Sea Floor Spreading and Plate Tectonics

Plate Tectonics is a theory developed in the late 1960s, to explain how the outer layers of the Earth move and deform. The theory has caused a revolution in the way we think about the Earth. Plate tectonics has proven to be so useful that it can predict geologic events and explain almost all aspects of what we see on the Earth. Tectonic theories attempt to explain why mountains, earthquakes, and volcanoes occur

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Late 19th Century Theories

- Contraction of the Earth due to cooling. It could explain compressional features, like fold/thrust mountain belts, but could not explain extensional features, such as rift valleys and ocean basins. Nor could it explain the shapes and positions of the continents.

features.

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Late 19th Century Theories

- Expansion of the Earth due to heating. This was suggested after radioactivity was discovered. This could explain why the continents are broken up, and could easily explain extensional features, but did not do well at explaining compressional features.

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Wegner's Theory of Continental Drift

Alfred Wegner was a German Meteorologist in the early 1900s who studied ancient climates. He put together the evidence of ancient glaciations and the distribution of fossil to formulate a theory that the continents have moved over the surface of the Earth, sometimes forming large supercontinents and other times forming separate continental masses. He proposed that prior to about 200 million years ago all of the continents formed one large land mass that he called Pangea.

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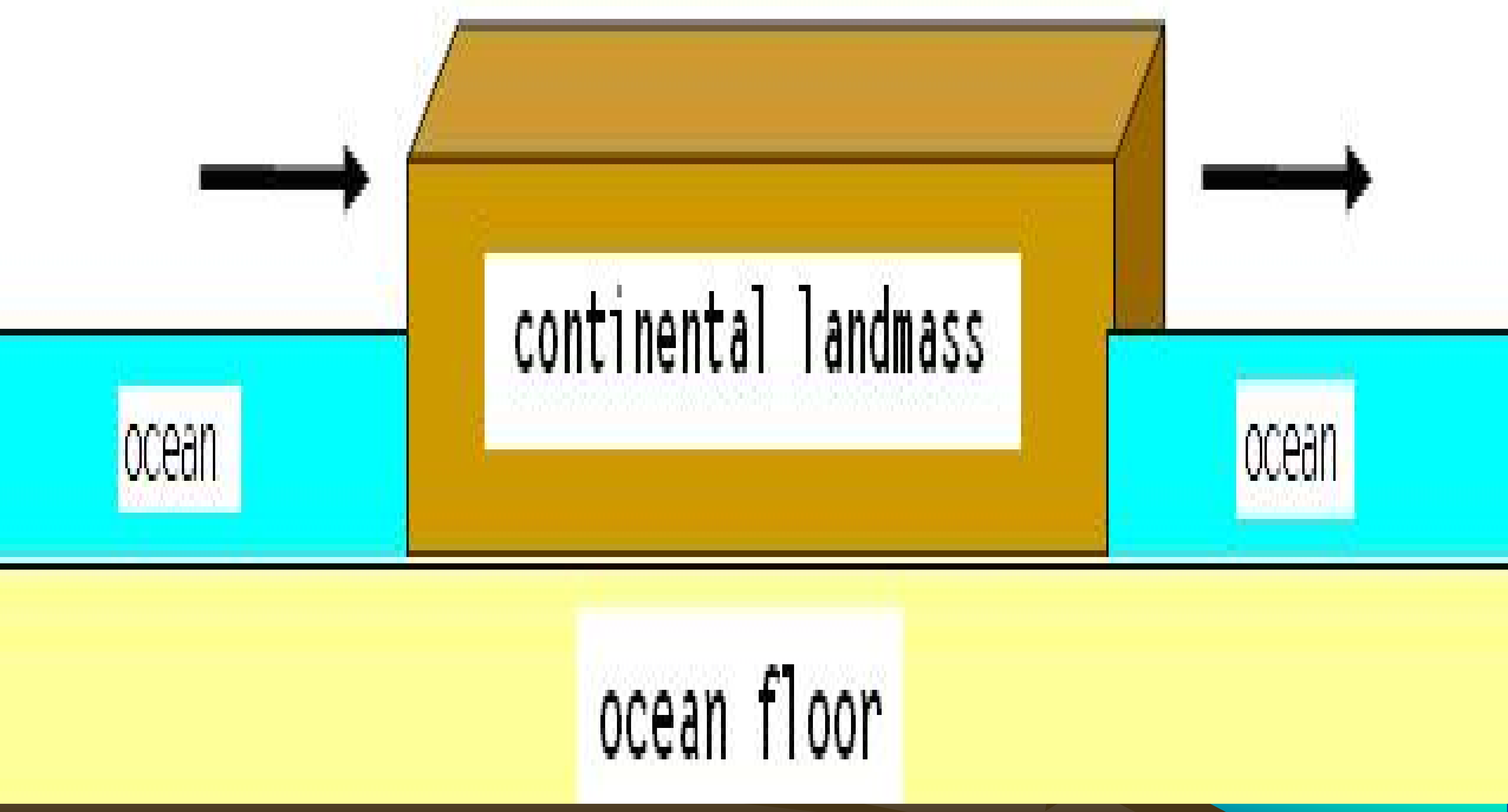

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Wegner's Theory of Continental Drift

The weakness of Wegner's theory, and the reason it was not readily accepted by geologists was that he proposed that the continents slide over ocean floor. Geophysicists disagreed, stating the ocean floor did not have enough strength to hold the continents and too much frictional resistance would be encountered.

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In 1950s and 1960s, studies of the Earth's magnetic field and how it varied through time (paleomagnetism) provided new evidence that would prove that the continents do indeed drift.

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The Earth's Magnetic Field and Paleomagnetism:

The Earth has a magnetic field that causes a compass needle to always point toward the North magnetic pole, currently located near the rotation pole.

The magnetic field is composed of lines of force.

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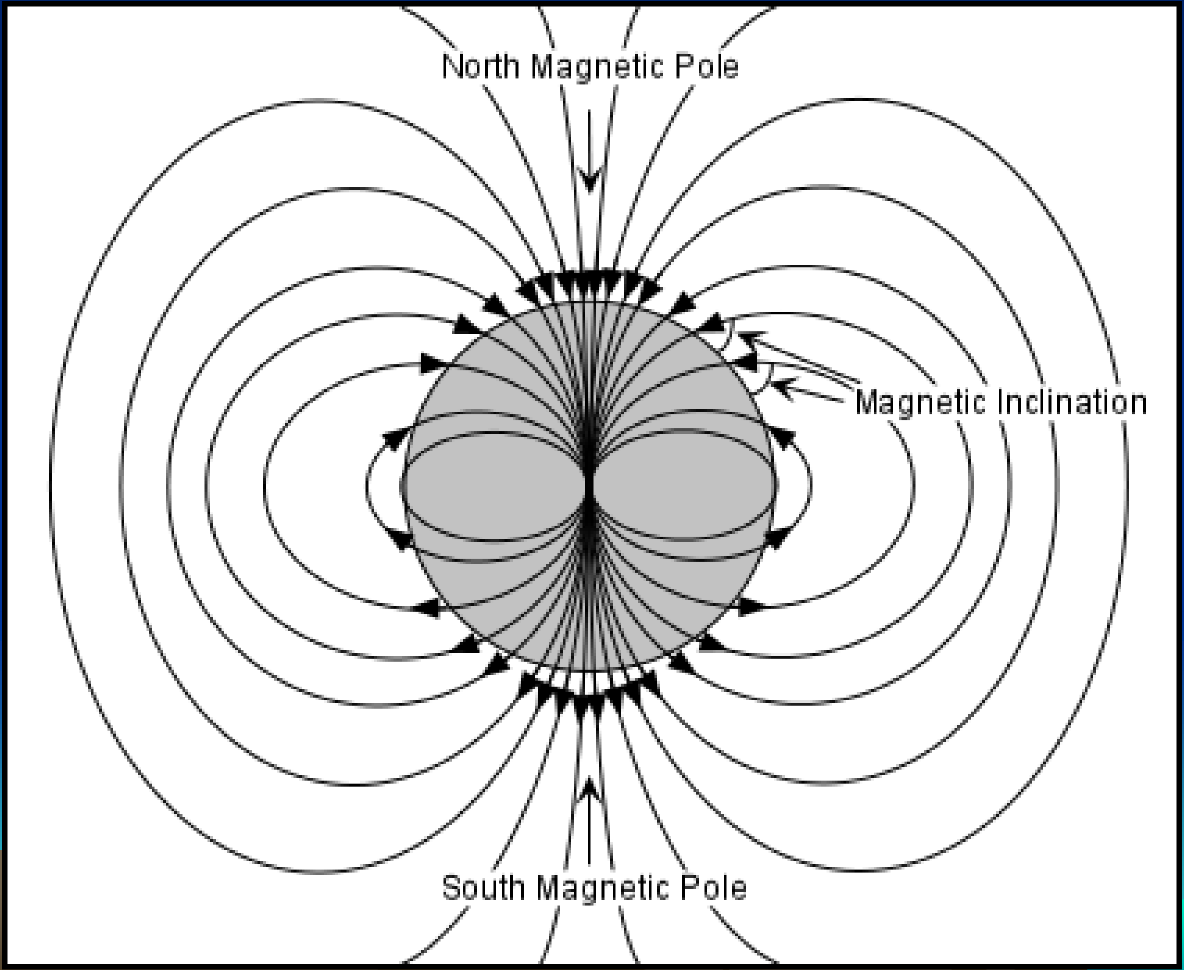
The Earth's Magnetic Field and Paleomagnetism:



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The Earth's Magnetic Field and Paleomagnetism:

A compass needle or a magnetic weight suspended from a string, points along these lines of force. Note that the lines of force intersect the surface of the Earth at various angles that depend on position on the Earth's surface. This angle is called the magnetic inclination. The inclination is 0^o at the magnetic equator and 90^o at the magnetic poles. Thus, by measuring the inclination and the angle to the magnetic pole, one can tell position on the Earth relative to the magnetic poles.

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The Earth's Magnetic Field and Paleomagnetism:

In the 1950s it was discovered that when magnetic minerals cool below a temperature called the ***Curie Temperature***, domains within the magnetic mineral take on an orientation parallel to any external magnetic field present at the time they cooled below this temperature.

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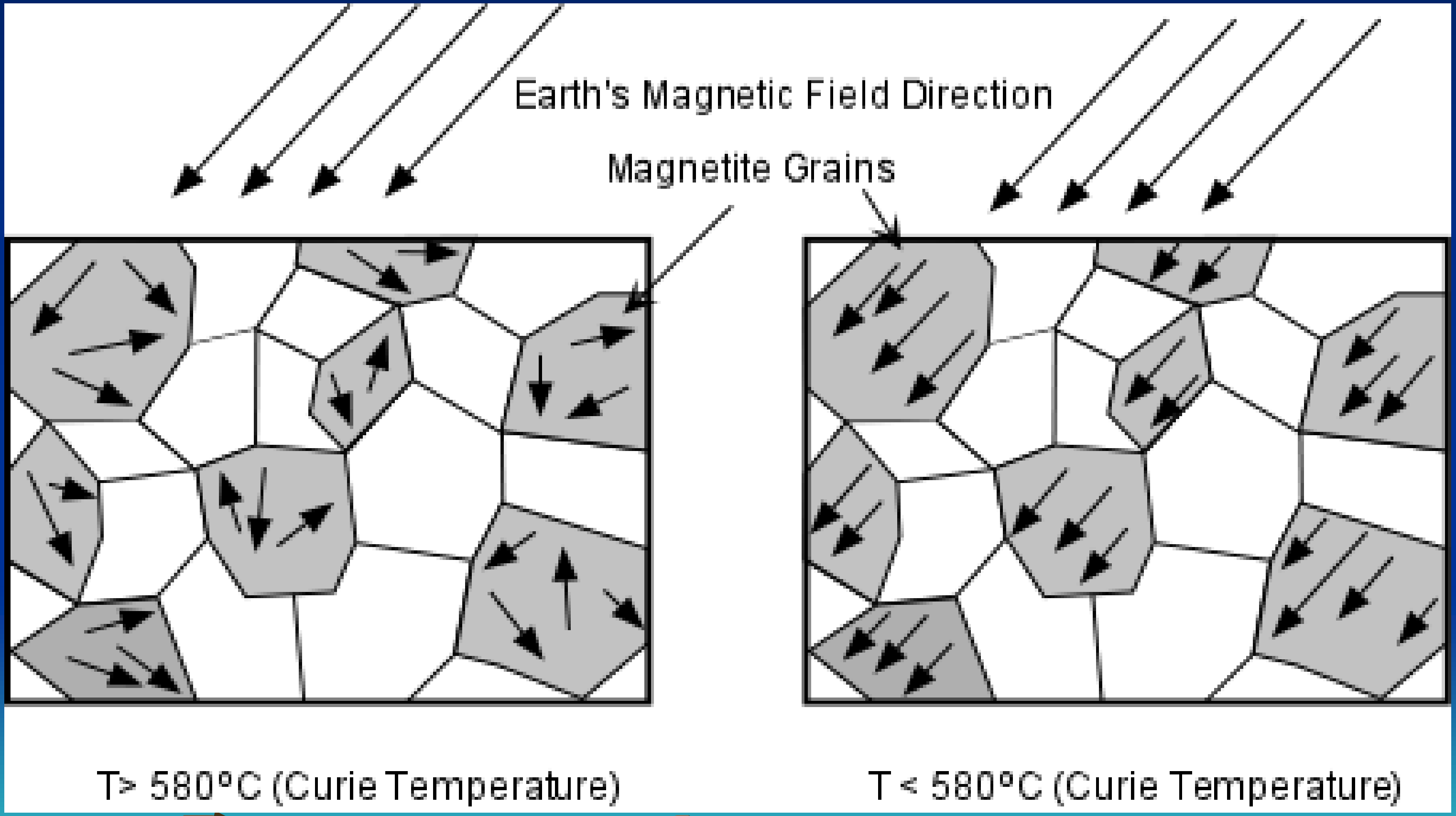
The Earth's Magnetic Field and Paleomagnetism:



Magnetite is the most common magnetic mineral in the Earth's crust and has a Curie temperature of 580°C

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The Earth's Magnetic Field and Paleomagnetism:

Since the magnetic minerals take on the orientation of the magnetic field present during cooling, we can determine the orientation of the magnetic field present at the time the rock containing the mineral cooled below the Curie Temperature, and thus, be able to determine the position of the magnetic pole at that time. This made possible the study of Paleomagnetism (the history of the Earth's magnetic field).

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Magnetic Reversals:

The polarity of a magnetic field is the orientation of its positive, *or north*, end and its negative, *or south*, end. Because many rocks record the orientation of the Earth's magnetic field at the time the rocks formed, we can construct a record of the Earth's polarity by studying magnetic orientations in rocks from many different ages and places. When geologists constructed such a record, they discovered that the Earth's magnetic field has reversed polarity throughout geologic history.

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Magnetic Reversals:

When a magnetic reversal occurs, the north magnetic pole becomes the south magnetic pole, and vice versa. The orientation of the Earth's field at present is referred to as normal polarity, and that during a time of opposite polarity is called reversed polarity. The Earth's polarity has reversed about 130 times during the past 65 million years. The reversal takes 3000 to 5000 years, a very short time compared with many other geologic changes.

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Sea-Floor Spreading:

The topographic studies of sea floor revealed the presence of two important topographic features of the ocean floor:

- Oceanic Ridges; long sinuous ridges that occupy the middle of the Atlantic Ocean and the eastern part of the Pacific Ocean.
- Oceanic Trenches - deep trenches along the margins of continents, particularly surrounding the Pacific Ocean.

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Sea-Floor Spreading:

Vine, Matthews, and Morely put this information together with the bands of magnetic stripes on the sea floor and postulated that the bands represents oppositely polarized rocks on either side of the oceanic ridges, and that new oceanic crust and lithosphere was created at the oceanic ridge by eruption and intrusion of magma.

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Sea-Floor Spreading:

As this magma cooled it took on the magnetism of the magnetic field at the time. When the polarity of the field changed new crust and lithosphere created at the ridge would take on the different polarity. This hypothesis led to the theory of sea floor spreading.

Sea Floor Spreading and Plate Tectonics

Sea-Floor Spreading:

1. New oceanic crust forms continuously as basaltic magma rises beneath the ridge axis. The new crust then spreads outward from the ridge.

2. As the new crust cools, it acquires the orientation of the Earth’s magnetic field.

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Sea-Floor Spreading:

3. The Earth's magnetic field reverses orientation on an average of every half-million years.

4. Thus, the magnetic stripes on the sea floor record a succession of reversals in the Earth's magnetic field that occurred as the sea floor spread away from the ridge.

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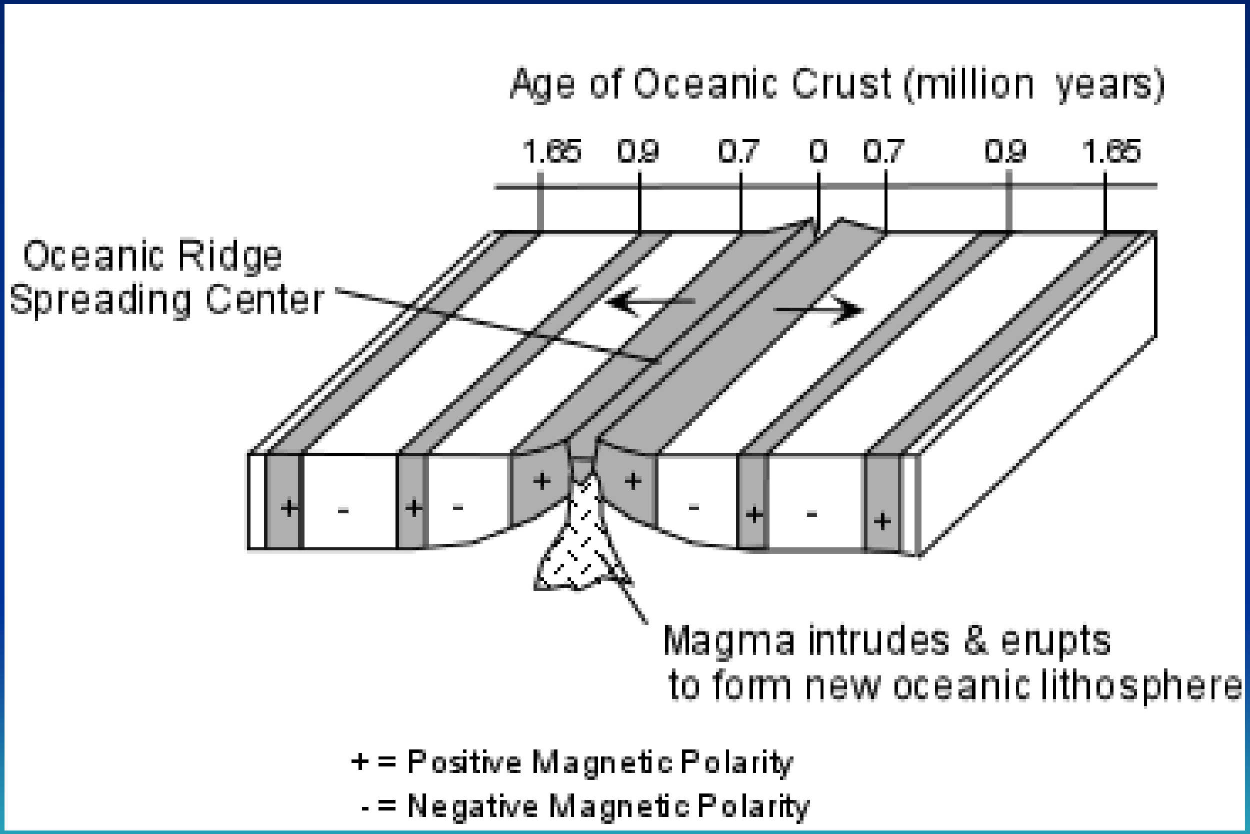
Sea-Floor Spreading:



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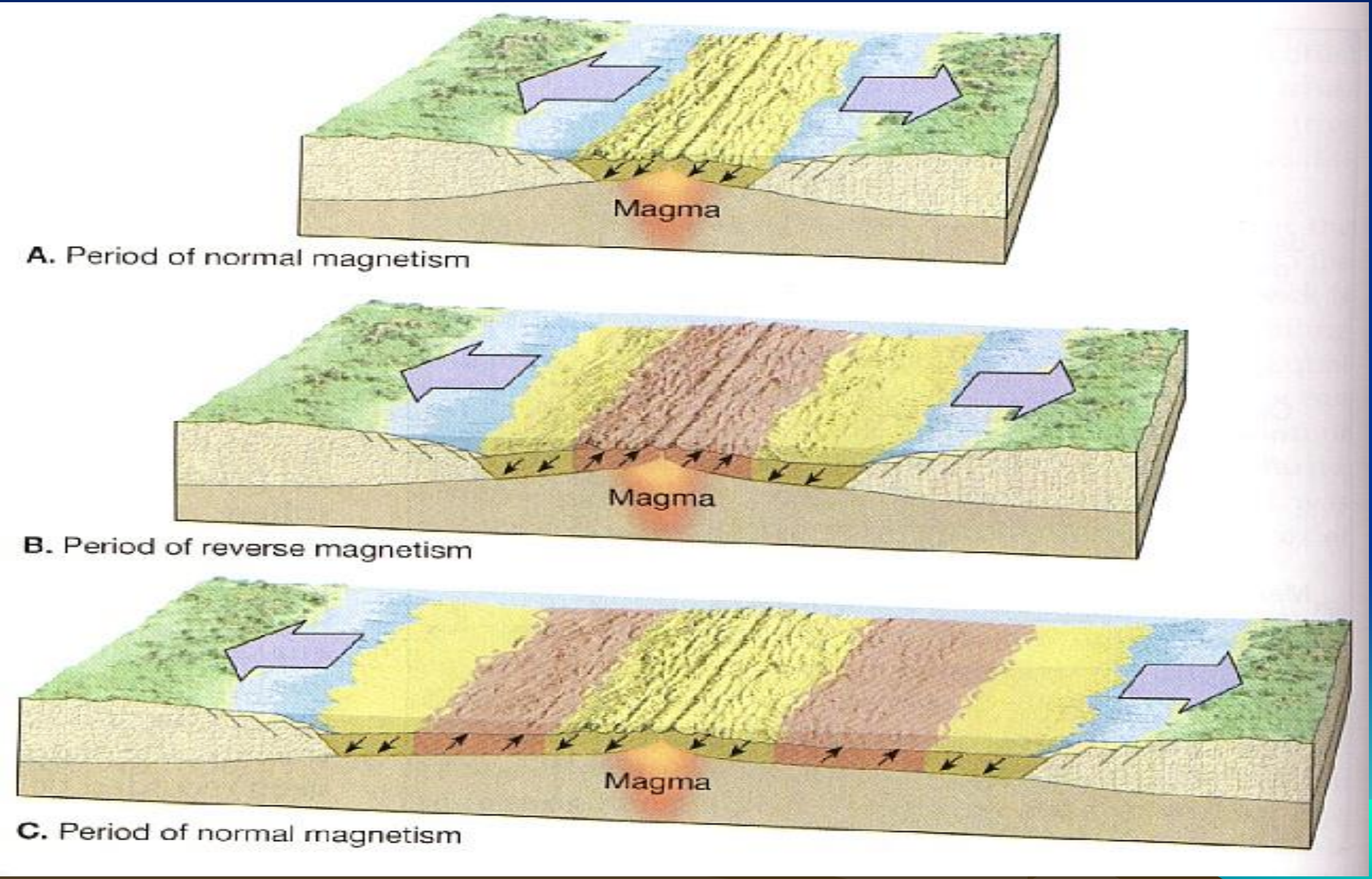
Sea-Floor Spreading:



Sea Floor Spreading and Plate Tectonics

Plate Tectonics :

By combining the sea floor spreading theory with continental drift and information on global seismicity, the new theory of Plate Tectonics became a coherent theory to explain crustal movements.

Plates are composed of lithosphere, about 100 km thick, that "float" on the ductile asthenosphere.

The plates behave as rigid bodies with some ability to flex, but deformation occurs mainly along the boundaries between plates.

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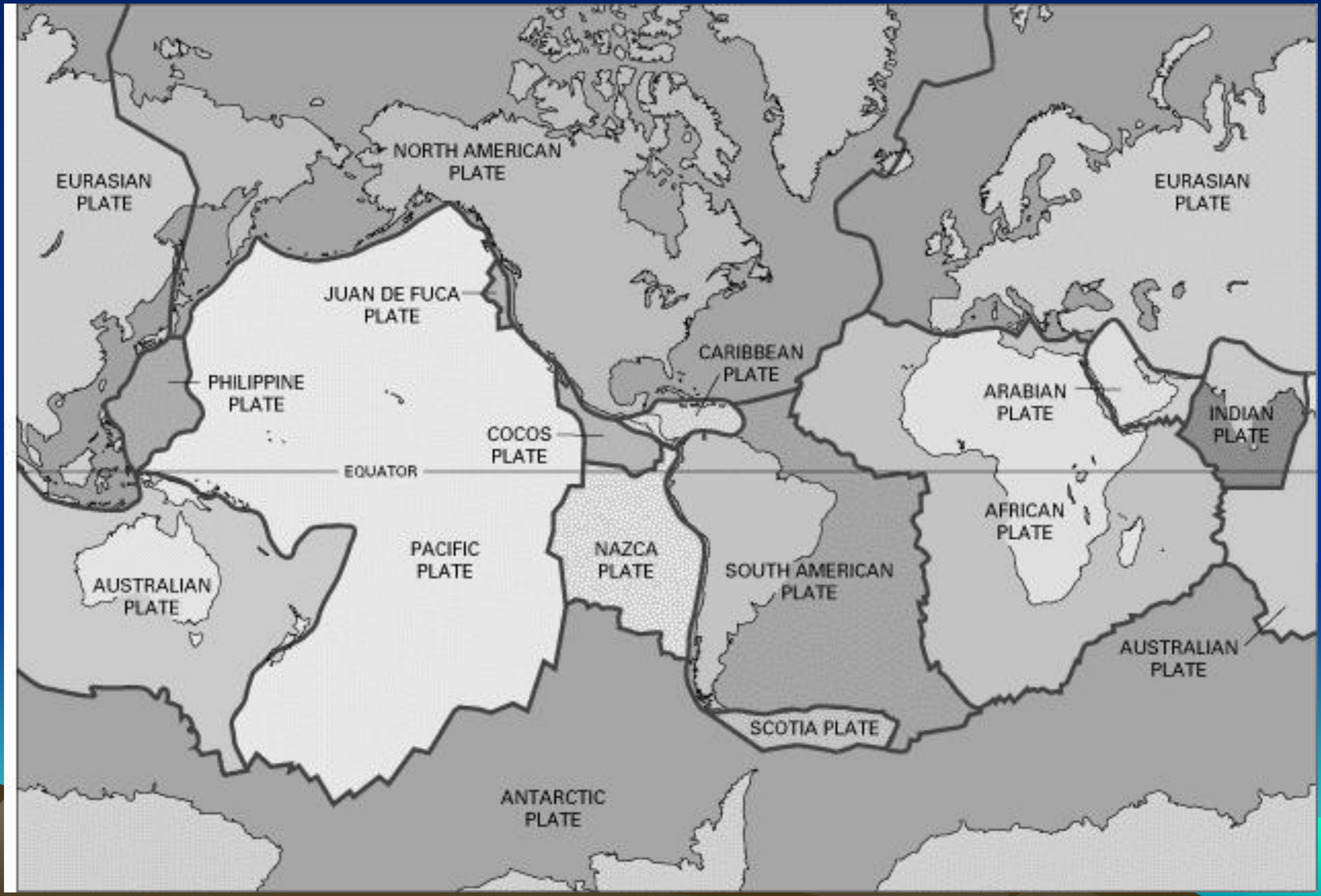
Plate Tectonics :



Sea Floor Spreading and Plate Tectonics

Plate Tectonics :

There are three types of plate boundaries:

1. Divergent Plate boundaries, where plates move away from each other.
2. Convergent Plate Boundaries, where plates move toward each other.
3. Transform Plate Boundaries, where plates slide past one another.

Sea Floor Spreading and Plate Tectonics

Plate Tectonics :

Divergent Plate Boundaries:

These are oceanic ridges where new oceanic lithosphere is created by upwelling mantle that melts, resulting in basaltic magmas which intrude and erupt at the oceanic ridge to create new oceanic lithosphere and crust. As new oceanic lithosphere is created, it is pushed aside in opposite directions. Thus, the age of the oceanic crust becomes progressively older in both directions away from the ridge.

Sea Floor Spreading and Plate Tectonics

Plate Tectonics :

Divergent Plate Boundaries:

Because the oceanic ridges are areas of young crust, there is very little sediment accumulation on the ridges. Sediment thickness increases in both directions away of the ridge, and is thickest where the oceanic crust is the oldest.

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Plate Tectonics :

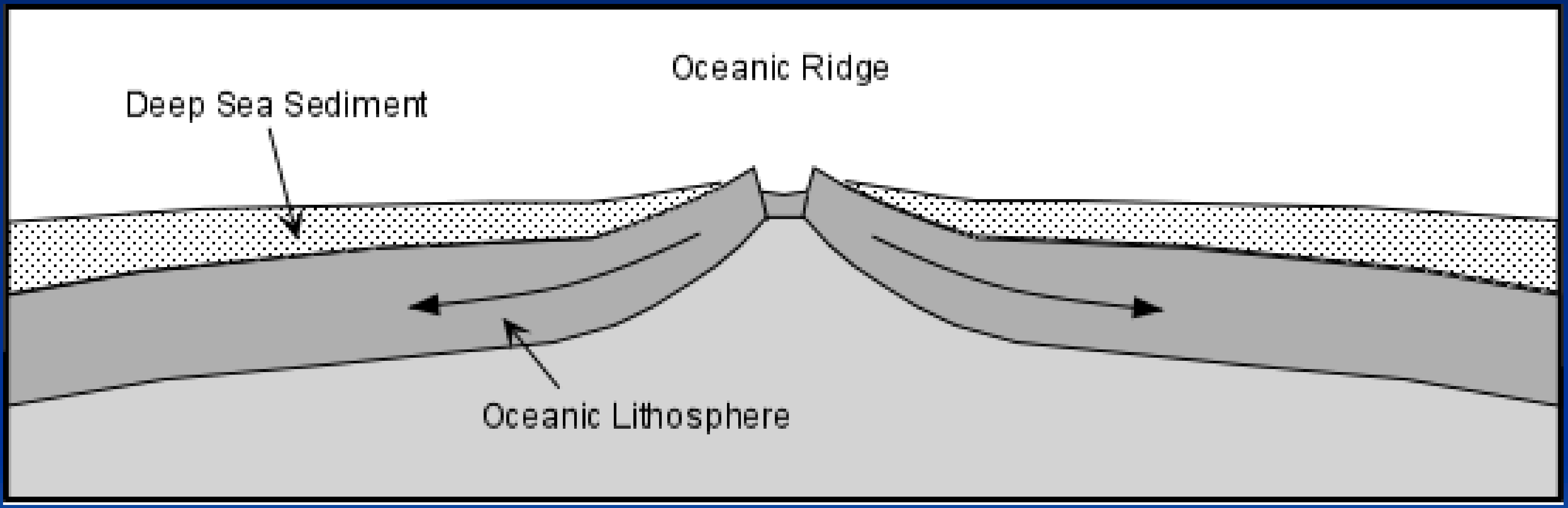

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Plate Tectonics :

Convergent Plate Boundaries

When a plate of dense oceanic lithosphere moving in one direction collides with a plate moving in the opposite direction, one of the plates subducts beneath the other. Where this occurs an oceanic trench forms on the sea floor and the sinking plate becomes a subduction zone. The Wadati-Benioff Zone, a zone of earthquakes located along the subduction zone.

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Plate Tectonics :

Convergent Plate Boundaries

If the subduction occurs beneath oceanic lithosphere, an island arc is produced at the surface.

If the subduction occurs beneath continental crust, a continental volcanic arc is produced.

If one of the plates has continental lithosphere on its margin, the oceanic plate will subduct because oceanic lithosphere has a higher density than continental lithosphere.

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Plate Tectonics :

Transform Plate Boundaries

Where lithospheric plates slide past one another in a horizontal manner, a transform fault is created. Earthquakes along such transform faults are shallow focus earthquakes.

Most transform faults occur where oceanic ridges are offset on the sea floor.

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Plate Tectonics :

Transform Plate Boundaries

Such offset occurs because spreading takes place on the spherical surface of the Earth, and some parts of a plate must be moving at a higher relative velocity than other parts.

Triple Junctions occur at points where thee plates meet. Various combinations can exist.

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Plate Tectonics :

Continental Rifting:

A new divergent plate boundary can form when continental lithosphere stretches, and thins to form a rift valley. As the rift widens and thins, upwelling asthenosphere can melt to produce magmas that start to create new oceanic lithosphere and spread the new plates apart.

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Plate Tectonics :

Continental Collisions:

When two plates that have low density continental lithosphere collide with one another subduction ceases because the continental lithosphere has too low of a density to be subducted. As the plates continue to collide fold – thrust mountain belts that develop along the zone of collision.

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Plate Tectonics :

Continental Collisions:

Currently the highest mountains in the world, the Himalayas represent this kind of event. The Himalayas resulted from a collision of the plate containing India with the plate containing Eurasia.

Sea Floor Spreading and Plate Tectonics

It’s all about Sea Floor Spreading and Plate Tectonics.

Have you ***Any Question***, feel free to ask.

Sea Floor Spreading and Plate Tectonics

Thank You

Sea Floor Spreading and Plate Tectonics

Questions:

1. What Wegner's theory describes?
2. Define paleomagnetism?
3. What is Curie Temperature?
4. Describe two important topographic features of sea floor spreading?
5. What is magnetic reversal?
6. Describe pangea?
7. How many types of plate boundaries? Define each briefly.