The outer core is responsible for Earth's magnetic field. As Earth spins on its axis, the iron inside the liquid outer core moves around. The movement causes powerful electric currents to develop in the liquid iron itself. These powerful currents cause lines of invisible force to stretch around the Earth and thousands of miles into space, creating a magnetic field. The magnetic field protects the Earth from harmful particles that come from the Sun.



Inner core

The inner core is the fourth layer inside the Earth. It is a solid metallic ball made mainly of iron. Here, temperatures reach extraordinary levels, estimated to be between 7,200–8,500°F (4,000–4,700°C). Although the inner core is very hot, it is not liquid like the outer core. The inner core is solid due to the pressure caused by the weight put on it by the Earth's other three layers, the crust, the mantle, and the outer core.



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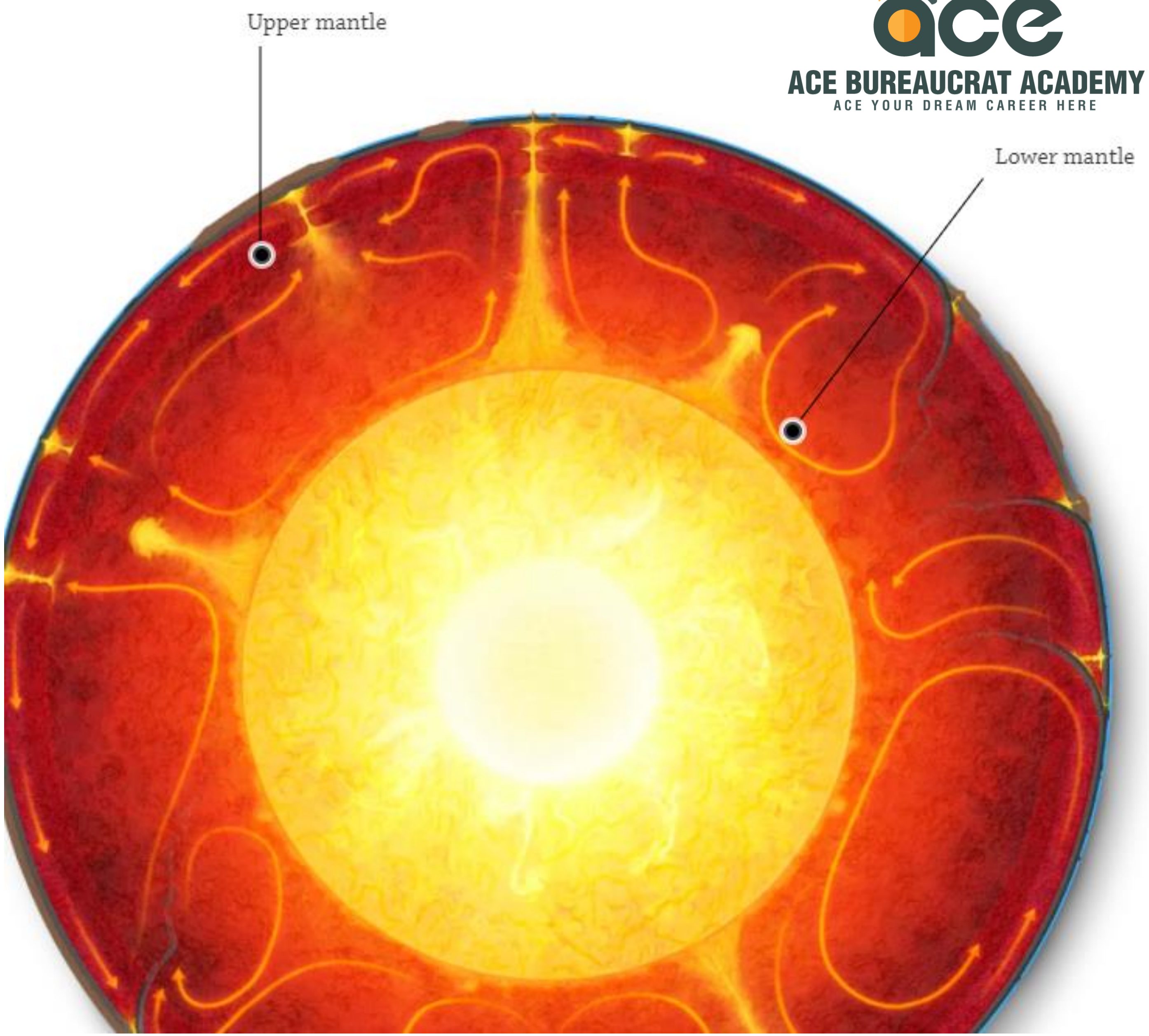
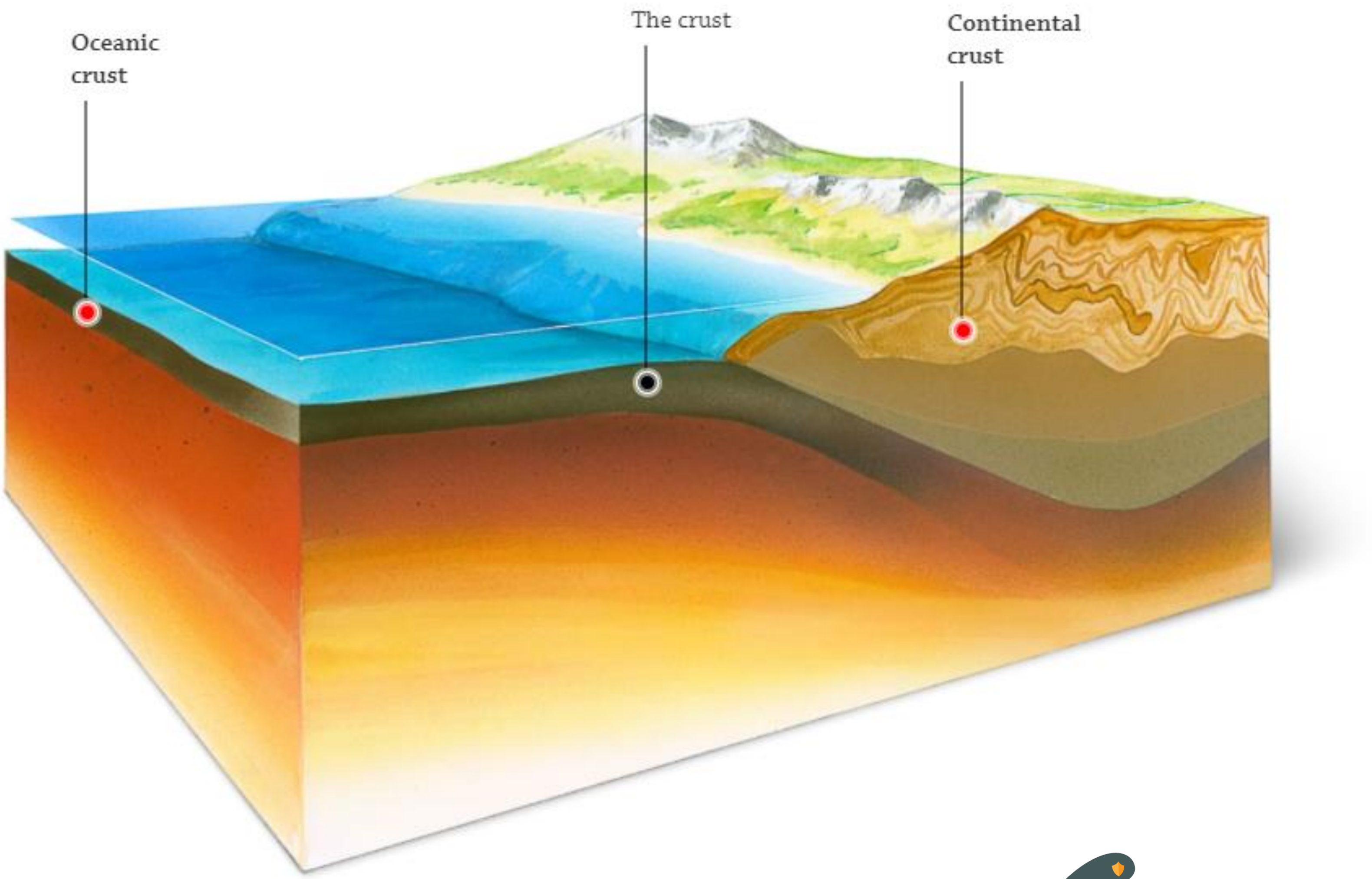
Mantle

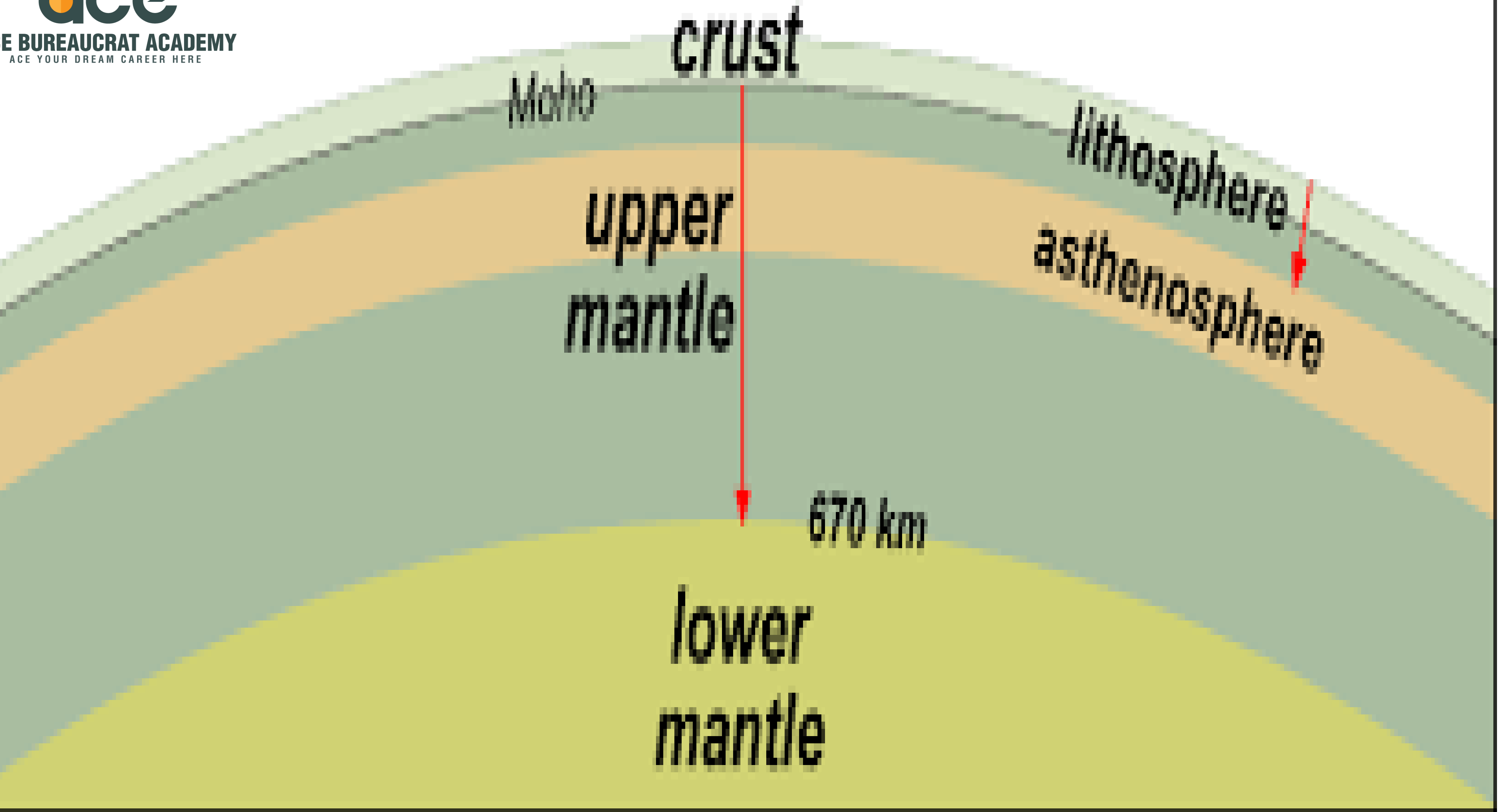
The mantle is Earth's second layer. The mantle has two main parts, the upper mantle and the lower mantle. The upper mantle is attached to the layer above it called the crust. Together the crust and the upper mantle form a fixed shell called the lithosphere, which is broken into sections called tectonic plates. Directly below the lithosphere is a less fixed, warmer region of the upper mantle called the asthenosphere. Here, the temperatures are so high that, in places, the rock that makes up the asthenosphere melts into liquid. Only tiny parts of the asthenosphere are liquid, but it is soft enough to move, pushing around the plates above. Rock samples from the upper mantle are occasionally brought to the surface by erupting volcanoes, allowing scientists to study them.



Crust

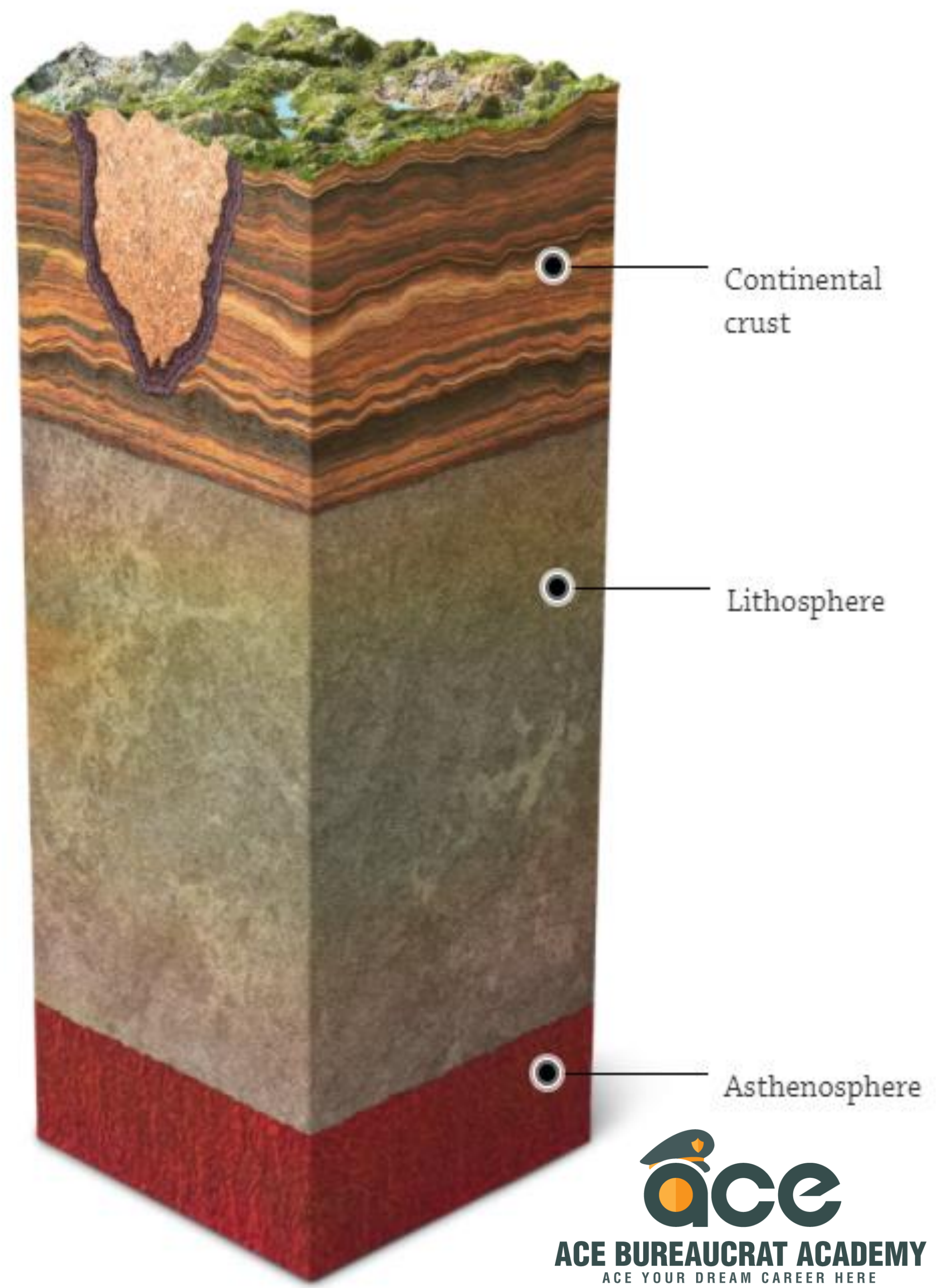
The crust is the thinnest layer of the Earth. It has an average thickness of about 18 miles (30km) below land, and around 6 miles (10km) below the oceans. The crust is the layer that makes up the Earth's surface and it lies on top of a harder layer, called the mantle. Together, the crust and the upper mantle form the Earth's outer shell. The crust is made up many types of rocks, which are lighter than the rocks that make up the mantle. There are two different types of crust. The continental crust makes up the land on Earth. The oceanic crust forms Earth's oceans. The continental crust is thicker than the oceanic crust, while the oceanic crust is thinner and denser, meaning that the rocks it is made up from are more closely packed together.




crust
Moho
lithosphere
upper
mantle
asthenosphere
670 km
lower
mantle

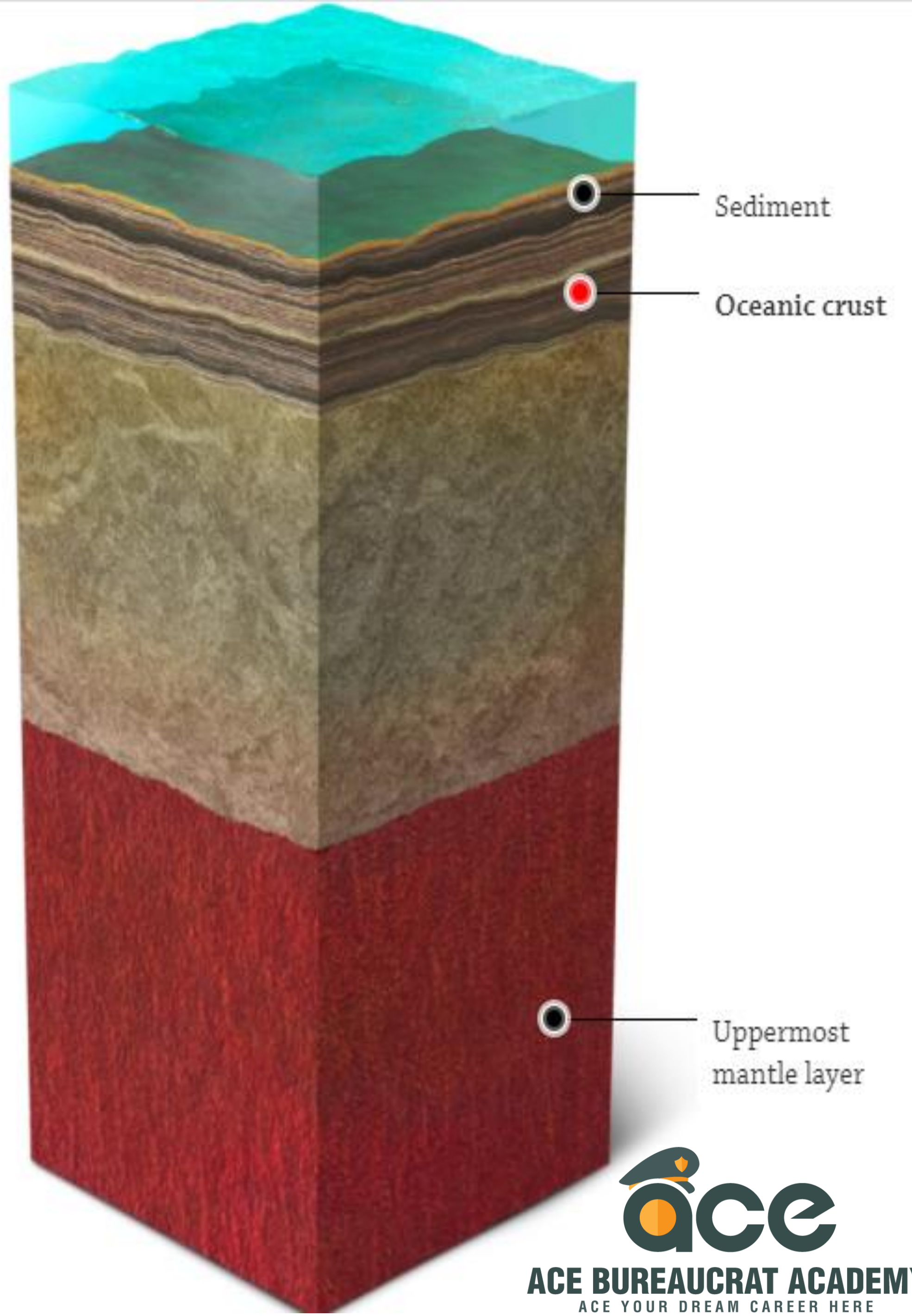
Continental crust

The crust is separated into two layers, the continental crust and the oceanic crust. The continental crust forms one-third of the Earth's surface, and makes up all of the dry land found on Earth. The continental crust varies in thickness between 6 and 43 miles (25 and 70km). It is made up of a variety of rock types, all of which are lighter than the denser, more tightly packed rocks found in the oceanic crust. Some of the rocks in the continental crust are up to 4 billion years old. This is because Earth does not replace the rocks in its continental crust from the mantle as often as its does the oceanic crust.



Oceanic crust

The crust is the first, and thinnest, layer of the Earth. It is separated into two different types: the oceanic crust and the continental crust. The oceanic crust forms two-thirds of the Earth's surface and makes up the ocean floor. It varies in thickness from 4 to 7 miles (6 to 11km). It is made up of only a few types of volcanic or igneous rock. Unlike the continental crust, the oceanic crust is continually recycled by the layer below it, called the mantle. The movement of the oceans causes the oceanic crust to pull up rocks from the mantle underneath it. As a result, the oceanic crust is no more than 200 million years old, whereas the continental crust, in places, can be billions of years old.



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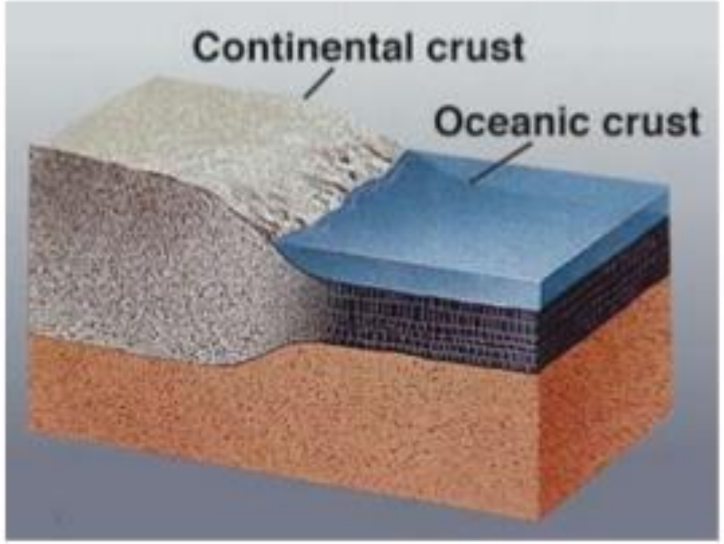
Structure of the Earth

The Crust

- This is where we live!
- Outermost layer
- 5 – 100 km thick
- Made of Oxygen, Silicon, Aluminum
- The Earth's crust is made of:
  - **Continental Crust**
    - thick (10-70km)
    - buoyant (less dense than oceanic crust)
    - mostly old
  - **Oceanic Crust**
    - thin (~7 km)
    - dense (sinks under continental crust)
    - young



QUESTIONS?

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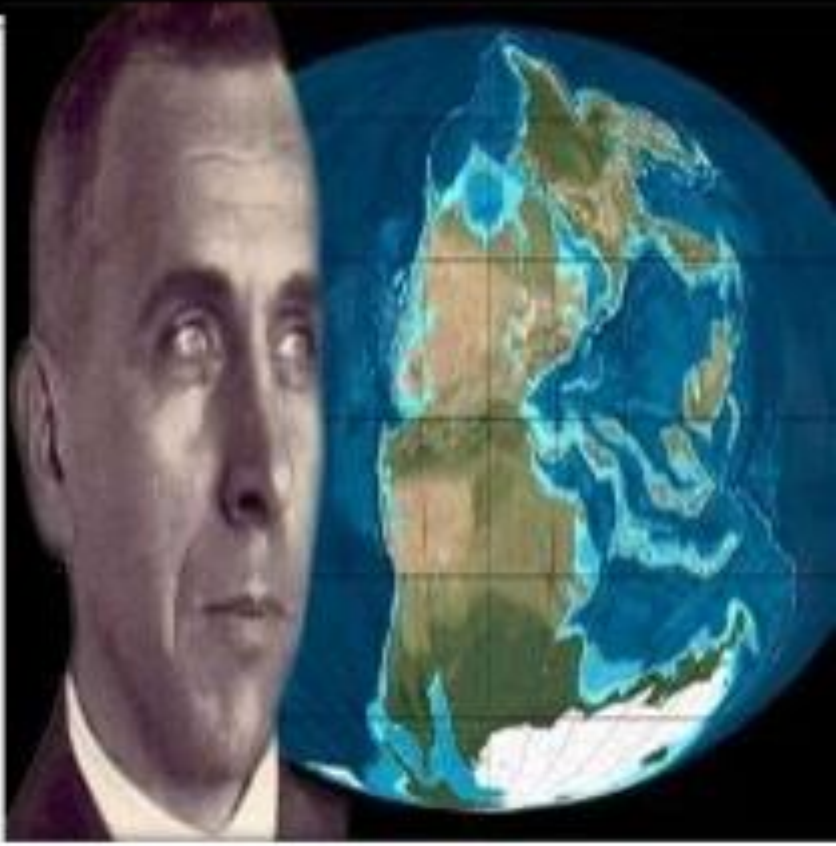
- How the lands and seas were distributed in past?
- Did the world occupy the same position in past as we see them on map today?
- How the map of ancient world look like?

THEORIES OF PALEOGEOGRAPHY

- Theory of continental drift.
- Theory of plate Tectonics

Theory of continental drift



- German Meteorologist Alfred Wegner proposed this theory in 1915.
- While working on the past climate.
- He observed that there are several places where the present climate dose not correspond with that of past.

1. Either the climate has changed
2. The position of the places has been altered.

- Continental drift was Wegener's theory that all continents had once been joined together in a single landmass and have drifted apart since.
- Wegener named this supercontinent Pangaea.
- It explained that the continents seemed to fit together like puzzles.


EURASIA
NORTH AMERICA
AFRICA
SOUTH AMERICA
PACIFIC OCEAN
before
EUROPE
NORTH AMERICA
ATLANTIC OCEAN
AFRICA
PACIFIC OCEAN
SOUTH AMERICA
after

Evidence

Wegener searched and found three main pieces of evidence

Geologic – evidence in the layers of rocks across continents

Fossil – evidence in the places certain fossils are found

Climate – evidence in the changing climates during the past

Wegener's problem

He could not find the force that was causing the continents to drift.
Because of this, he could not convince anyone that continents could move.
He died in Greenland on an expedition.
At the time of his death, no one believed his hypothesis!

Technology developed during the 1940's changed all that!

Plate Tectonics

The convective flows of Mantle material cause the Crust and some portion of the Mantle, to slide on the hot molten outer core. This sliding of Earth's mass takes place in pieces called *Tectonic Plates*

Plate Tectonics

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- Plate tectonics is the modern version of continental drift theory.
- In 1960s, this concept was formulated by a Canadian geophysicist J.Tozo Wilson.
- The Earth's lithosphere is composed of seven or eight major plates depending on how they are defined and many minor plates.
- Lithosphere is outer layer 100km of earth crust.
- Below this semi molten or hot material layer known as asthenosphere.
- it is not the continents that are moving, but the "plates" of lithosphere "floating" in effect on the asthenosphere

- Earthquakes, volcanicactivity, mountainbuilding and oceanic trench formation occur along these plate boundaries.
- The relative movement of the plates typically ranges from zero to 100 mm annually.
- Tectonic plates are able to move because the Earth's lithosphere has greater mechanical strength than the underlying asthenosphere

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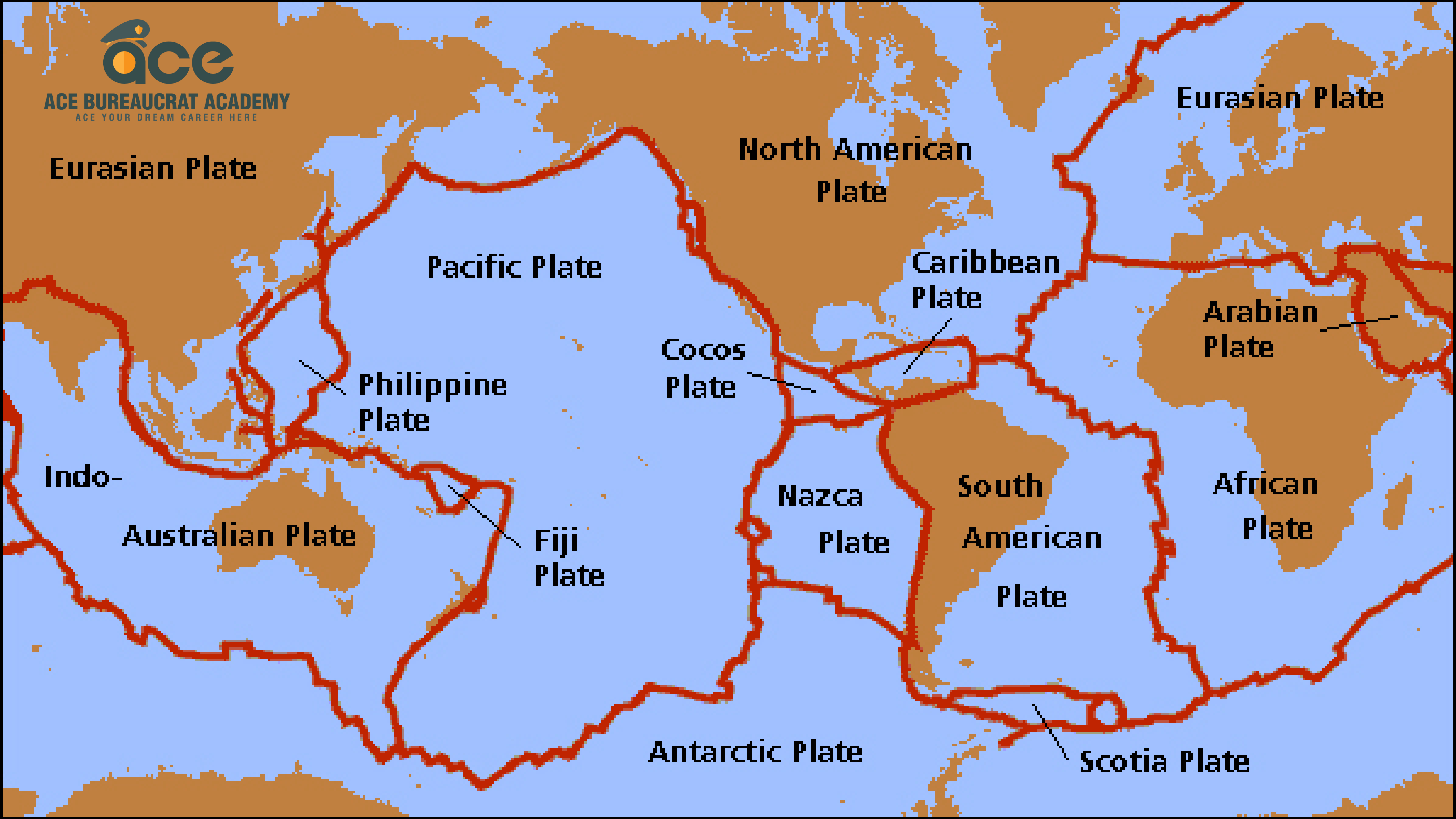
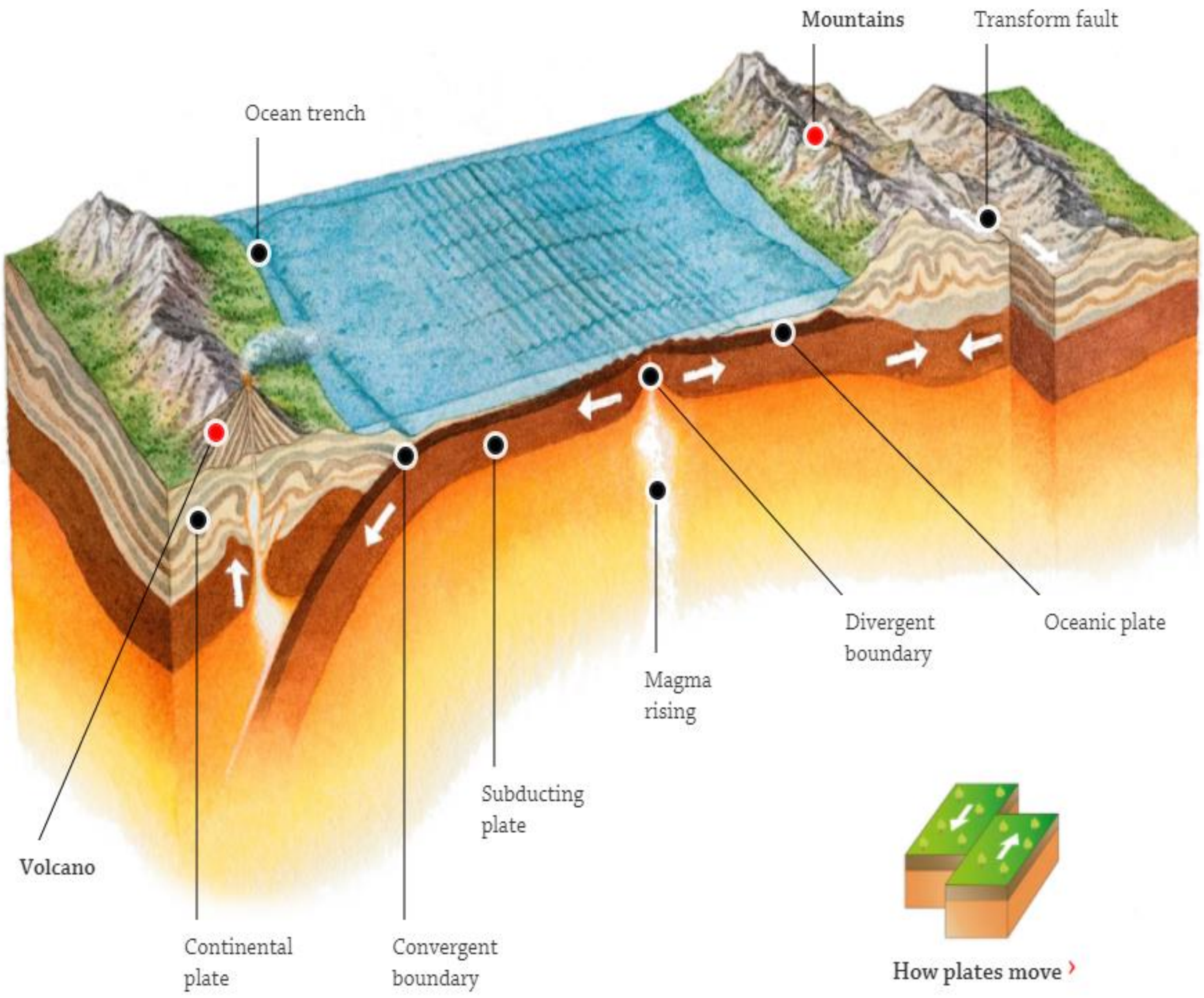


Intermediate-sized plates include the *Caribbean*, *Nazca*, *Philippine*, *Arabian*, *Cocos*, *Scotia*, and *Juande Fuca plates*. These plates, with the exception of the Arabian plate, are composed mostly of oceanic lithosphere.

Tectonic plates

Earth's surface appears to be still, but it is actually constantly on the move. Its outer shell is made up of huge slabs of moving rock called tectonic plates. The plates fit together like puzzle pieces to make up Earth's surface. Their movements change the planet's features, depending on how the plates meet. Some plates are crunching together, and may form mountains. Others are splitting apart. When this occurs under the ocean, it creates new ocean floor. Some plates grind past each other. These are the most likely to cause earthquakes.

Tectonic plates move on average about 1 in (2.5 cm) per year—this is about as fast as a fingernail grows.



How plates move ›

- The earth's crust is broken into about seven major plates, each of which behaves for the most part as a rigid body that slides over the partially molten mantle, in which deformation occurs plastically.

Tectonic earthquakes result from motion between these plates. The plates are driven by the convective motion of the material in the Earth's mantel, which in turn is driven by heat generated at the Earth's core

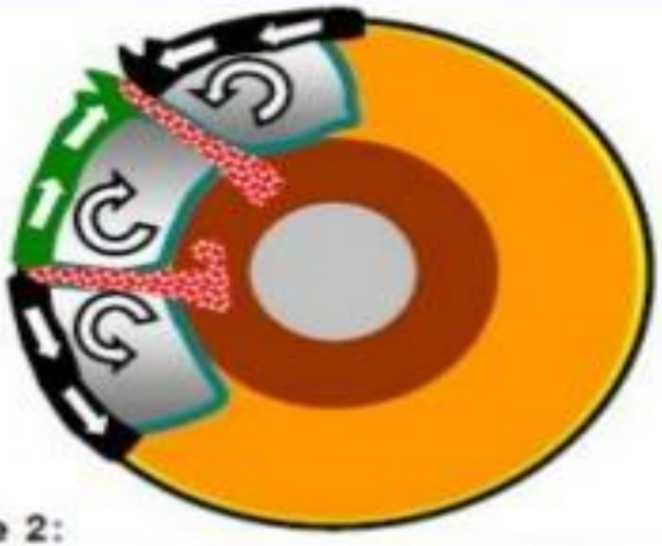
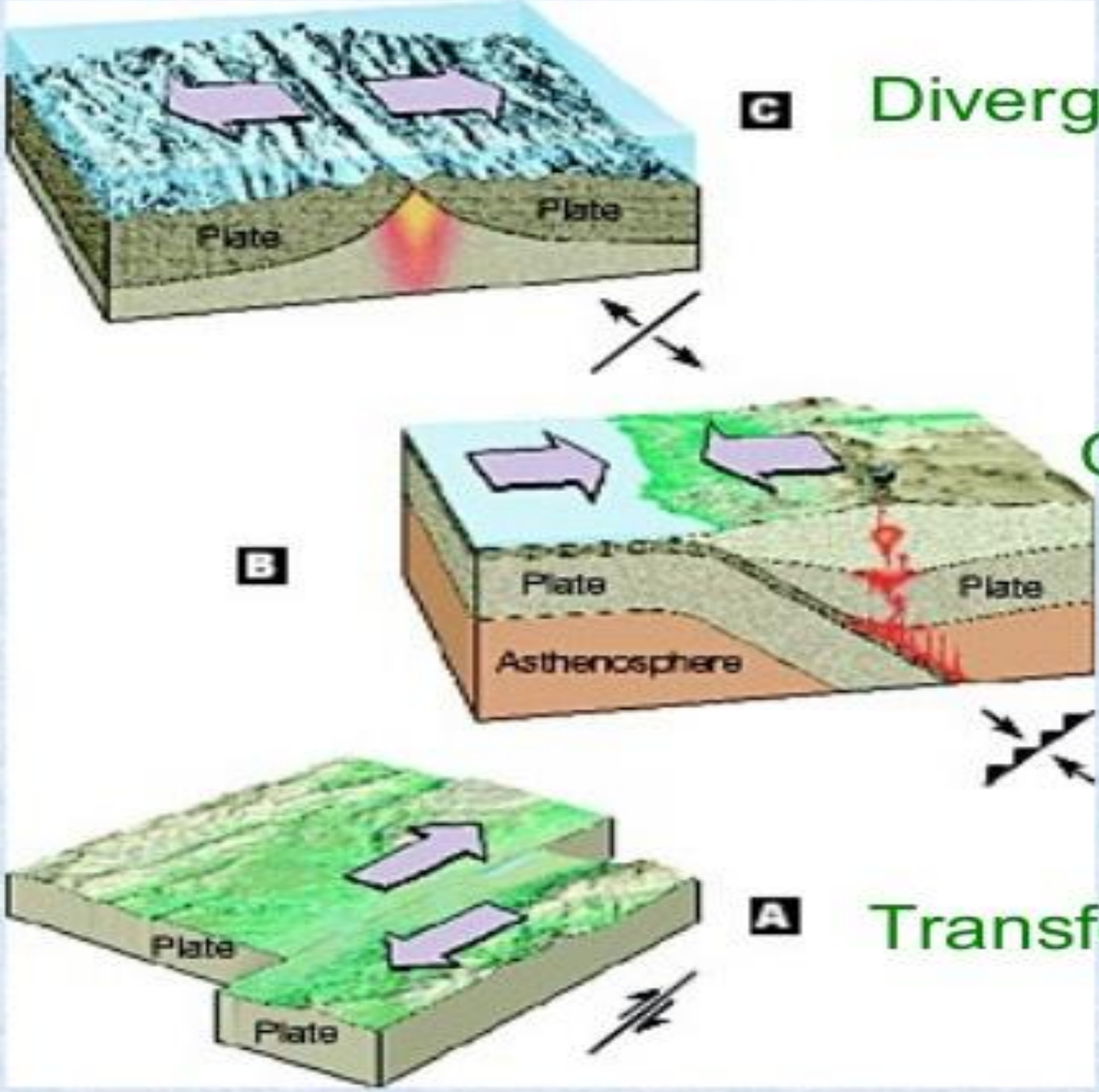


Figure 2:
Local Convective Currents in the Mantle

How plates move

The edges, or boundaries, of tectonic plates meet up in different ways. There are three main types of boundaries: transform, convergent, and divergent. At transform boundaries, plates move past each other. This is one of the most common causes of earthquakes. At convergent boundaries, plates move toward each other. They can push together and cause mountain ranges to form. At other times, one plate gets pushed down beneath the other plate. This can cause volcanoes. At divergent boundaries, plates move apart from each other. When this happens, new plate material forms.



Divergent Boundary

Convergent Boundary

Transform Boundary

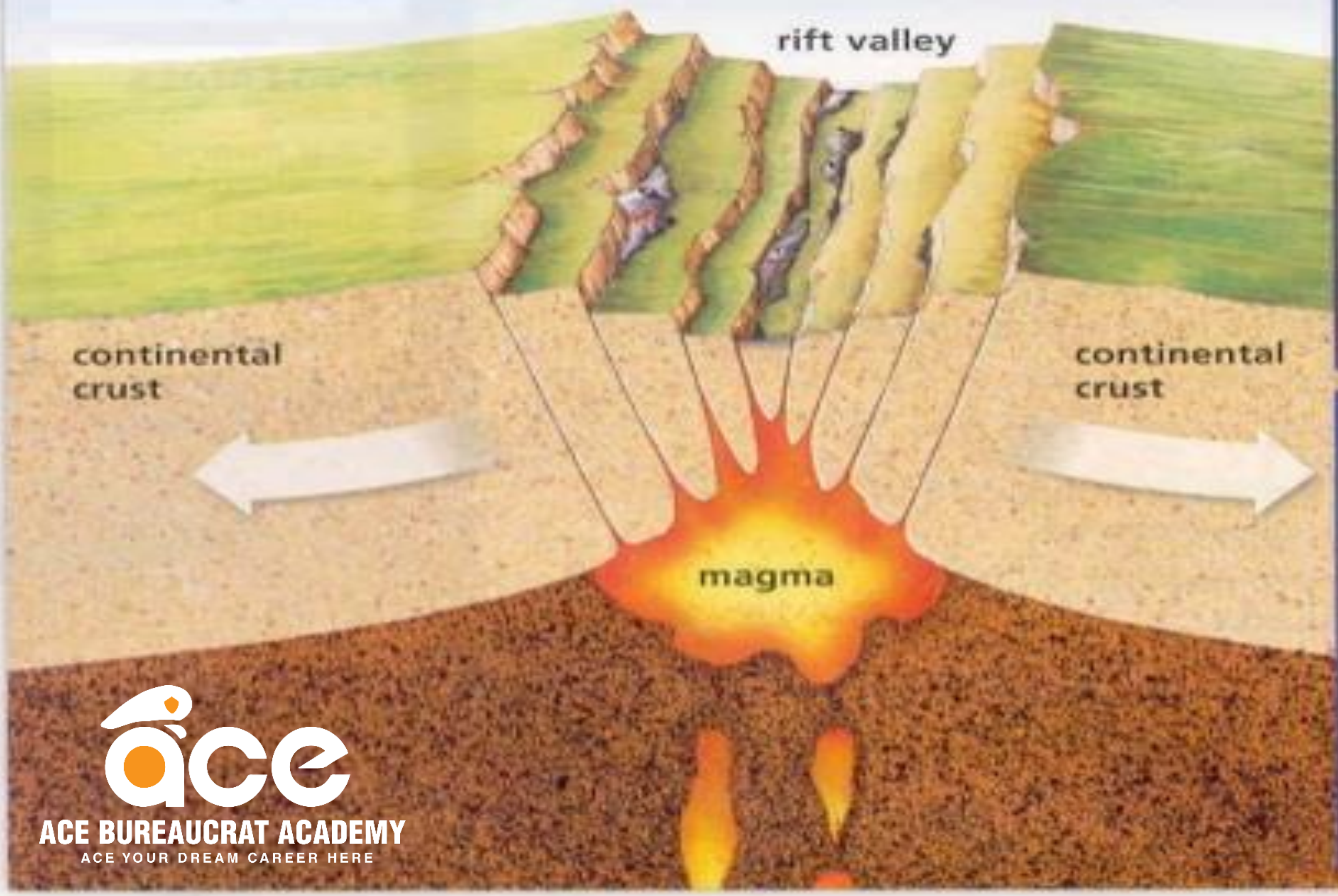
Divergent Boundary

- Regions where two tectonic plates are moving apart
- Occurs between oceanic plates, continental

Divergent Boundary on Land

See Page 26

As rift valleys widen, continents begin to split apart.



Rift Valley Widens

As the rift widens, the valley floor thins and sinks.

Valley Fills With Water

The valley floor falls below sea level, which allows water to enter.

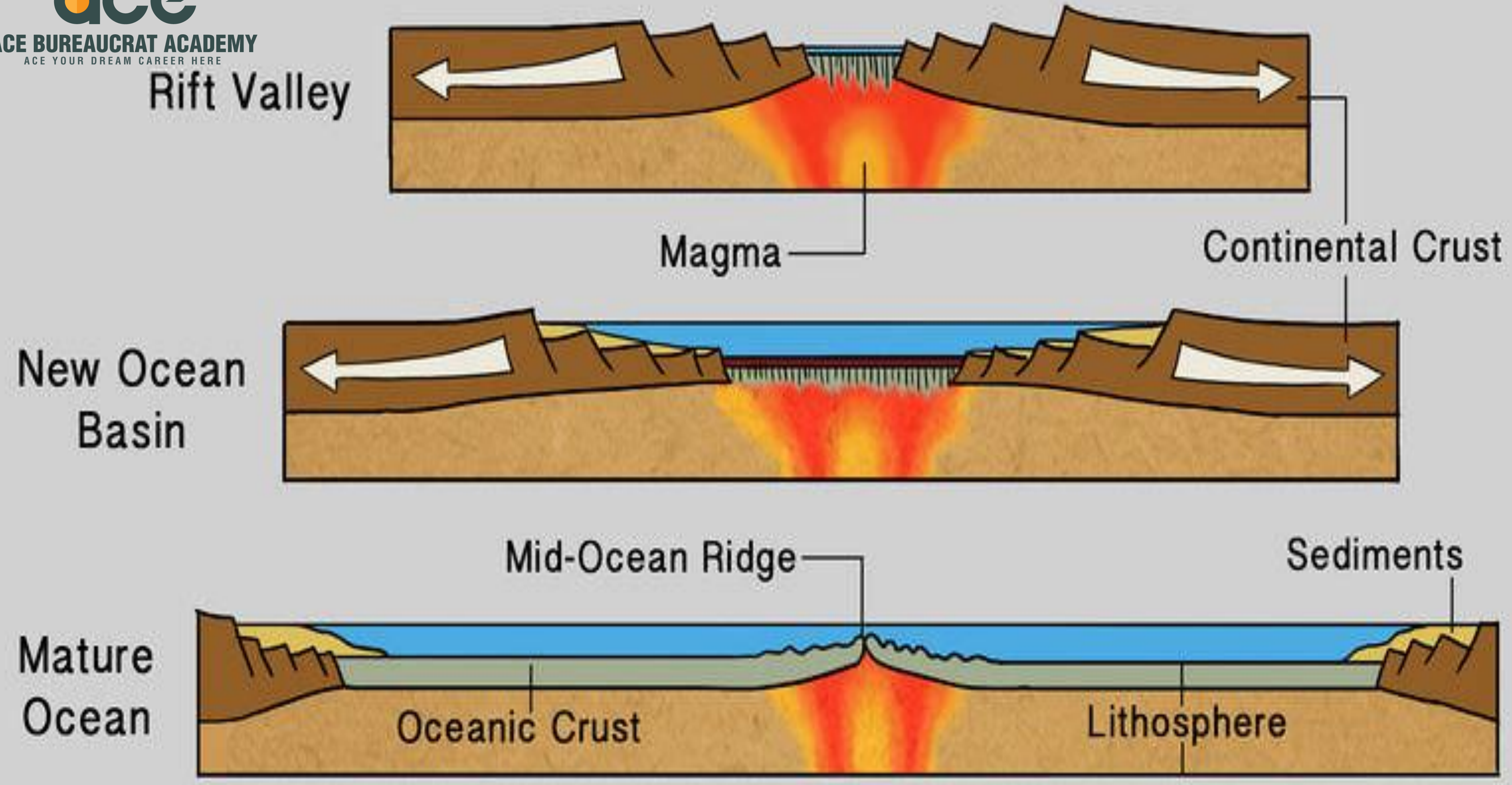

Rift Valley
Magma
Continental Crust
New Ocean
Basin
Mid-Ocean Ridge
Sediments
Mature
Ocean
Oceanic Crust
Lithosphere

Plate Divergence on Land (continental)

- A divergent plate boundary can also occur within a continent. This is called **continental rifting**. Magma rises beneath the continent. The crust **thins, breaks, and then splits apart**. This first produces a **rift valley**.
- The East African Rift is a rift valley. **Eastern Africa** is splitting away from the **African continent**. Early in the rift formation, streams and rivers flow into the low valleys and long, narrow lakes can be created. Eventually, the widening crust along the boundary may become thin enough that a **piece of the continent breaks off**, forming a **new tectonic plate i.e oceanic crust** will form. **This is how the Atlantic Ocean formed when Pangaea broke up.**

Divergent Boundary – Arabian and African Plates

Seafloor Spreading/Mid Ocean Ridges (Oceanic)

- Divergent boundaries in the middle of the ocean contribute to **seafloor spreading**. As plates made of oceanic crust pull apart, a crack in the ocean floor appears. **Magma** then oozes up from the mantle to fill in the space between the plates, forming a raised ridge called a **mid-ocean ridge**. The magma also spreads outward, forming new ocean floor and new oceanic crust.
- The rising magma causes the ridge to be buoyant. This is why there is a **mountain range** running through the oceans. The plates pulling apart cause earthquakes.
- Example
- Most mid-ocean ridges are located deep below the sea. The island of Iceland sits right on the **Mid-Atlantic ridge**

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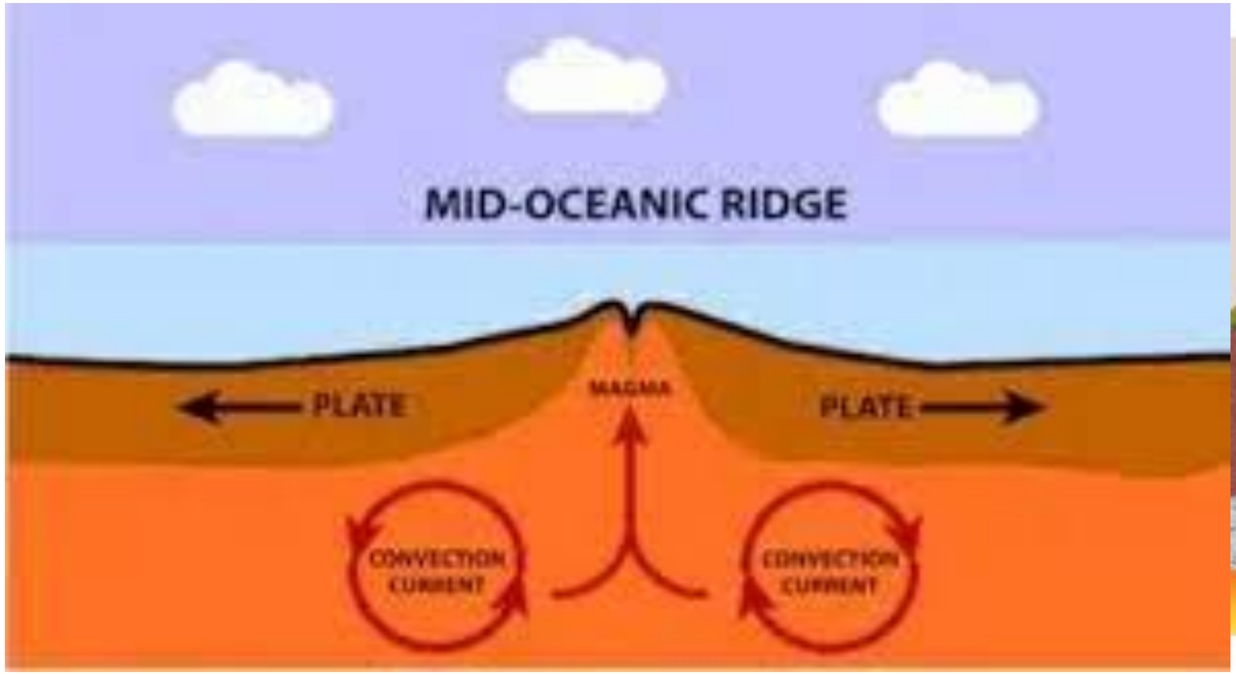
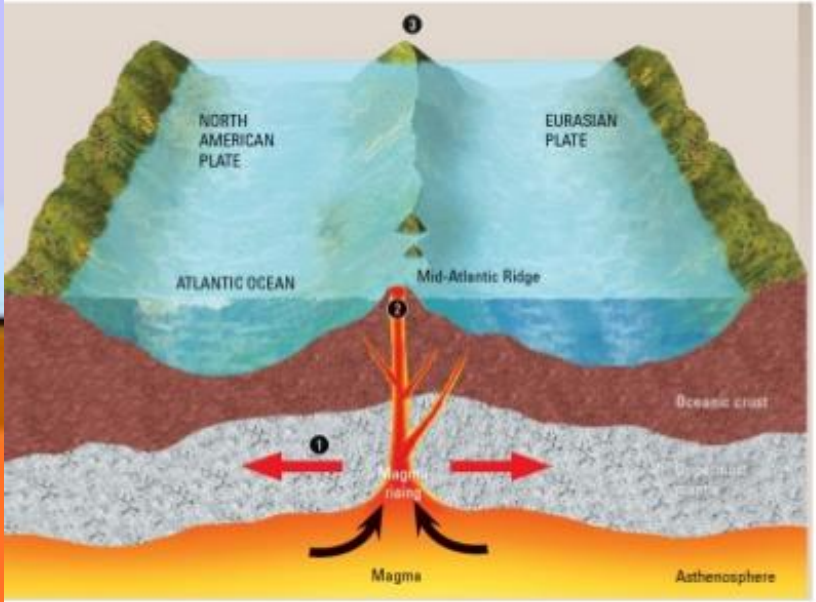
1. Oceanic-oceanic plate divergence





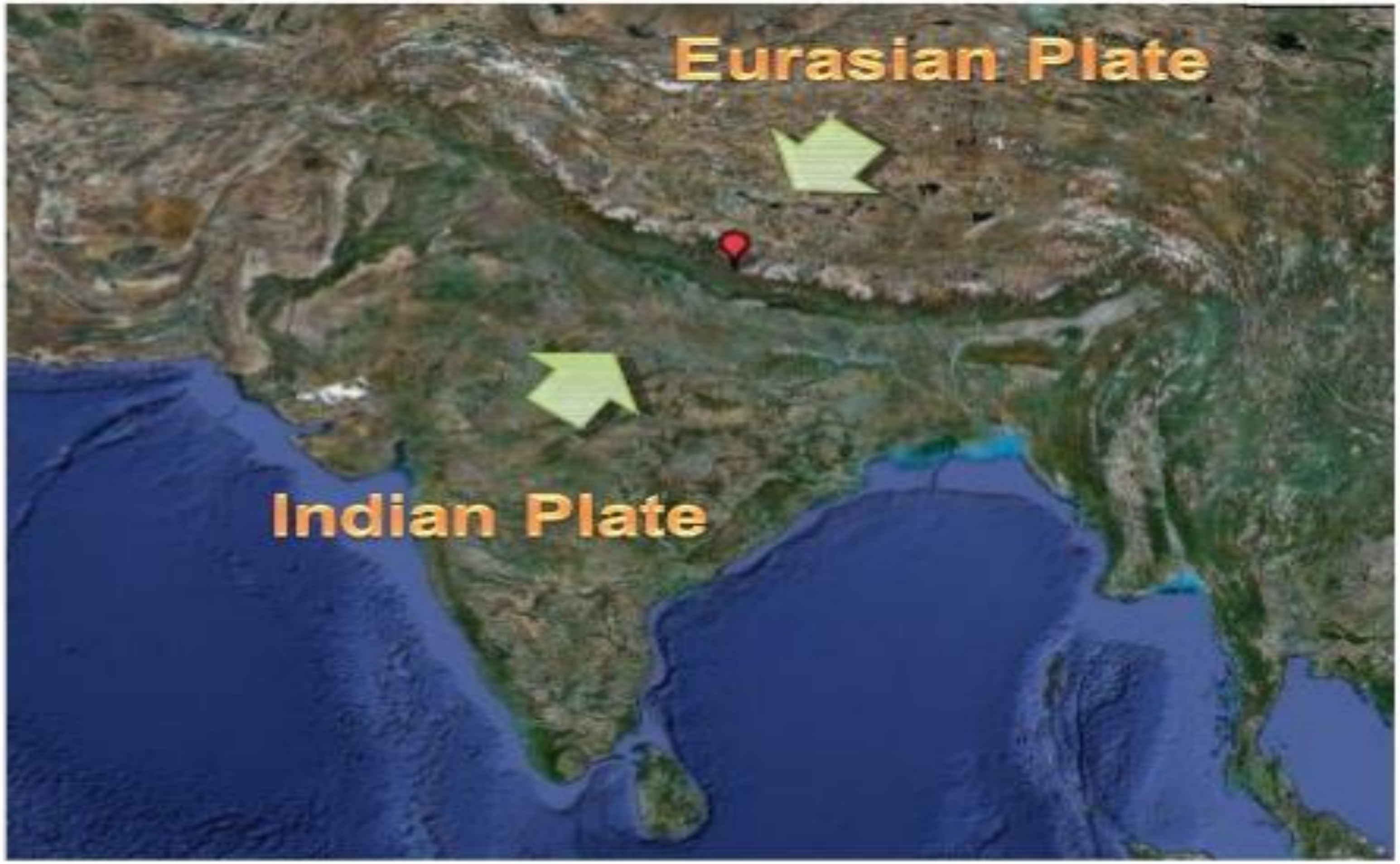
Bii) New sea floor is formed when the magma cools and solidifies. This process is called sea-floor spreading.

Bii) Magma rises at the zone of divergence/spreading zone to form a ridge of new ocean floor called mid-oceanic ridge.

Convergent Boundary

- Border formed from by the direct collision of two plates

Convergent Boundary – Indian and Eurasian Plates



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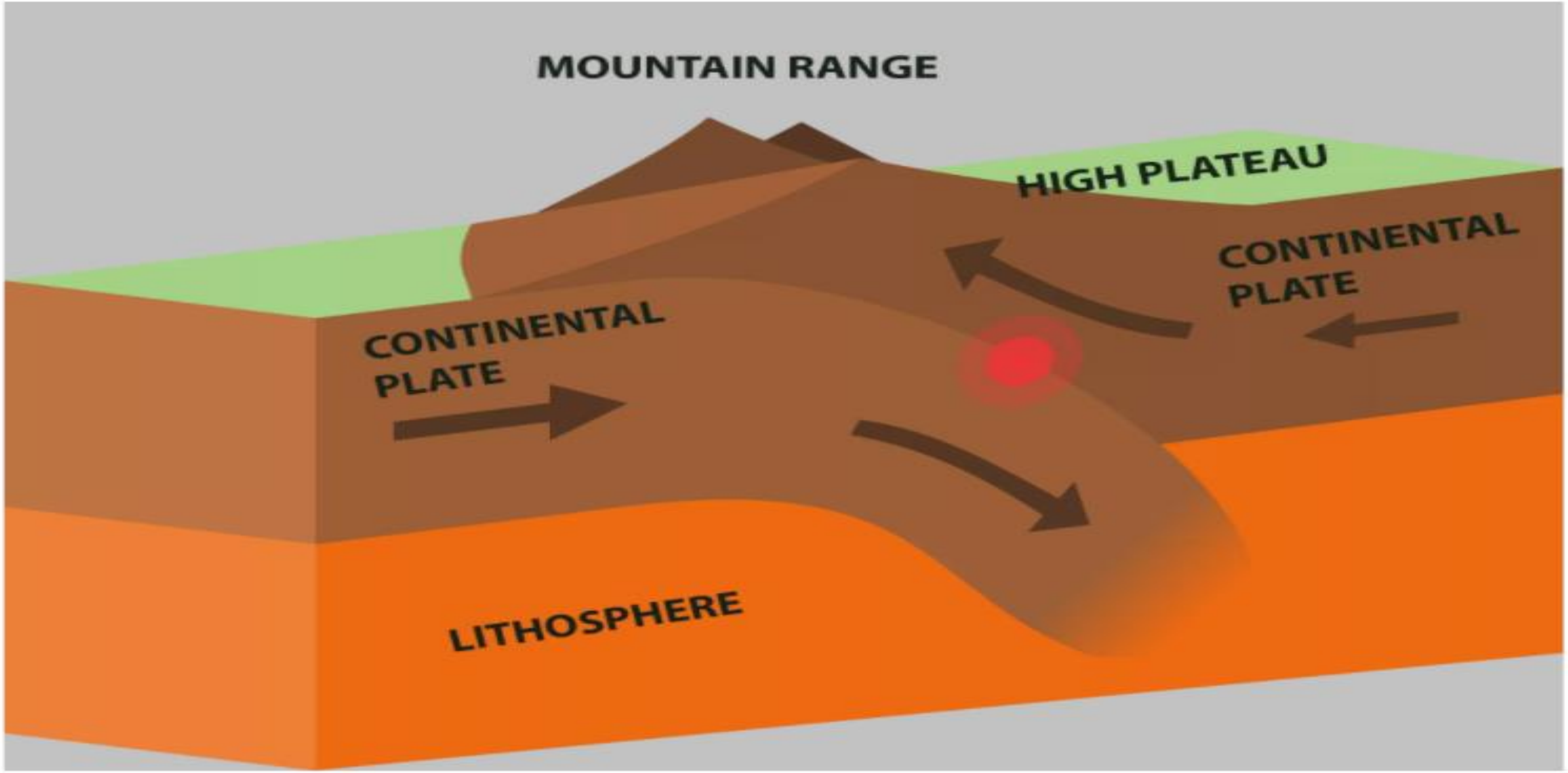
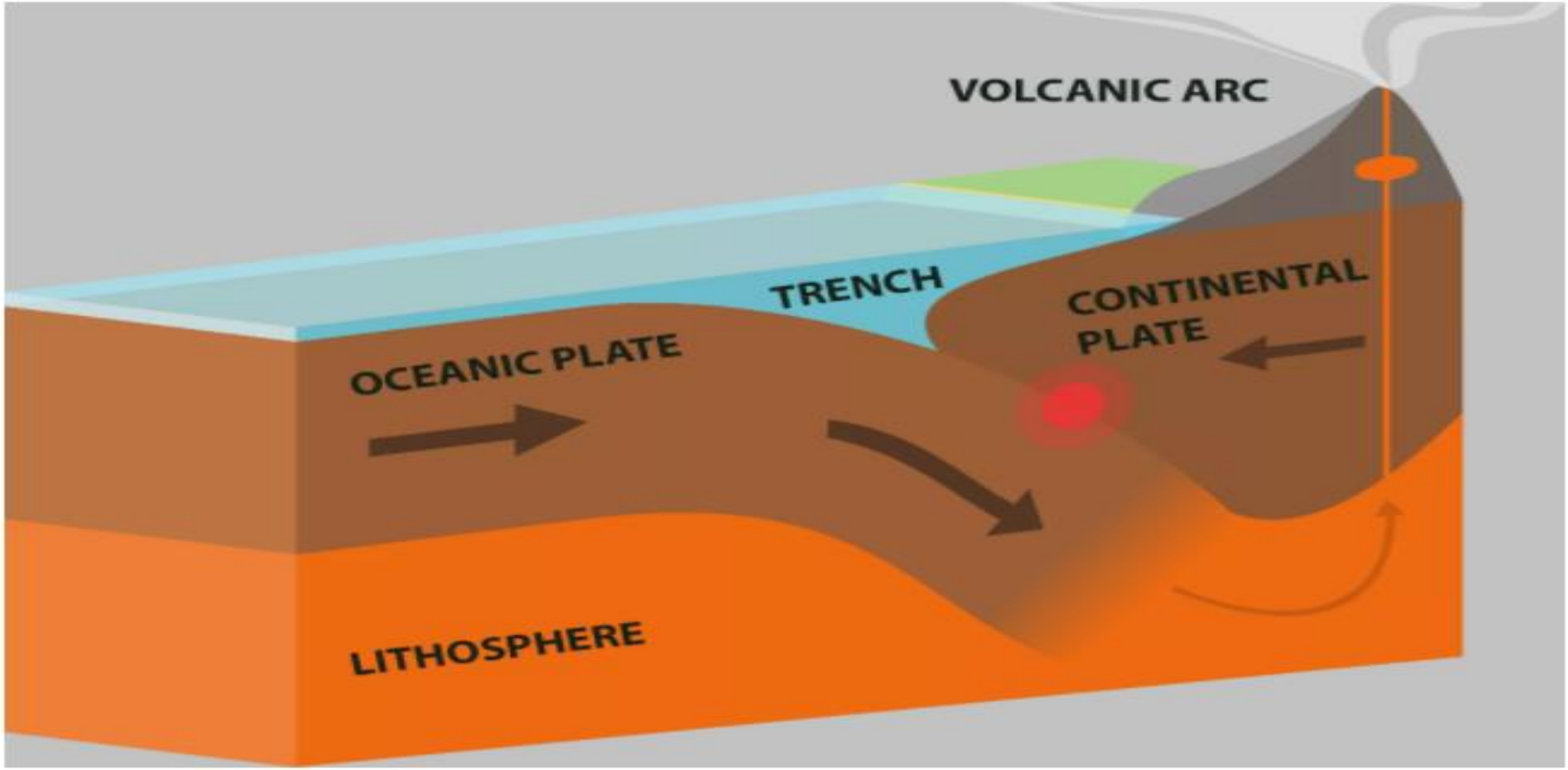
Continental-Continental Boundaries



Continental-Continental Boundaries

- Continental-continental convergent boundaries pit large slabs of crust against each other. This results in very little **subduction,** as most of the rock is **too light to be carried** very far down into the dense mantle. Instead, the continental crust at these convergent boundaries gets folded, faulted, and thickened, forming great **mountain chains** of uplifted rock.
- **Magma cannot penetrate this thick crust; instead, it cools intrusively and forms granite.**
- **Examples**
- **The Himalayas and the Tibetan Plateau**, the result of **50 million years of collision** between the **Indian and Eurasian plates**, are the most spectacular manifestation of this type of boundary.

Oceanic-Continental Boundaries



Oceanic-Continental Boundaries

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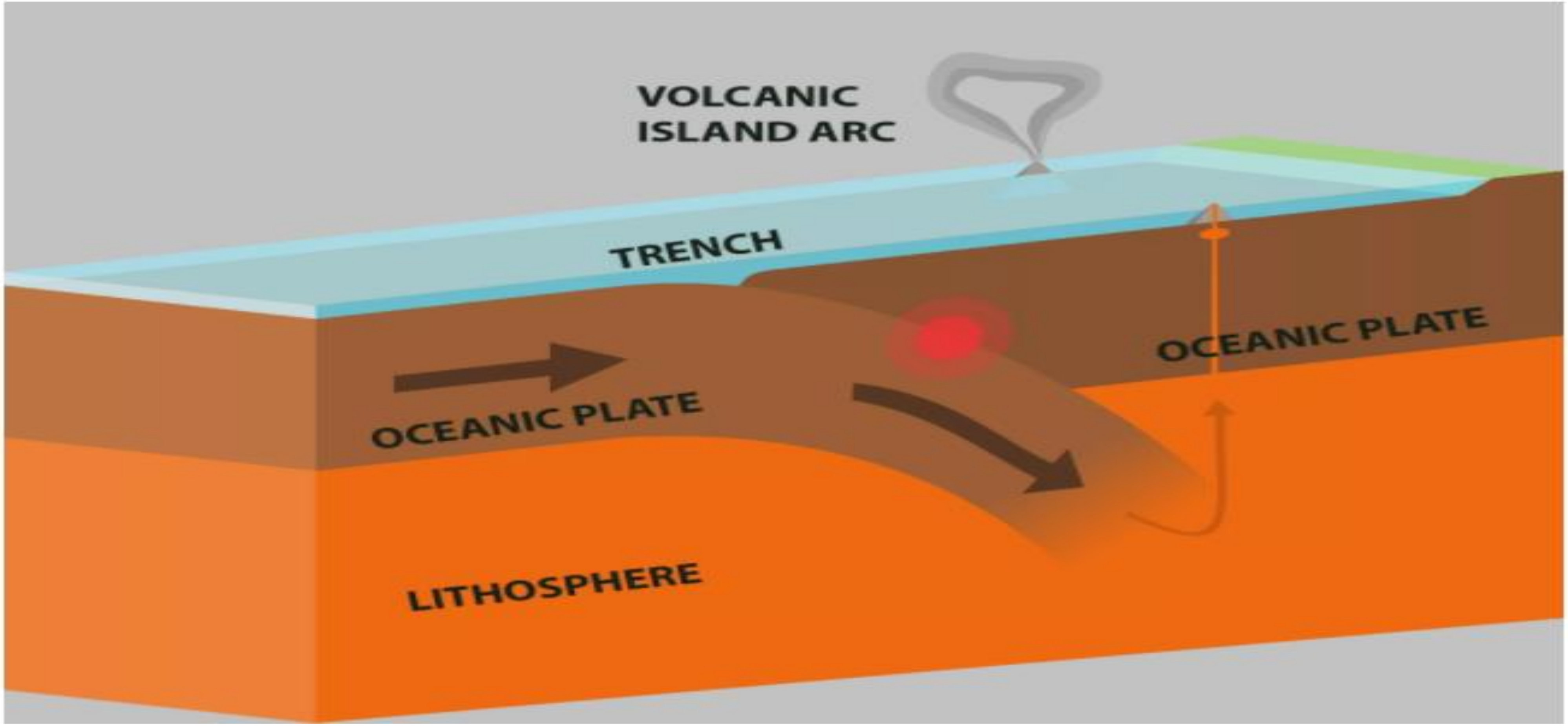
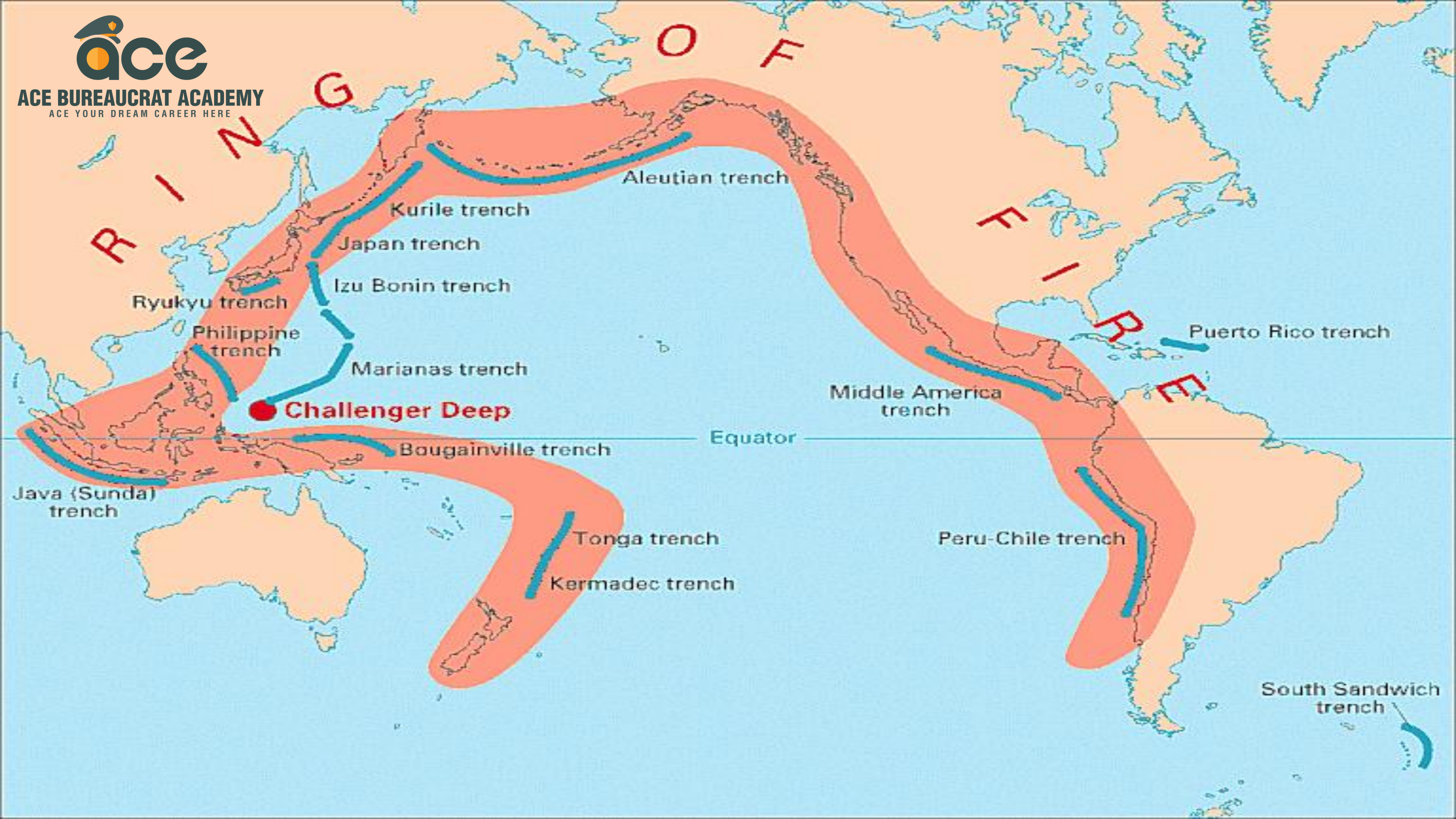
- When oceanic and continental plates collide, the oceanic plate undergoes **subduction** and **volcanic arcs** arise on land. These volcanoes release lava with chemical traces of the continental crust they rise through.
- The Cascade Mountains of western North America and the Andes of western South America feature such active volcanoes. So do Italy, Greece, Kamchatka, and New Guinea, Japan, Alaska, Chile.
- **(Due to such volcanism in Chile , there is higher metal deposition and world's largest copper mine in Chile)**
- Oceanic plates are denser than continental plates, which means they have a higher subduction potential. They are constantly being pulled into the mantle, where they are melted and recycled into new magma.

Oceanic-Oceanic Boundaries

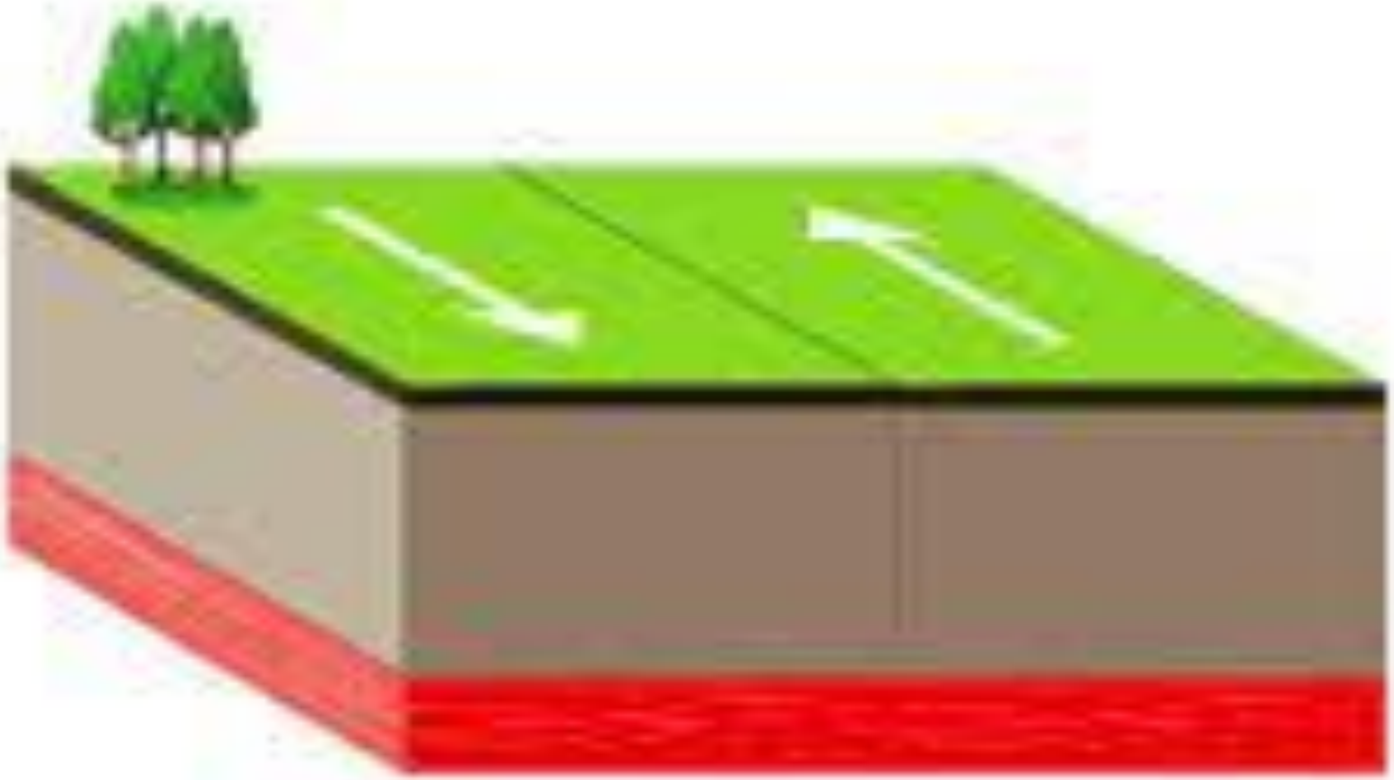


Oceanic-Oceanic Boundaries

- When two oceanic plates collide, the denser plate sinks below the lighter plate and eventually forms dark, heavy, basaltic volcanic islands.
- The western half of the Pacific Ring of Fire is full of these volcanic island arcs, including the , Japanese, Ryukyu, Philippine, Mariana, Solomon.
- There are more than 13000 islands in Indonesia.


RING OF FIRE
Aleutian trench
Kurile trench
Japan trench
Izu Bonin trench
Ryukyu trench
Philippine trench
Marianas trench
Challenger Deep
Equator
Bougainville trench
Java (Sunda) trench
Tonga trench
Kermadec trench
Puerto Rico trench
Middle America trench
Peru-Chile trench
South Sandwich trench

Transform Boundary



Transform Boundaries — Grinding Plates

- At transform boundaries, tectonic plates are not moving directly toward or directly away from each other. Instead, two tectonic plates **grind past each other in a horizontal direction.** This kind of boundary results in a **fault** — a crack or fracture in the earth's crust that is associated with this movement.

- The motion of the plates at a transform boundary has given this type of fault another name — a **strike-slip fault**.
- The best-studied strike-slip fault is the

San Andreas Fault in California. It is located at the boundary between the **Pacific and North American plates** and runs roughly 800 miles (1,300 km) through Northern and Southern California

- ***Chaman Fault (present at west of Pakistan)***
- **In 1935, 50,000 deaths near this fault due to earthquake**

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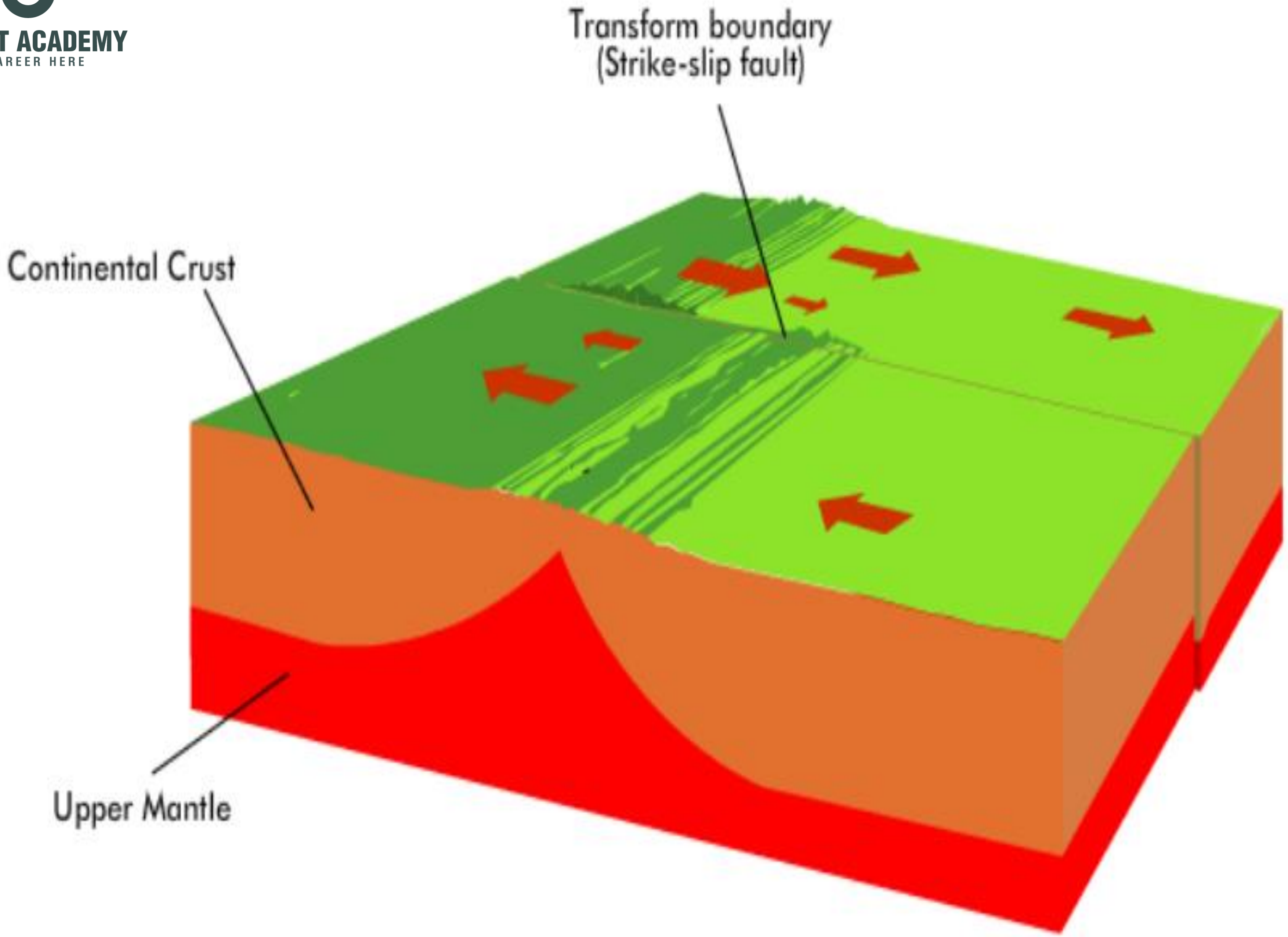
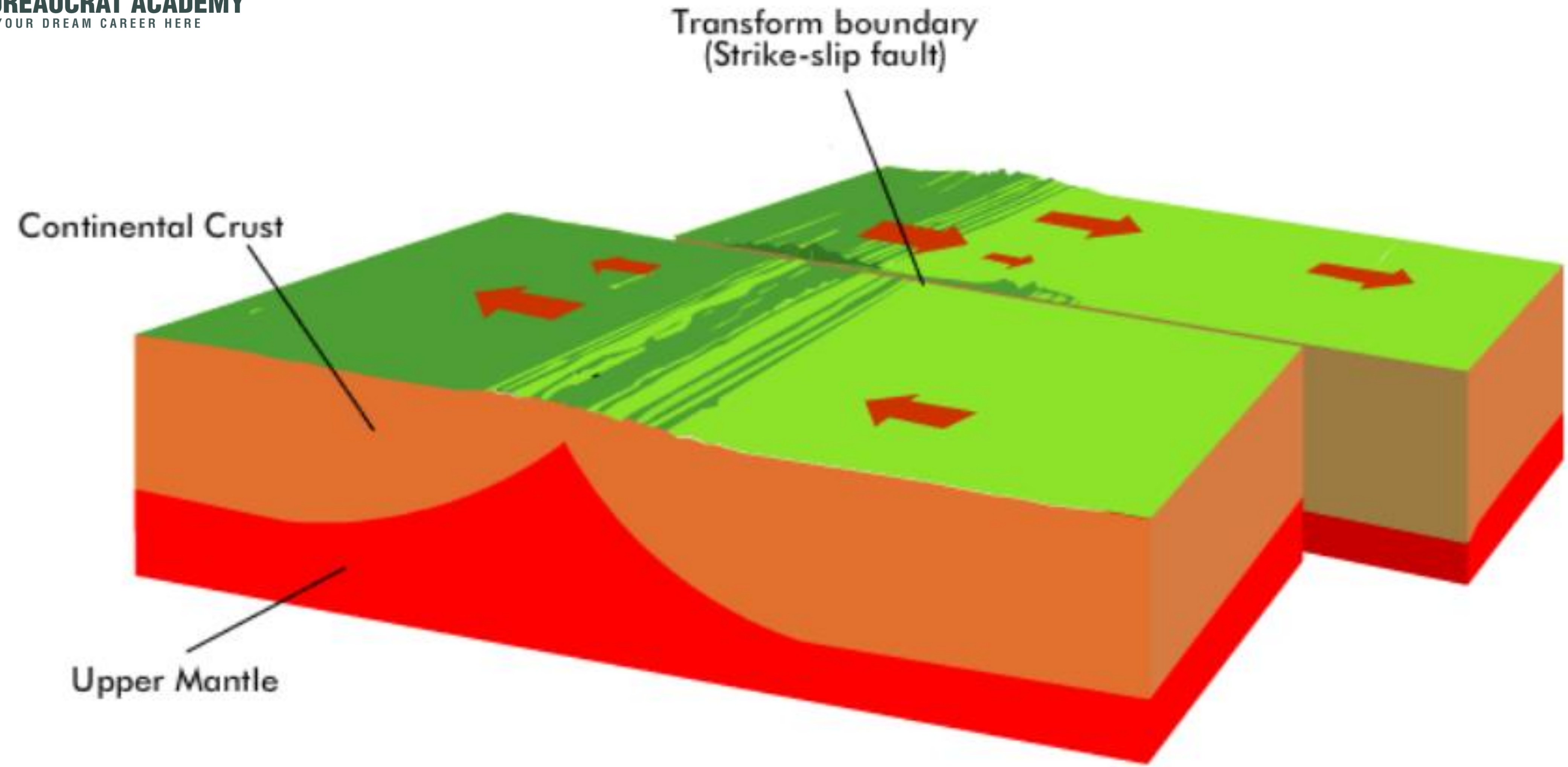
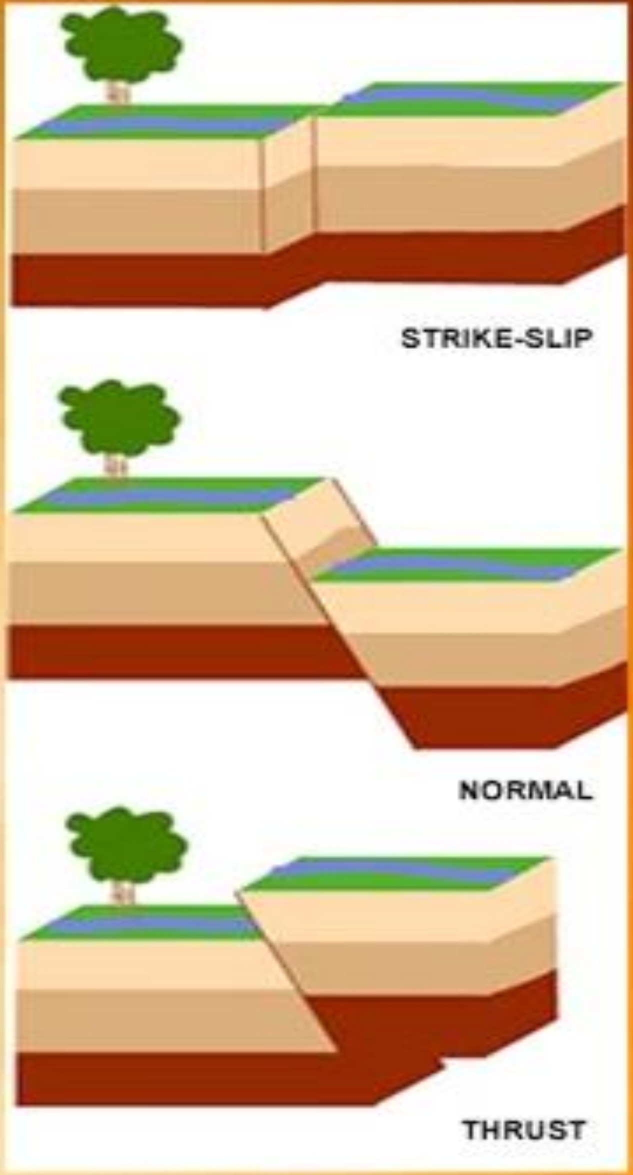



Transform boundary
(Strike-slip fault)
Continental Crust
Upper Mantle

Faults

- Large fractures (a break) in the earth's crust.

- Types of Faults
  - Normal
  - Reverse (Thrust)
  - Strike-Slip



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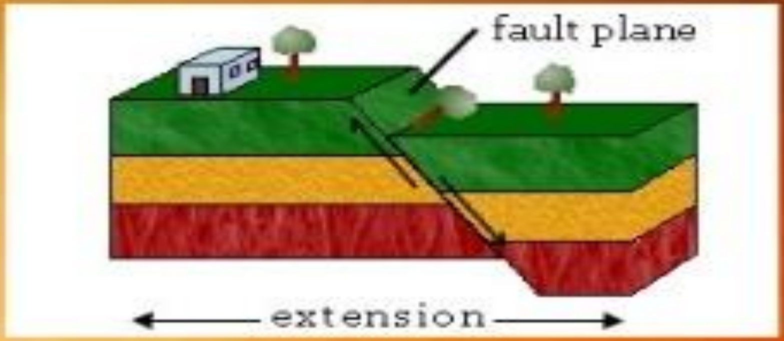
Types of Faults

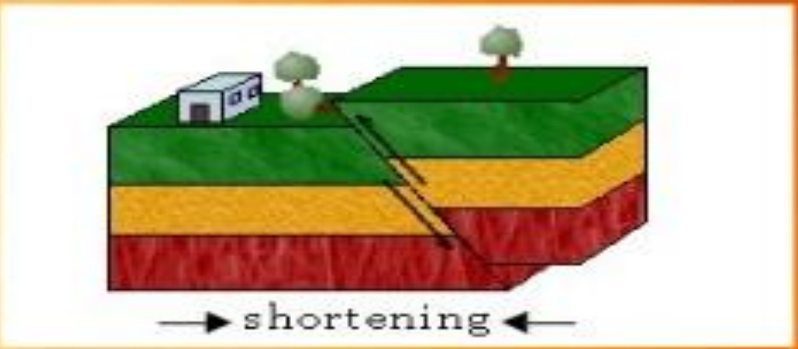
Normal Faults

- Rock moves down



Reverse Faults

- Rock moves upward



Strike-slip faults

- Rocks slide past one another in opposite directions.

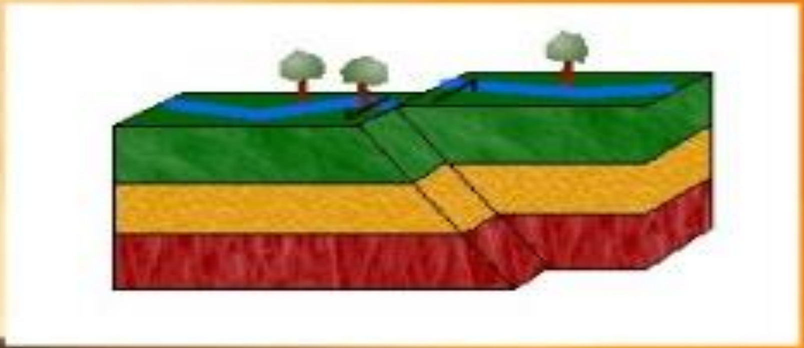


Plate Boundaries

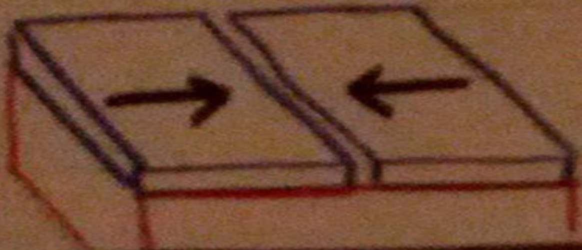
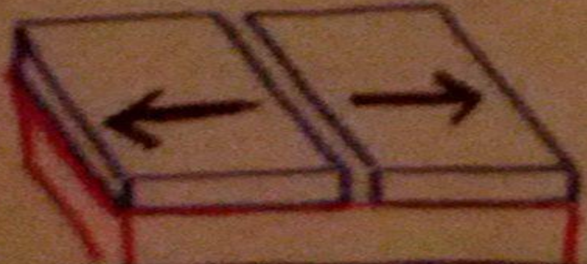
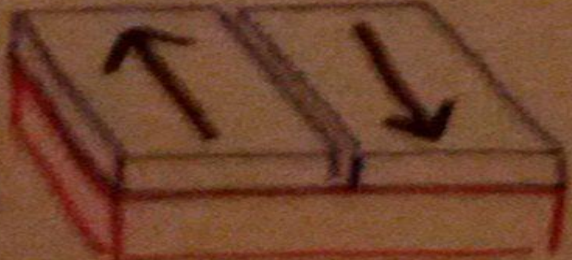
Scientific Name (description)	Diagram	Lithosphere...	Geologic Process
Convergent (colliding)		is destroyed	• earthquakes • volcanoes • mountain formation
divergent (spreading)		is formed	• earthquakes • volcanoes • volcanic mountain formation
transform (sliding)		is neither formed nor destroyed	• earthquakes

Plate Boundary Type		Geologic Activities	Changes in Landform Areas
Convergent	Continental → ← Continental	• Earthquakes	• Folded Mountain ranges • Faults
	Continental → ← Oceanic	• Subduction - More dense crust is pushed under less dense crust and re-melted into the Earth's Mantle • Crust is re-melted and recycled into the Earth's Mantle • Earthquakes • Volcanoes	• Volcanic Arcs (chains of volcanoes) • Trenches - deepest parts of the Earth's oceans • Faults
	Oceanic → ← Oceanic	• Subduction - More dense crust is pushed under less dense crust and re-melted into the Earth's Mantle • Crust is re-melted and recycled into the Earth's Mantle • Earthquakes • Volcanoes	• Volcanic Island Arcs (chains of volcanic islands) • Trenches - deepest parts of the Earth's oceans • Faults
Divergent	Oceanic ← → Oceanic	• New crust formation • Sea-floor spreading • Earthquakes • Volcanoes (approximately 80% of Earth's volcanic activity)	• Mid-ocean ridges • Ocean basins • Hydro-thermal vents • Faults
	Continental ← → Continental	• New crust formation • Earthquakes • Volcanoes	• Rift valleys • Faults
Transform	Continental - Continental	• Earthquakes	• Faults
	Oceanic – Oceanic	• Earthquakes	• Faults

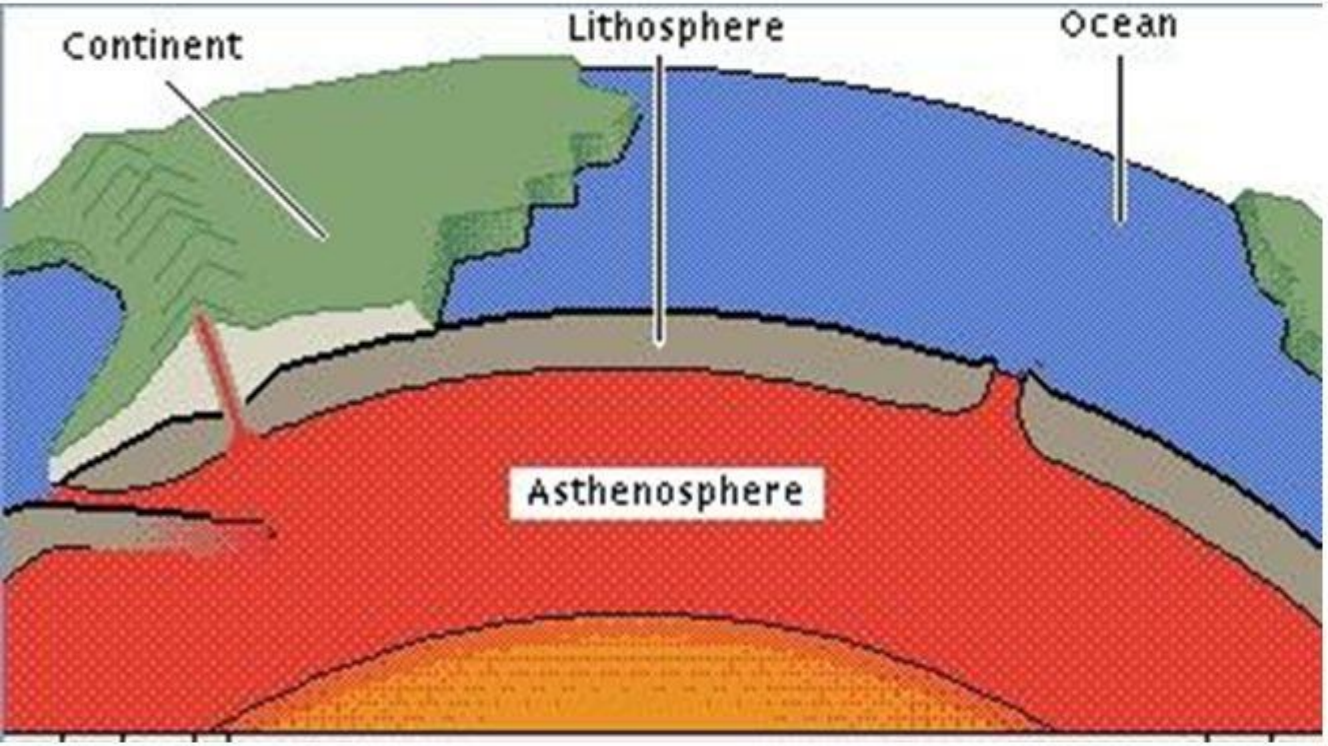
Examples of Plate Boundaries

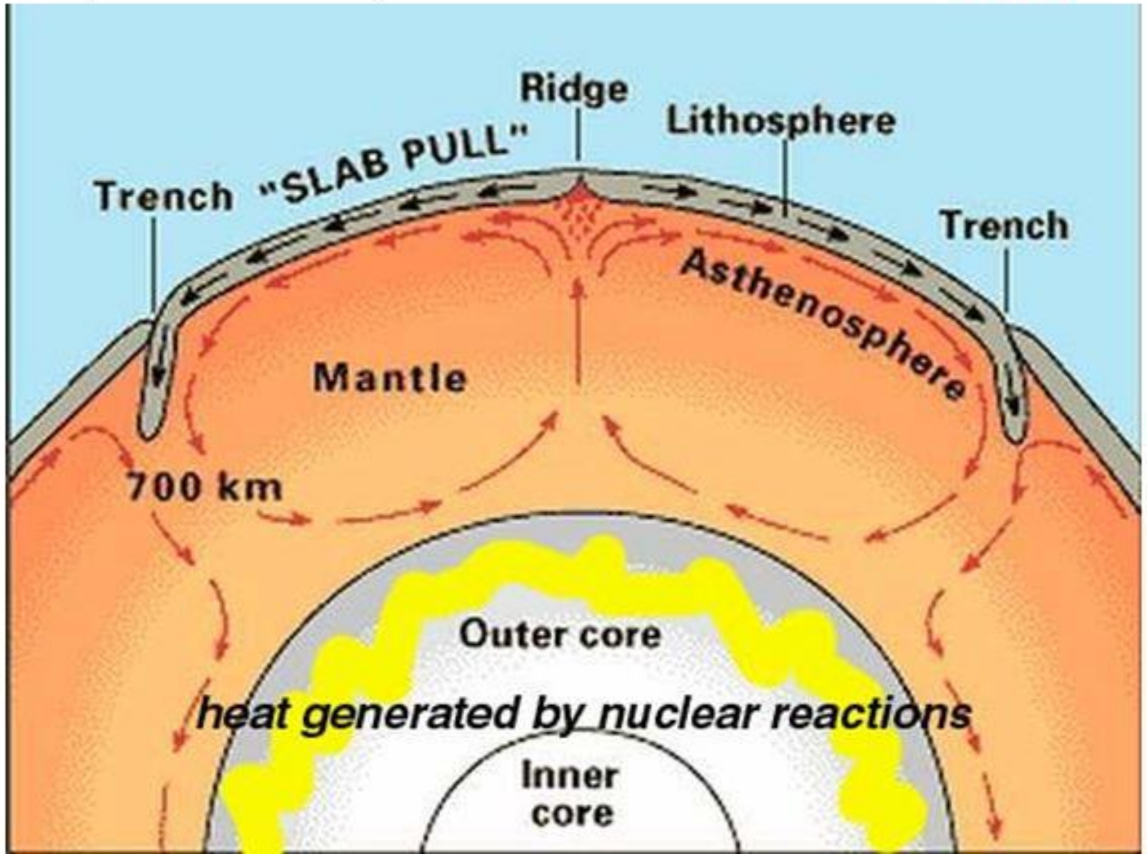
TABLE 2.1 CHARACTERISTICS, TECTONIC PROCESSES, FEATURES, AND EXAMPLES OF PLATE BOUNDARIES

Plate boundary	Plate movement	Crust types	Sea floor created or destroyed?	Tectonic process	Sea floor feature(s)	Geographic examples
Divergent plate boundaries	Apart ← →	Ocean–ocean	New sea floor is created	Sea floor spreading	Mid-ocean ridge; volcanoes; young lava flows	Mid-Atlantic Ridge, East Pacific Rise
		Continent–continent	As a continent splits apart, new sea floor is created	Continental rifting	Rift valley; volcanoes; young lava flows	East Africa Rift Valleys, Red Sea, Gulf of California
Convergent plate boundaries	Together → ←	Ocean–continent	Old sea floor is destroyed	Subduction	Trench; volcanic arc on land	Andes Mountains, Cascade Mountains
		Ocean–ocean	Old sea floor is destroyed	Subduction	Trench; volcanic arc as islands	Aleutian Islands, Mariana Islands
		Continent–continent	N/A	Collision	Tall mountains	Himalaya Mountains, Alps
Transform plate boundaries	Past each other → ←	Oceanic	N/A	Transform faulting	Fault	Mendocino Fault, Eltanin Fault (between mid-ocean ridges)
		Continental	N/A	Transform Faulting	Fault	San Andreas Fault, Alpine Fault (New Zealand)

LITHOSPHERE vs ASTHENSOPHERE

- **LITHOSPHERE** - crust together with a hard upper part of the mantle (PLATES, Crust under continents, crust under ocean
- **ASTHENOSPHERE** – (Below Lithosphere) So much pressure and heat the rocks can flow like a liquid. Allows Lithosphere to "float" on top of it.
- HOW TO REMEMBER: L.A. Lithosphere on outside, Asthenosphere on in the inside. L.A.





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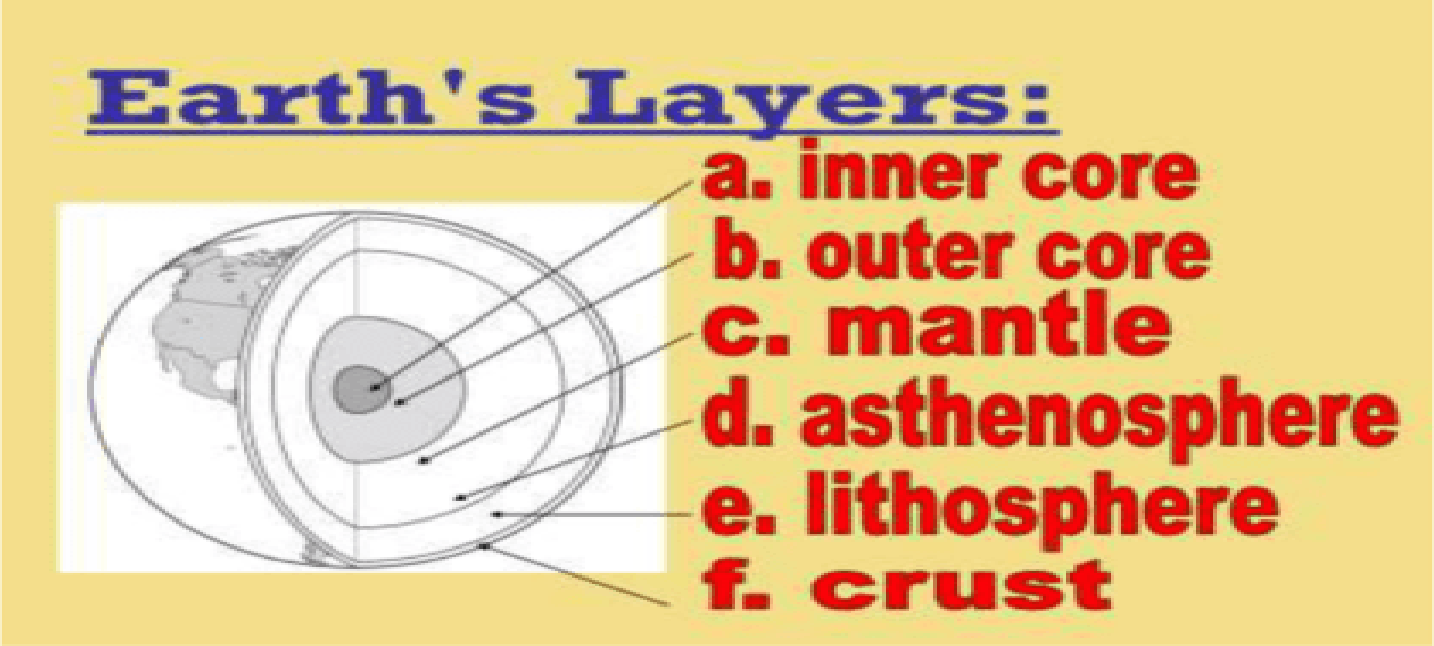


2. Describe the differences between continental crust and oceanic crust.

   Oceanic crust is thinner but more dense, mostly made from basalt, while continental crust is thicker, less dense and made from rock similar to granite.

3. What are tectonic plates? About how many tectonic plates is Earth's crust broken up into?

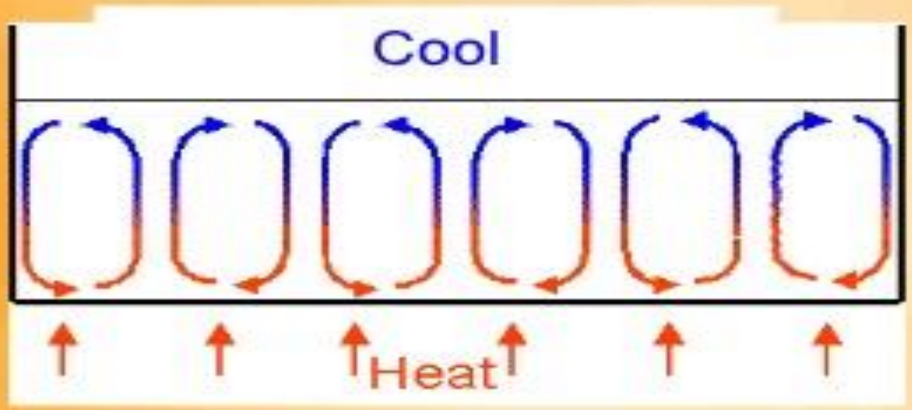
   Tectonic plates are pieces of the Earth's lithosphere that are broken into large sections and move around on top of the asthenosphere. There about 10-12 major tectonic plates with a couple smaller sub-plates.

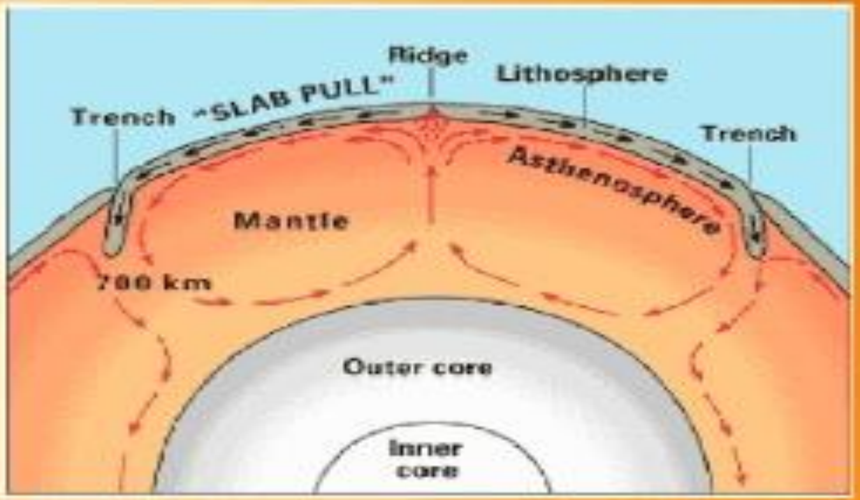
4. How do scientists know about the structure of Earth's interior?

   Scientists know about Earth's inner structure by studying earthquakes and seismic waves. They analyzed the various speeds the different seismic waves travel and determined the thickness and density of Earth's layers.

Convection Currents

- Convection cells in the mantle **move the plates**.
  - *Hot in the center, less dense magma rises up due to heat.*
  - *When the magma reaches the surface, it cools and sinks back down creating a circular pattern of movement.*
- This process happens continually.





- Hot – goes UP
- Cool – goes DOWN

Review

- Name the 3 main layers of the Earth
- What is a tectonic plate?
- What was Pangea?
- What is Sea-Floor spreading?
- Name the three different types of plate boundaries and one location on Earth for each one

Questions

- Explain the structure of earth and its atmosphere.
- What is the difference between asthenosphere and lithosphere? Explain various components of lithosphere.
- Write the diagnostic feature of all of the 3 boundaries (convergence, divergence and transform) along with diagram of each.

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GOOD LUCK