Today's Quiz

1) Vocabulary Chapter 1b and 12
2) Review Chapters 11

Plate Tectonics

Chapters 1b and 12

Presidential Palace, Haiti Earthquake
Mw7.0 (2010)

Today's Quiz

1) Vocabulary Chapters 1b and 12
2) Review of Chapter 11

Check out iclicker when you bring up your quiz.

Within Earths deep interior, the transition from solid mantle to liquid outer core is due to _____.

a) an increase in the temperature toward the center of the planet causes the outer core to be molten.

b) the greater pressure at depth.

c) the metal core has a lower melting temperature than the silicate rock of the mantle.

d) a combination of greater pressure and greater depth.

e) don't know

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b) a decrease in the temperature toward the center of the planet.

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Within Earths deep interior, the transition from liquid outer core to a solid inner core is due to _____.

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The asthenosphere is capable of deforming plastically because_____

a) the more mafic rocks of the asthenosphere have a lower melting temperature than the underlying mesosphere.

b) the greater pressure at depth leads to melting.

c) the asthenosphere is mostly a liquid.

d) the temperature of the rocks at asthenospheric depths are close to the solidus of ultramafic rocks.

e) don't know

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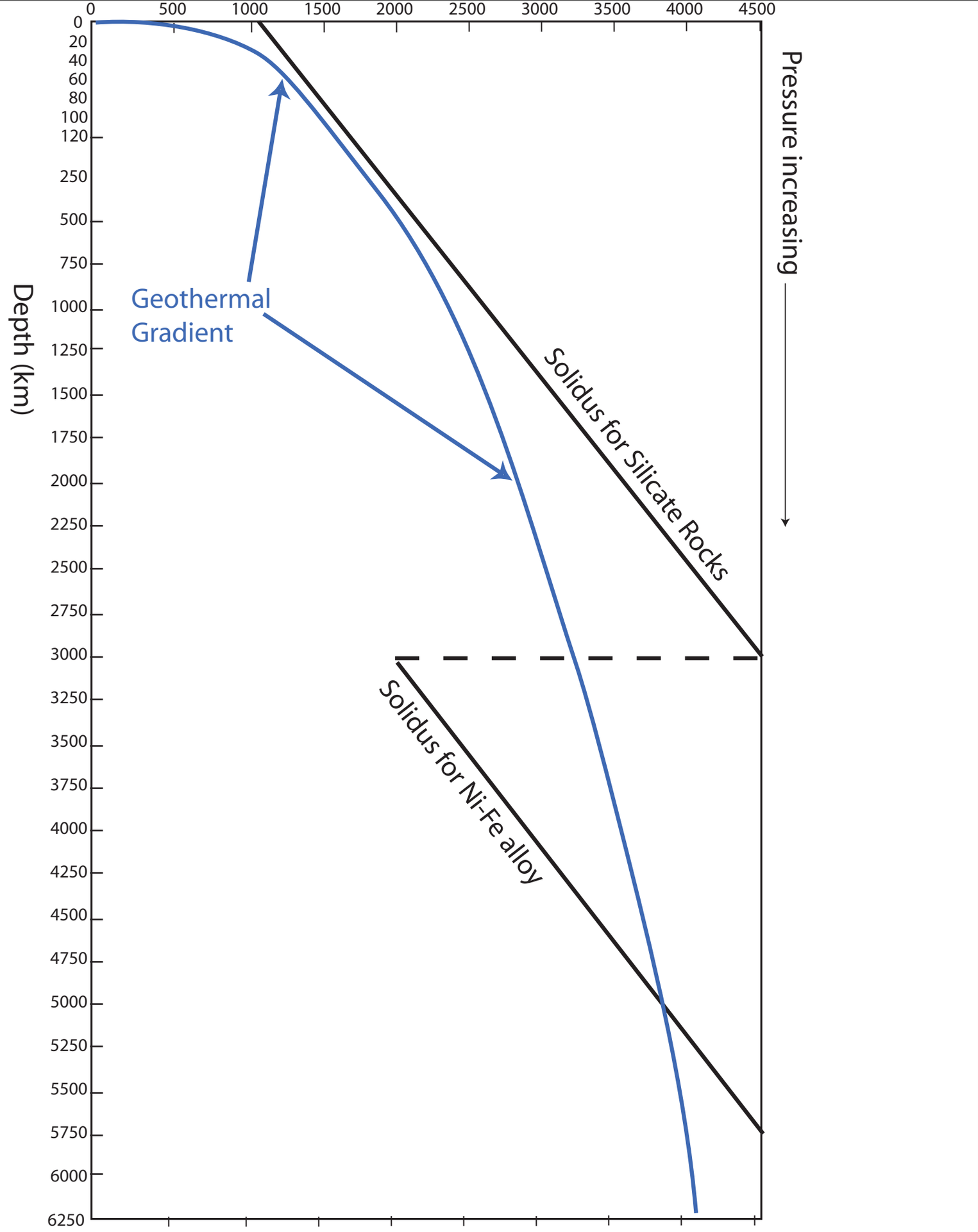
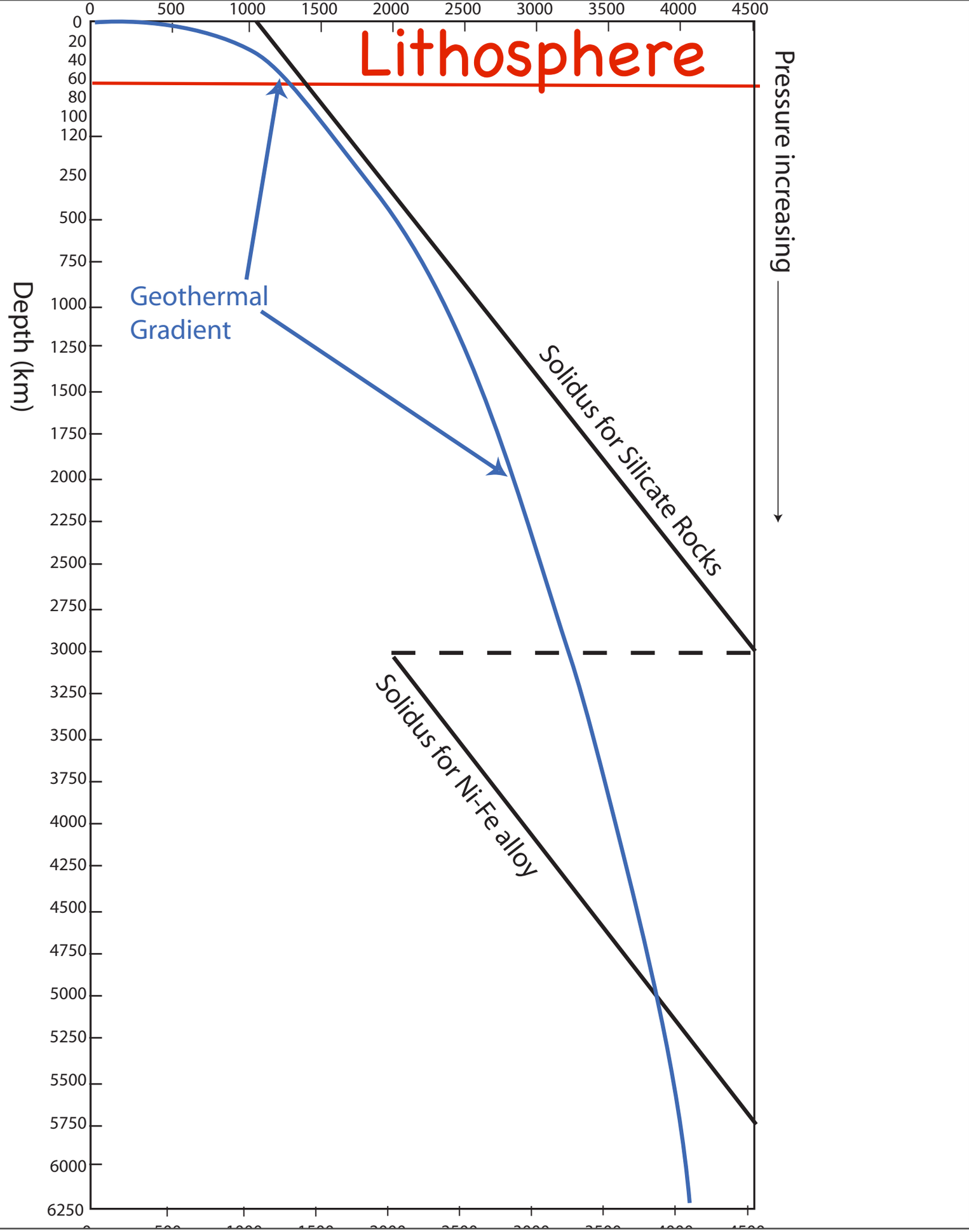
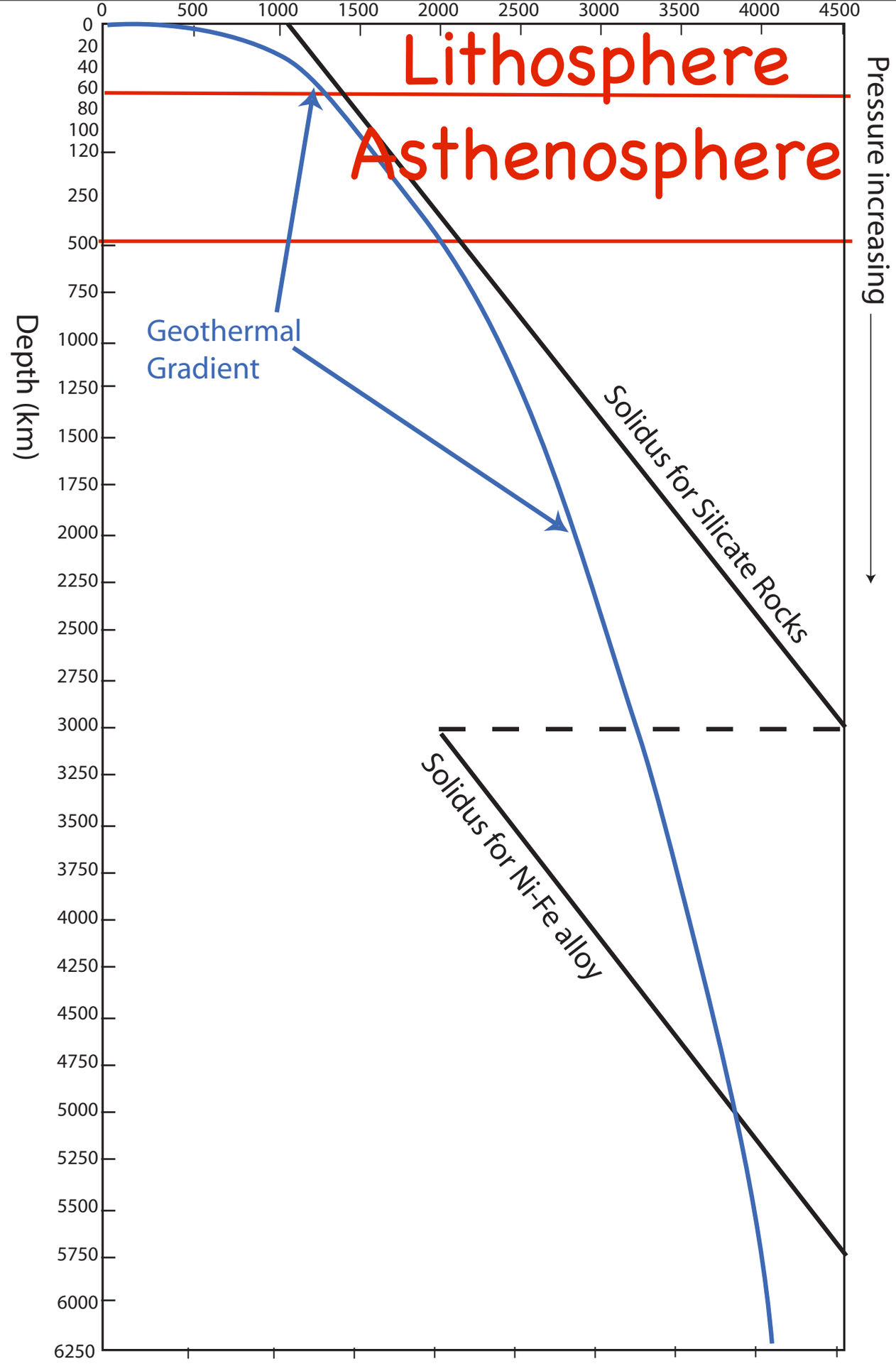
The Earth's Rheology



The Earth's Rheology



The Earth's Rheology



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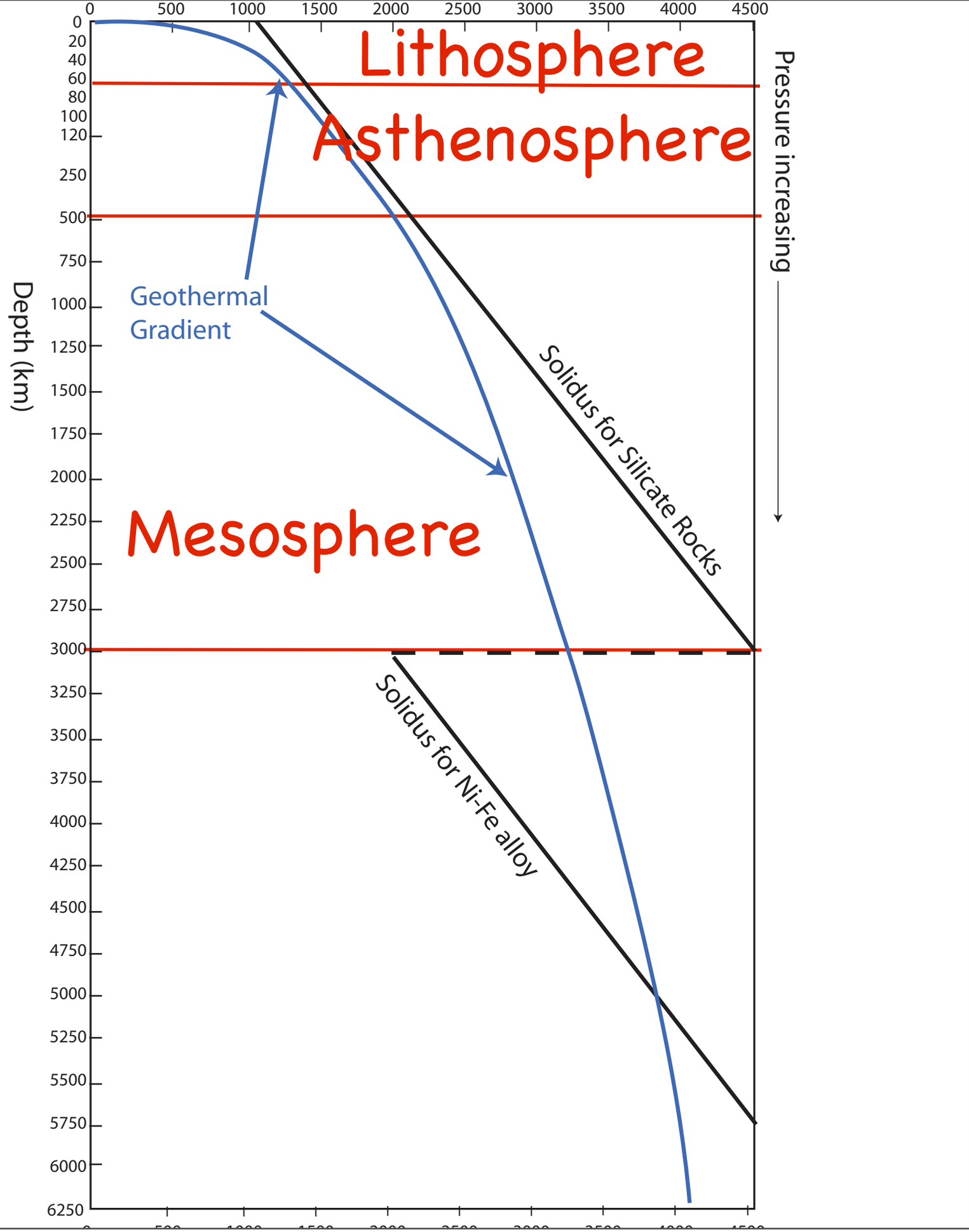

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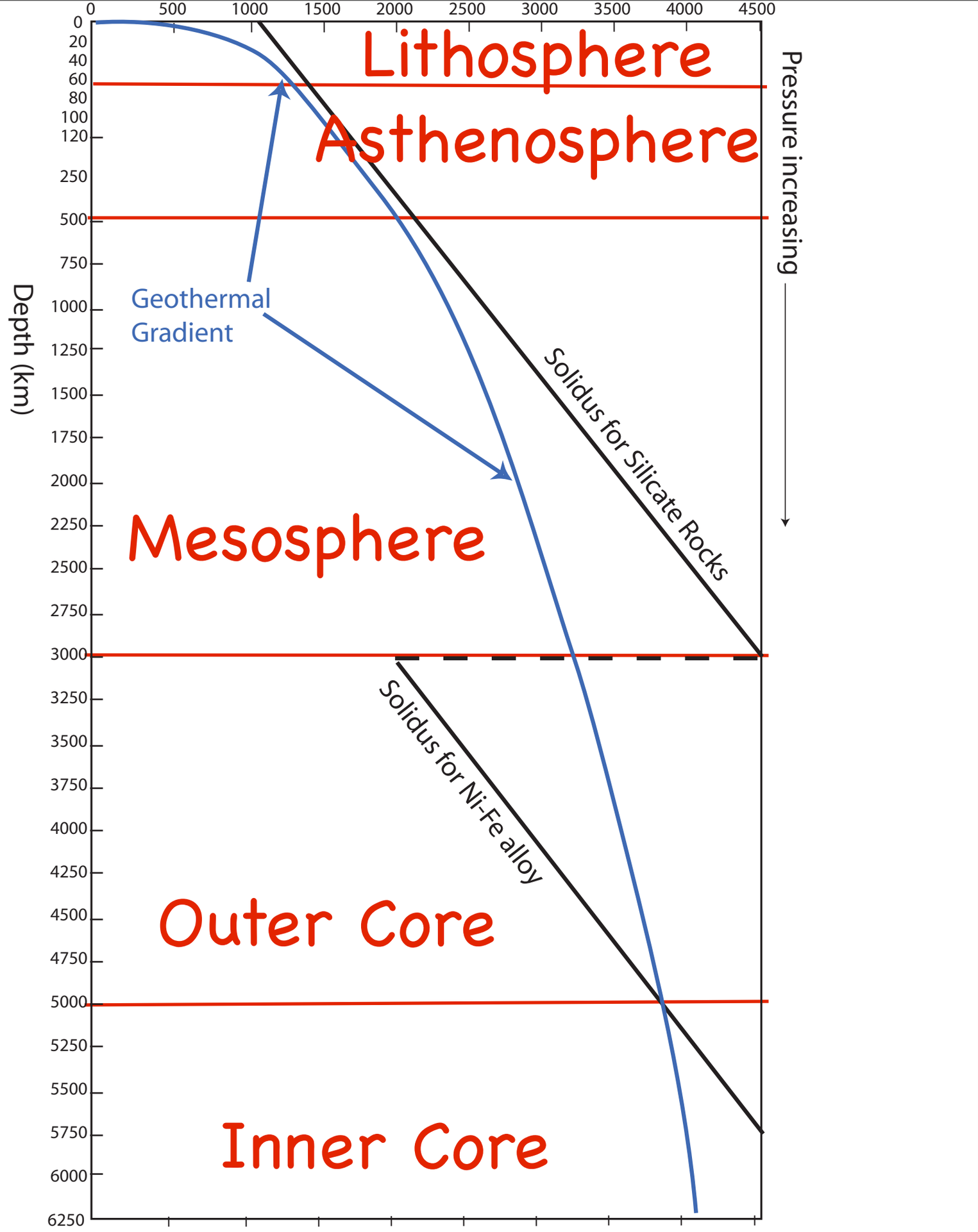


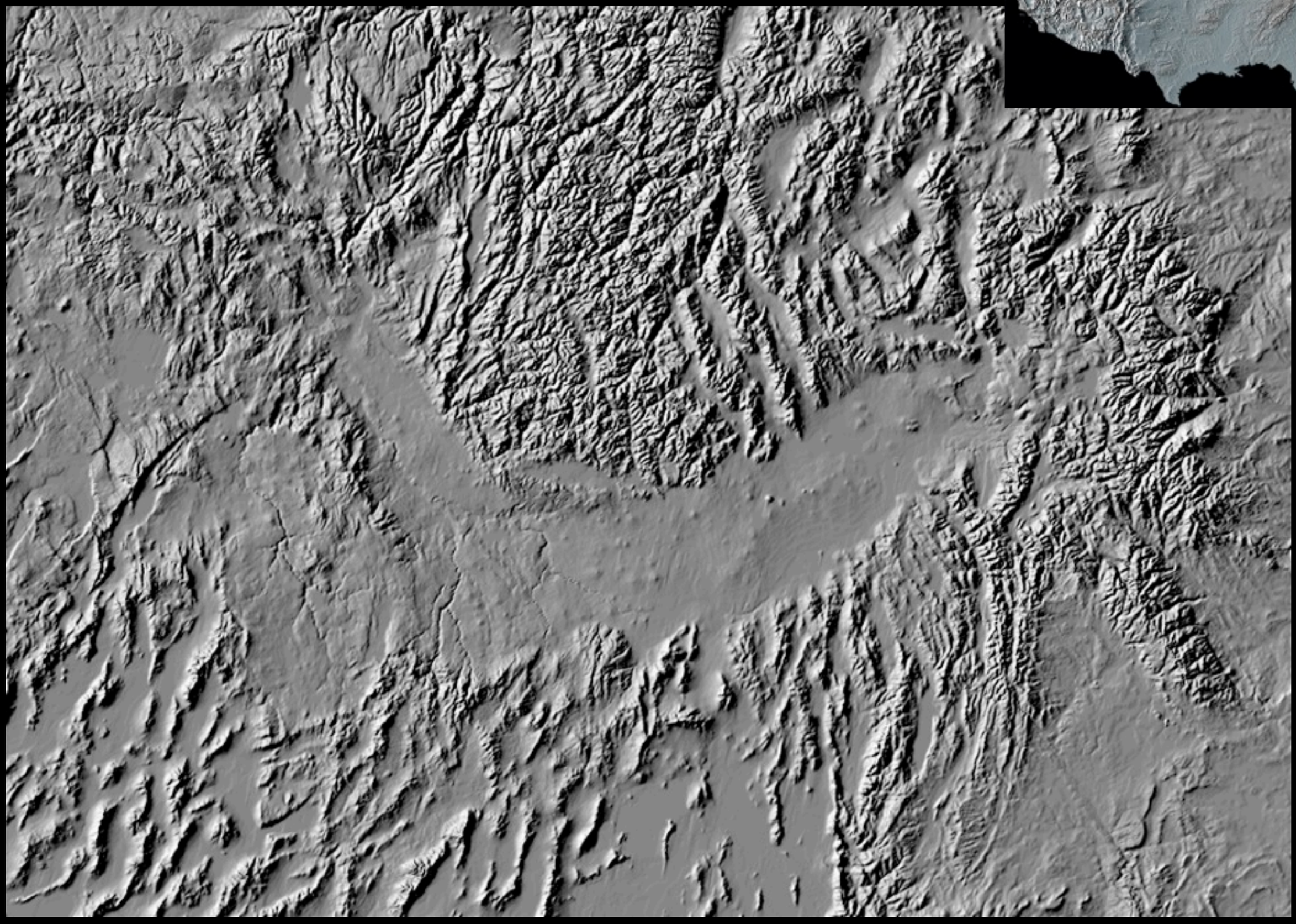
Plate Tectonics?

Chapters 1b and 12

Presidential Palace, Haiti Earthquake Mw7.0 (2010)

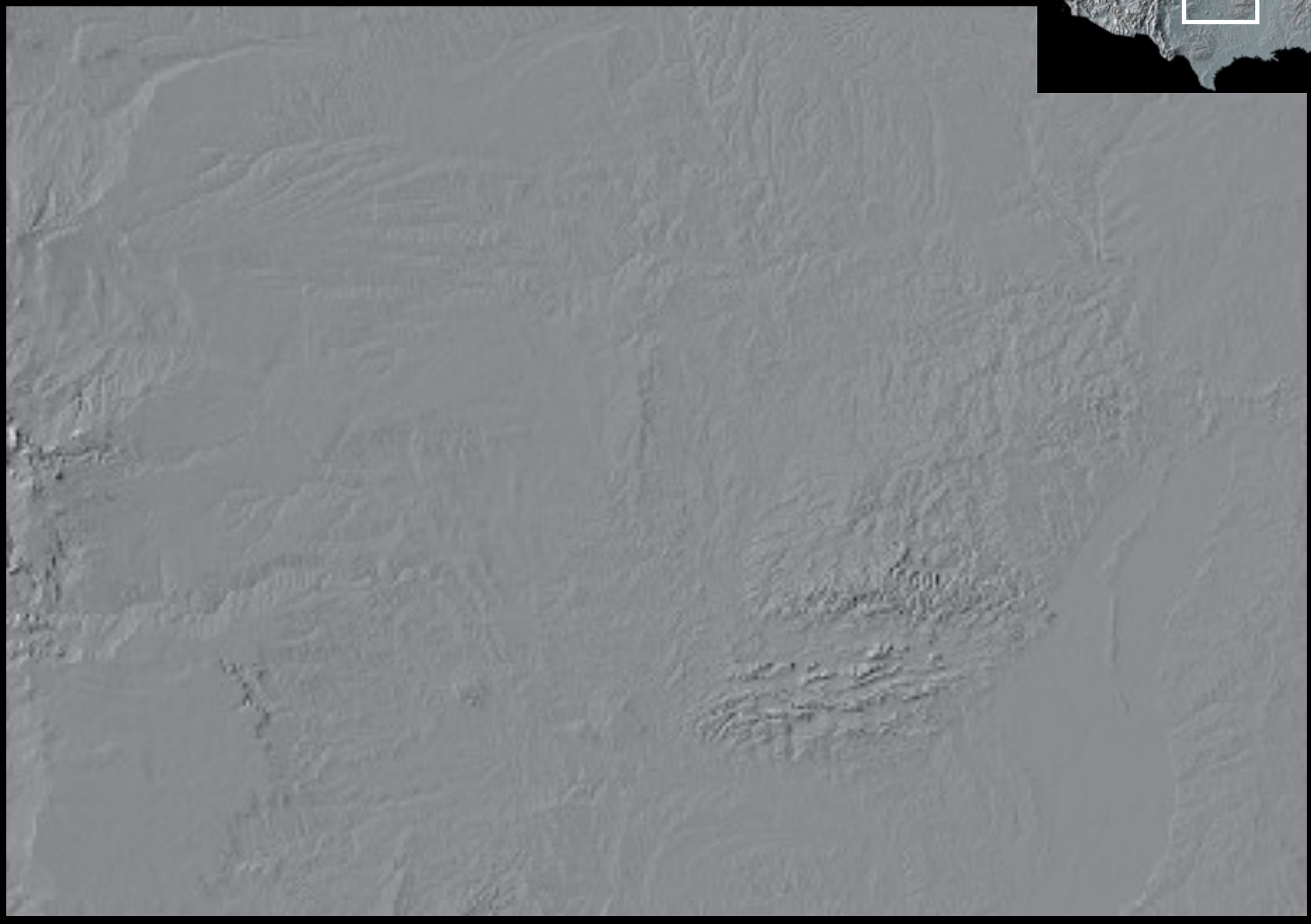
North

What do you see?



North

Compare?



“Plate Tectonic Theory”

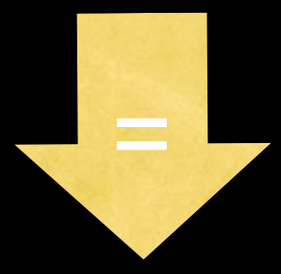
Continental Drift hypothesis

+

Sea Floor Spreading hypothesis

+

Vine-Mathews hypothesis



“Plate Tectonic Theory”

Continental Drift hypothesis

+

Sea Floor Spreading hypothesis

+

Vine-Mathews hypothesis

Making of a Theory?

=

“Plate Tectonic Theory”

Alfred Wegener (1880-1930)
"Continental Drift hypothesis" (1915)

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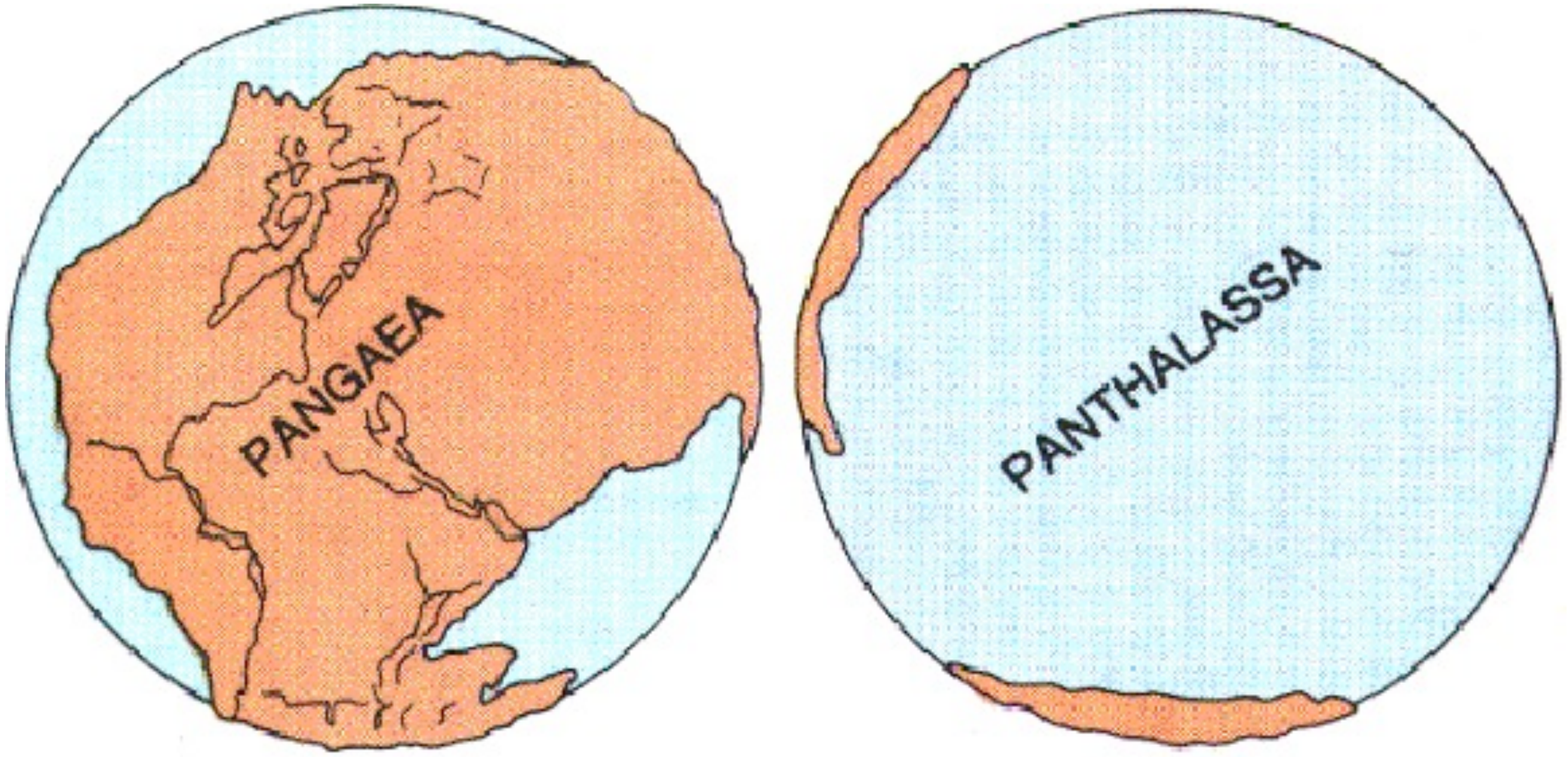


Figure 3: According to Wegener's theory only one "super-continent", called *Pangaea*, and one ocean, called *Panthalassa*, existed about 250 million years ago.

Alfred Wegener (1880-1930)
"Continental Drift hypothesis" (1915)

Laurasia

PANGEA
Entire supercontient

Gondwanaland

Super Continent Formation (250 Million Years ago)

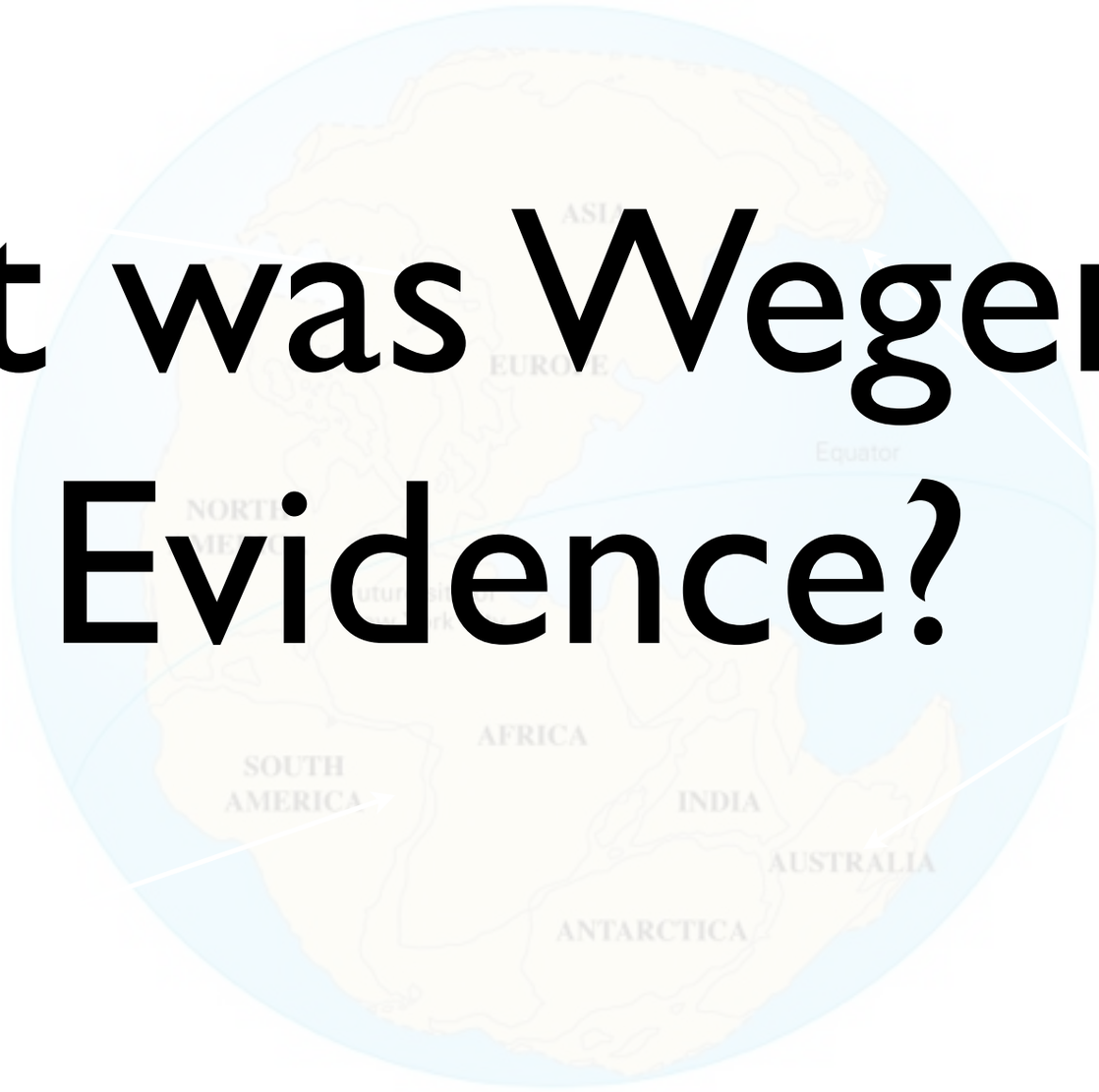
Alfred Wegener (1880-1930)
"Continental Drift hypothesis" (1915)

What was Wegener's Evidence?

Laurasia

PANGEA

Entire supercontient



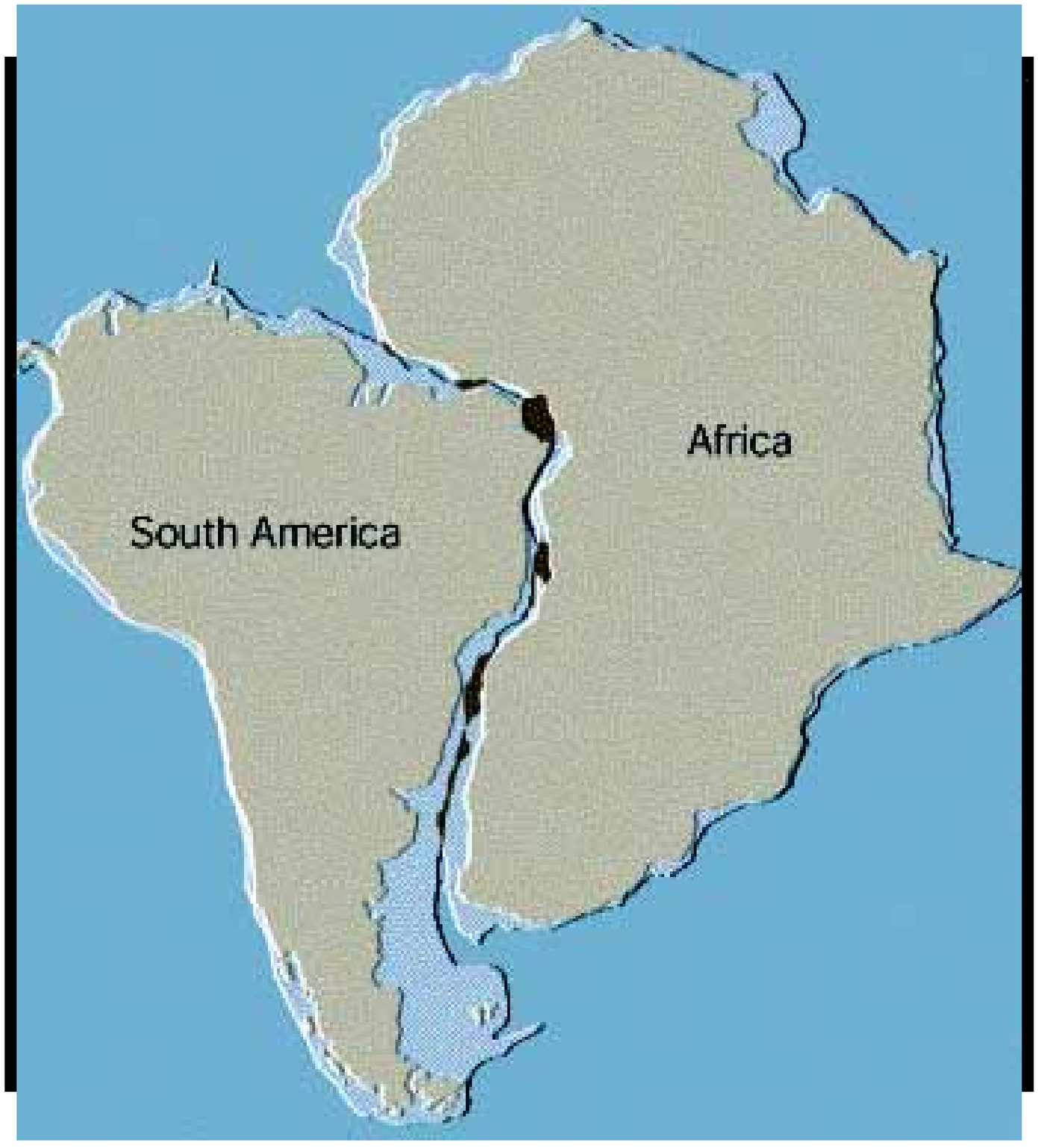
Gondwanaland

Super Continent Formation (250 Million Years ago)

Fit of the Continents

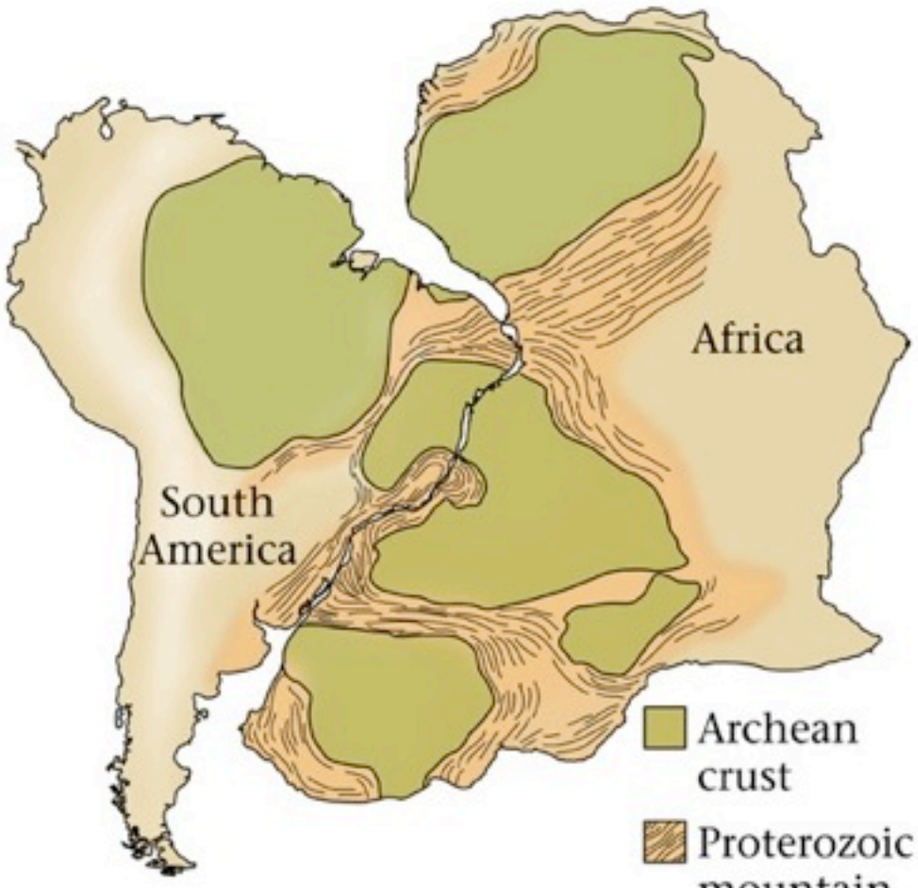
Fit of the Continents

Fit of the Continents



Mountain belts of the World

Mountain Belt Continuity



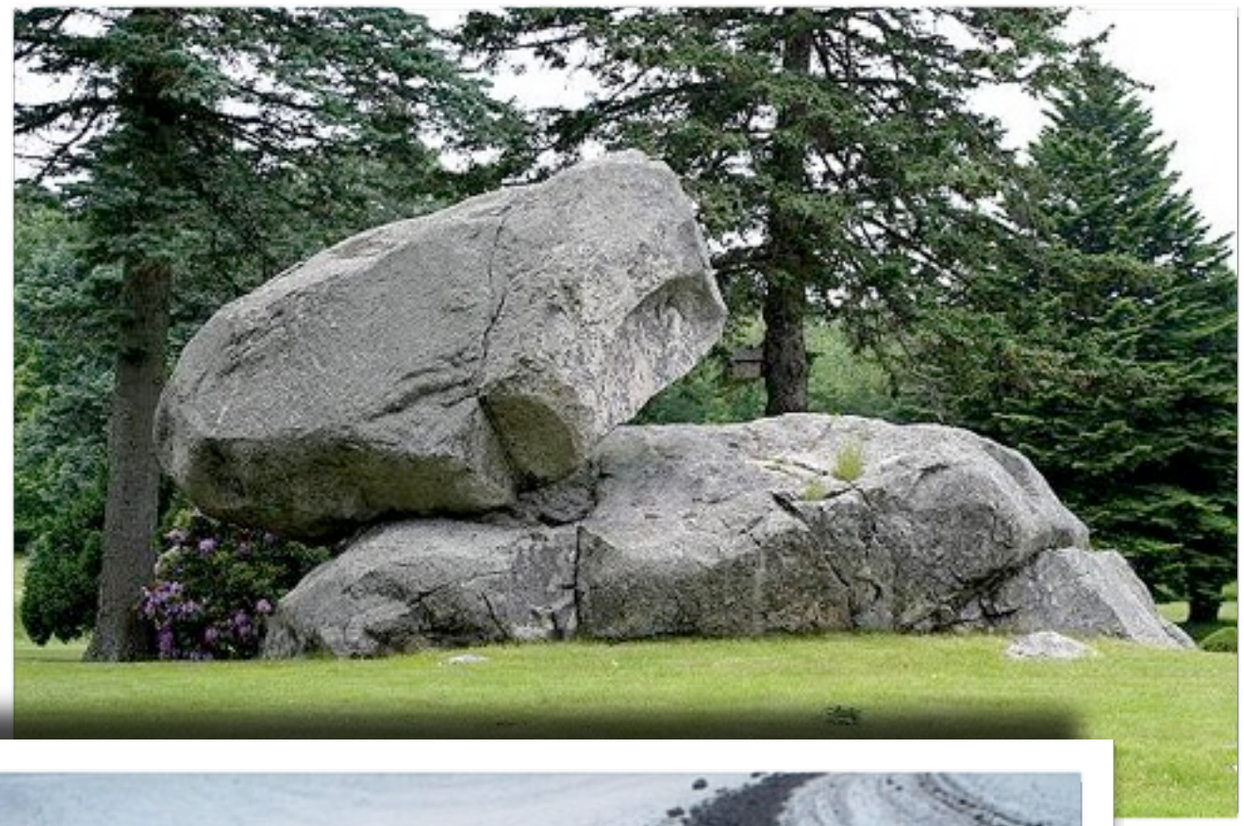
(a)

(b)

Super Continent Formation (250 Million Years ago)

Glacial/Ice Sheet Evidence

Glacial/Ice Sheet Evidence



Glacial/Ice Sheet Evidence

Glacial/Ice Sheet Evidence

Wegener's Solution

Fossil Evidence

Modern Animal Distribution

Fossil Evidence

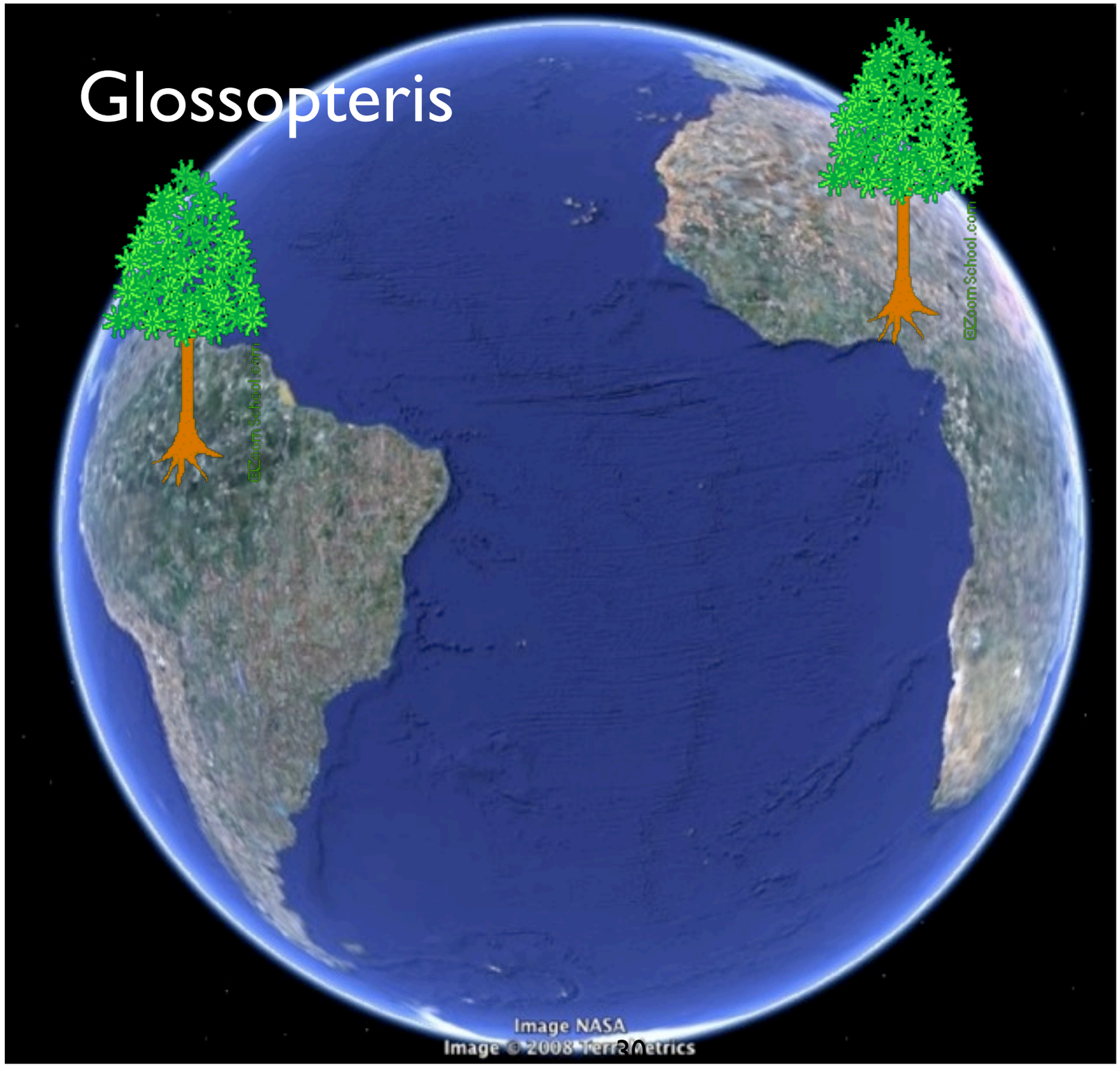
Modern and Ancient Animal Distribution

Fossil Evidence

Ancient Distribution

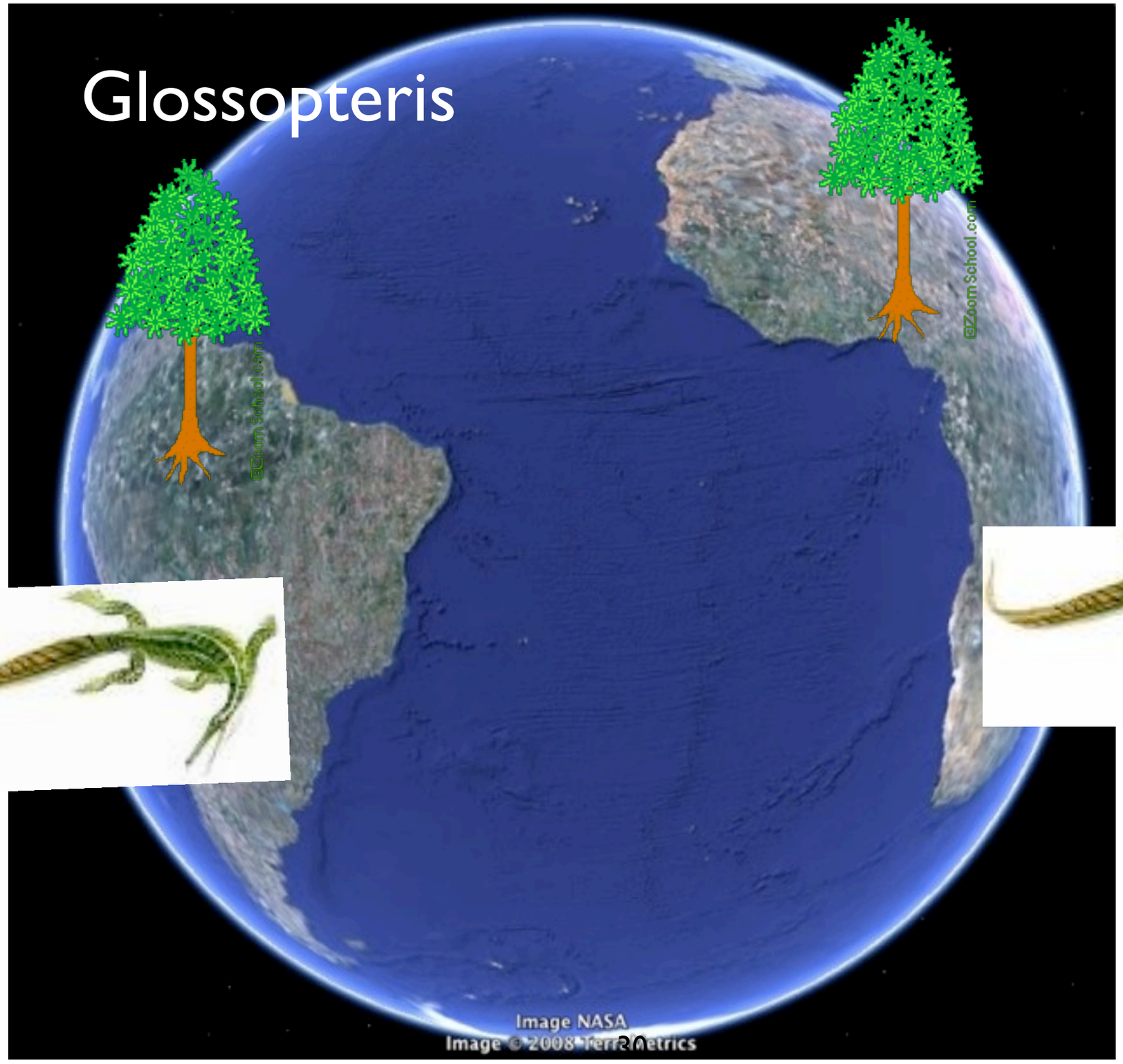
Fossil Evidence

Ancient Distribution



Fossil Evidence

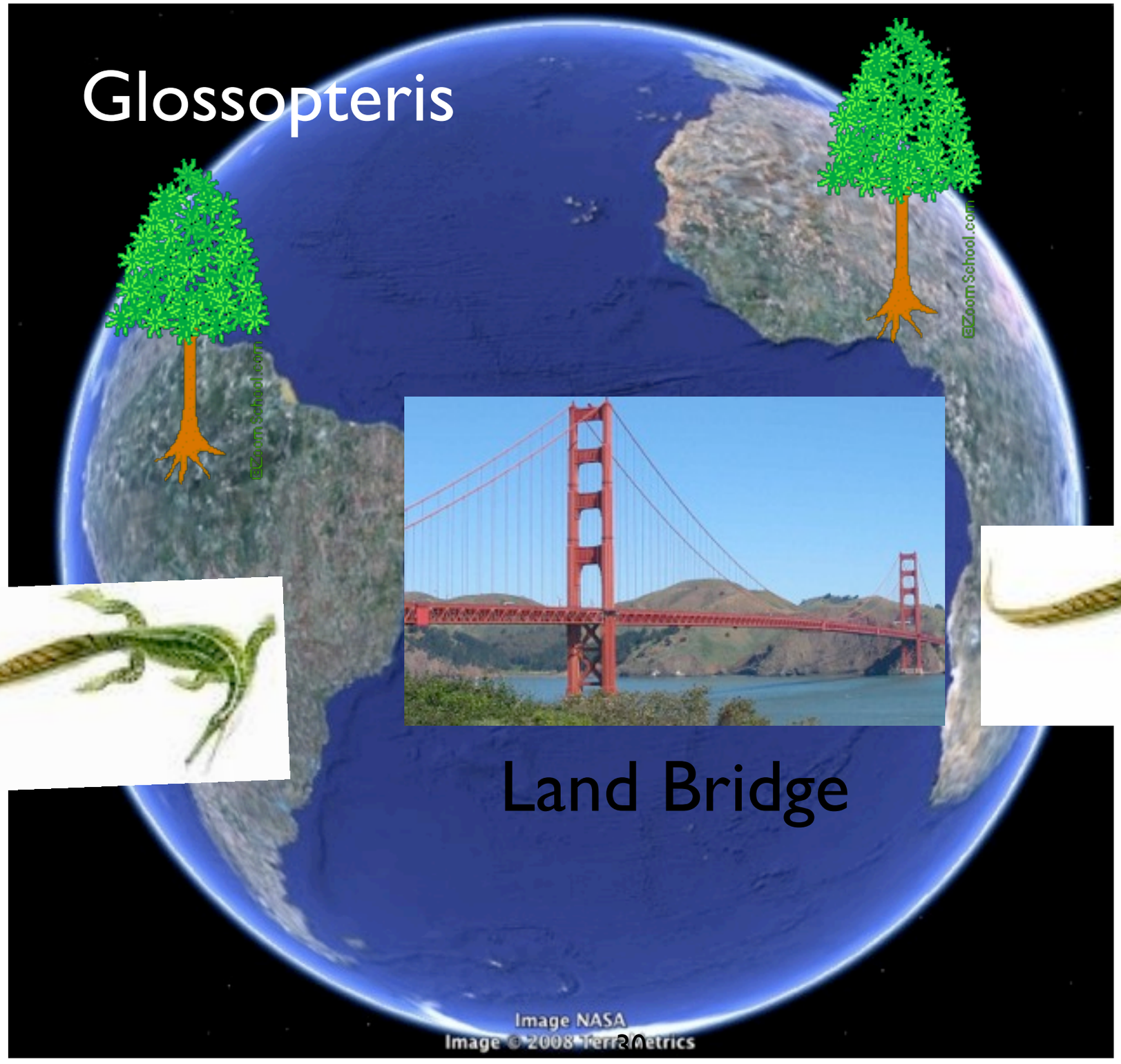
Ancient Distribution



Mesosaurus

Fossil Evidence

Ancient Distribution



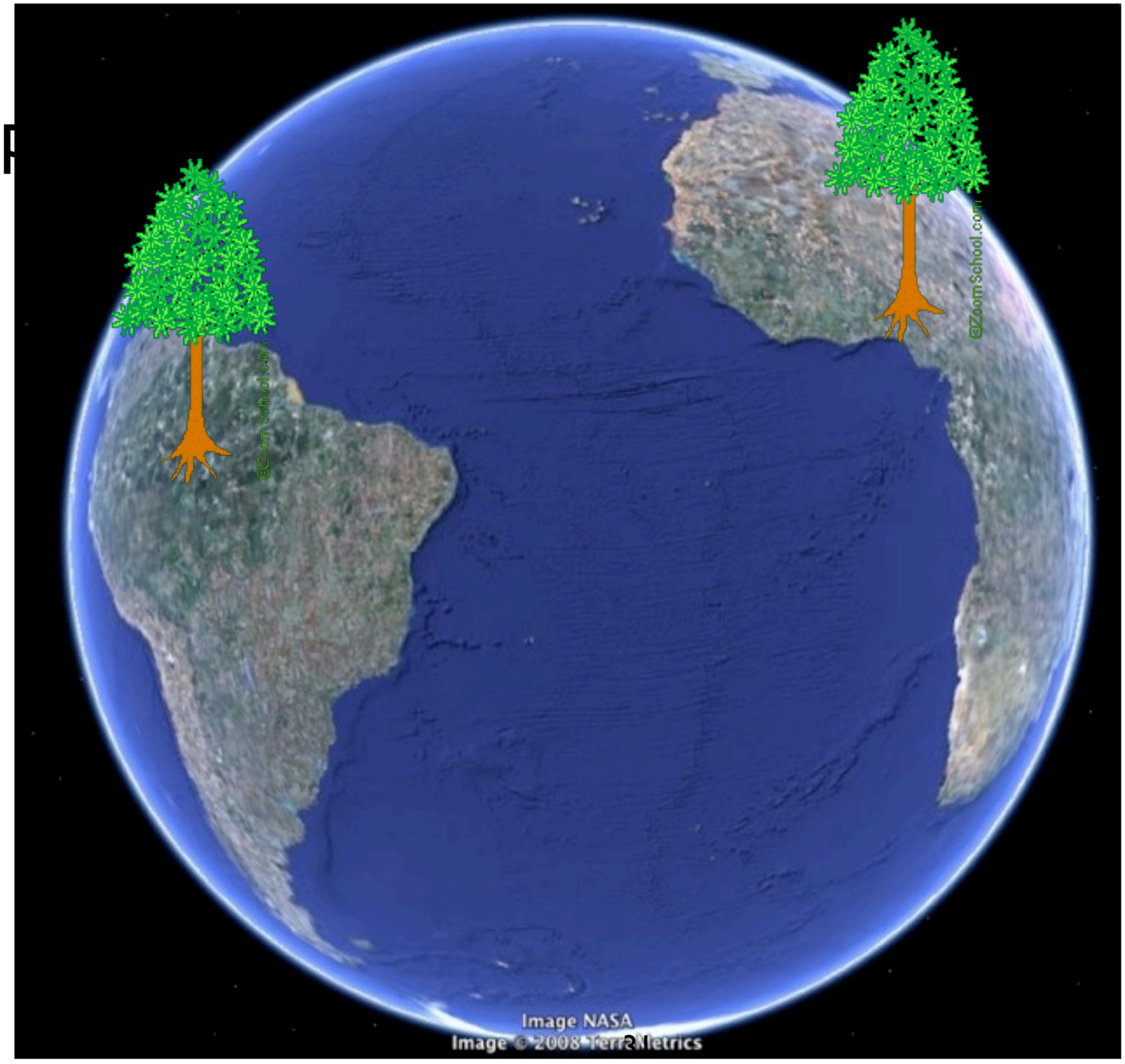
Fossil Evidence

Ancient Distribution

Fossil Evidence

Ancient Distribution

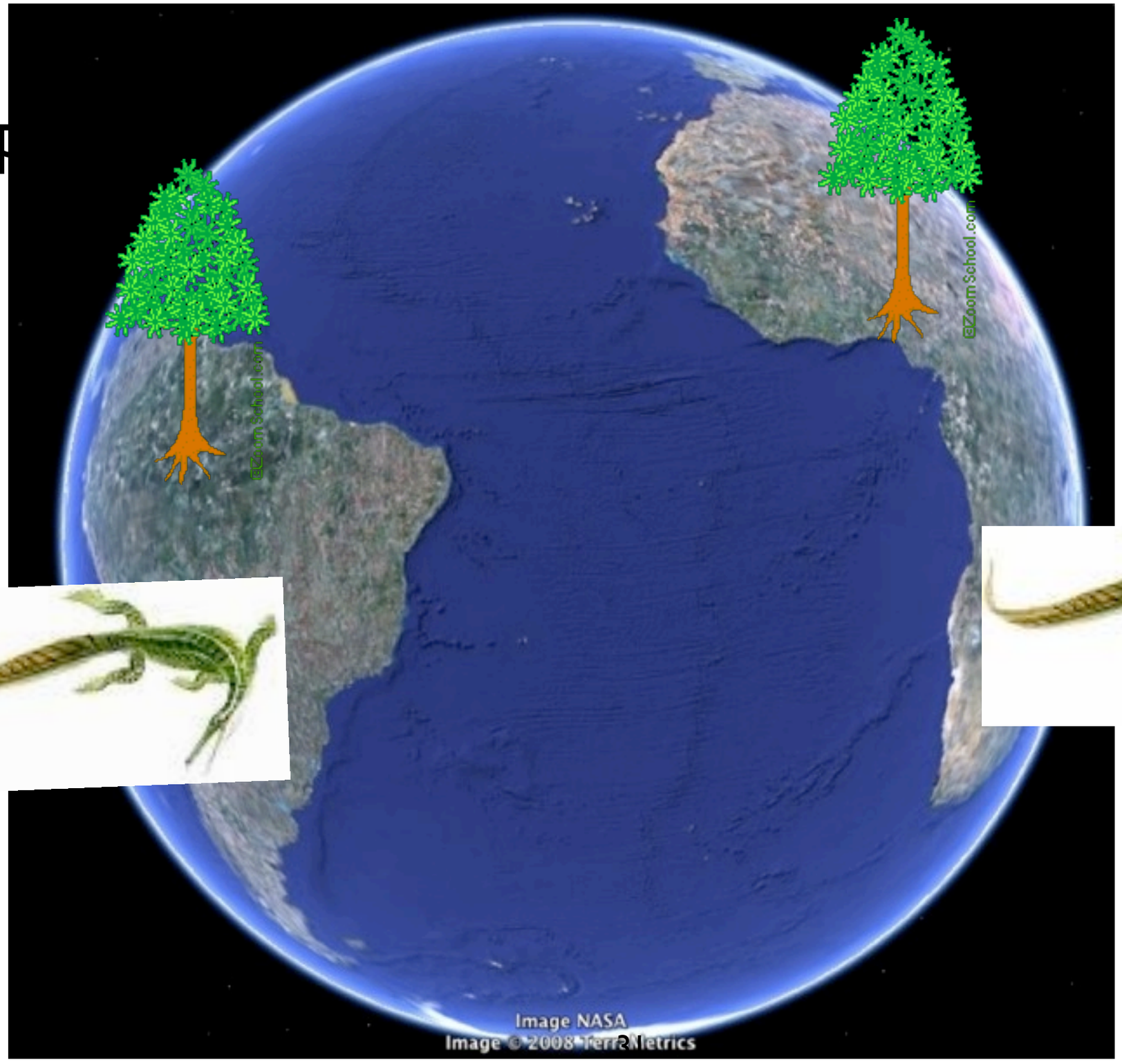
Glossop



Fossil Evidence

Ancient Distribution

Glossop



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Ancient Distribution

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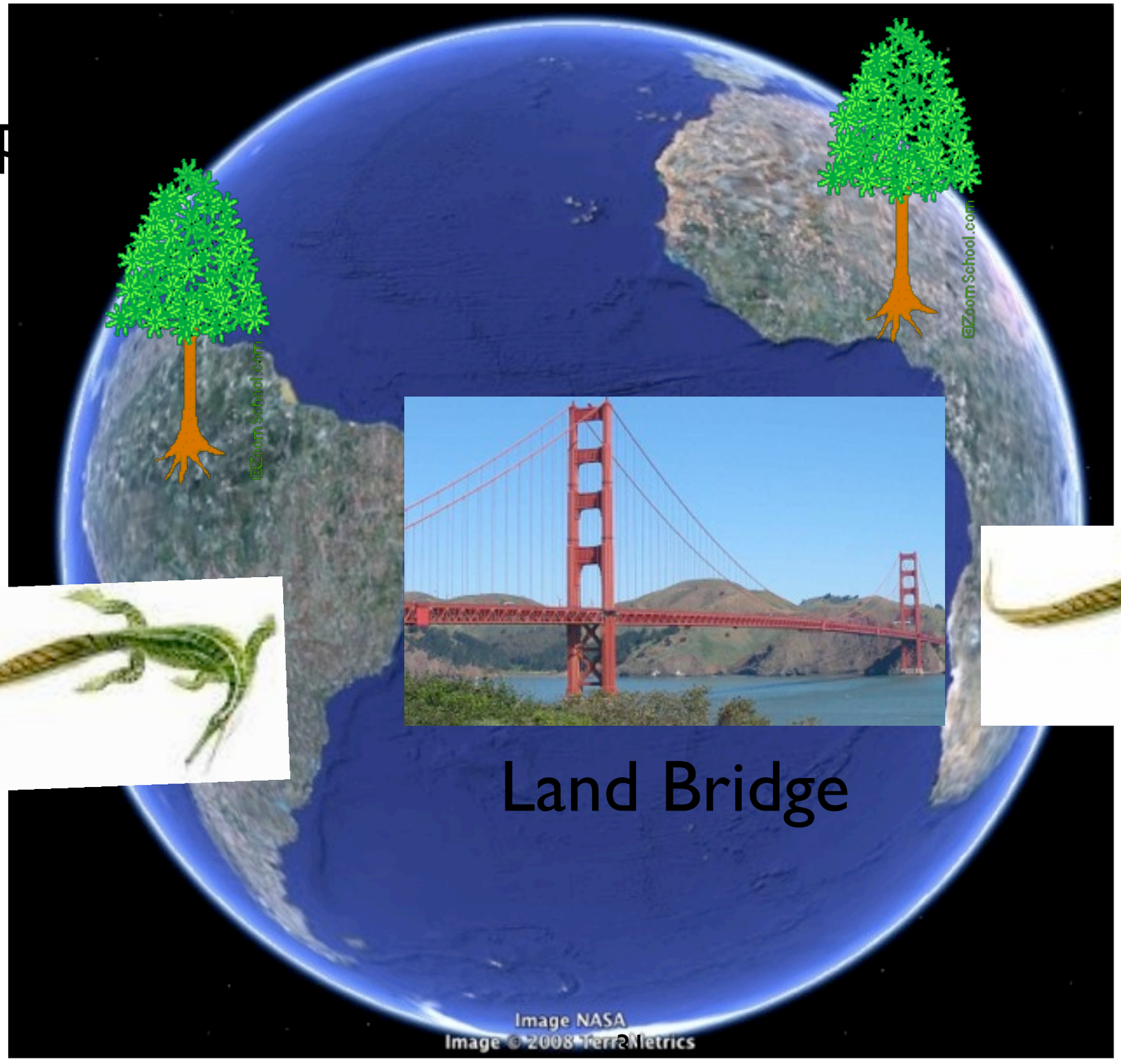


Land Bridge

Mesosaurus

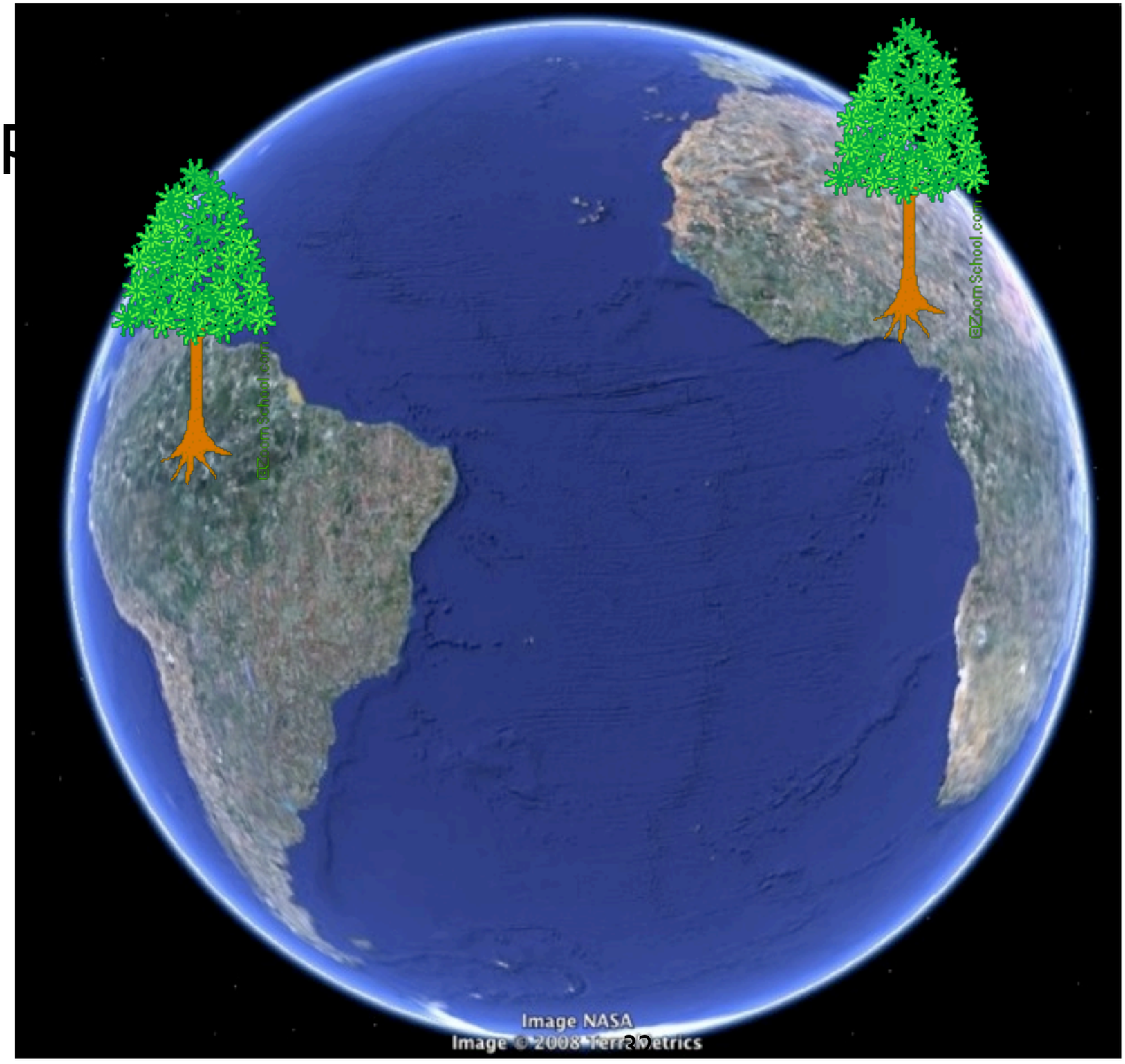
Fossil Evidence

Ancient Distribution

Fossil Evidence

Ancient Distribution

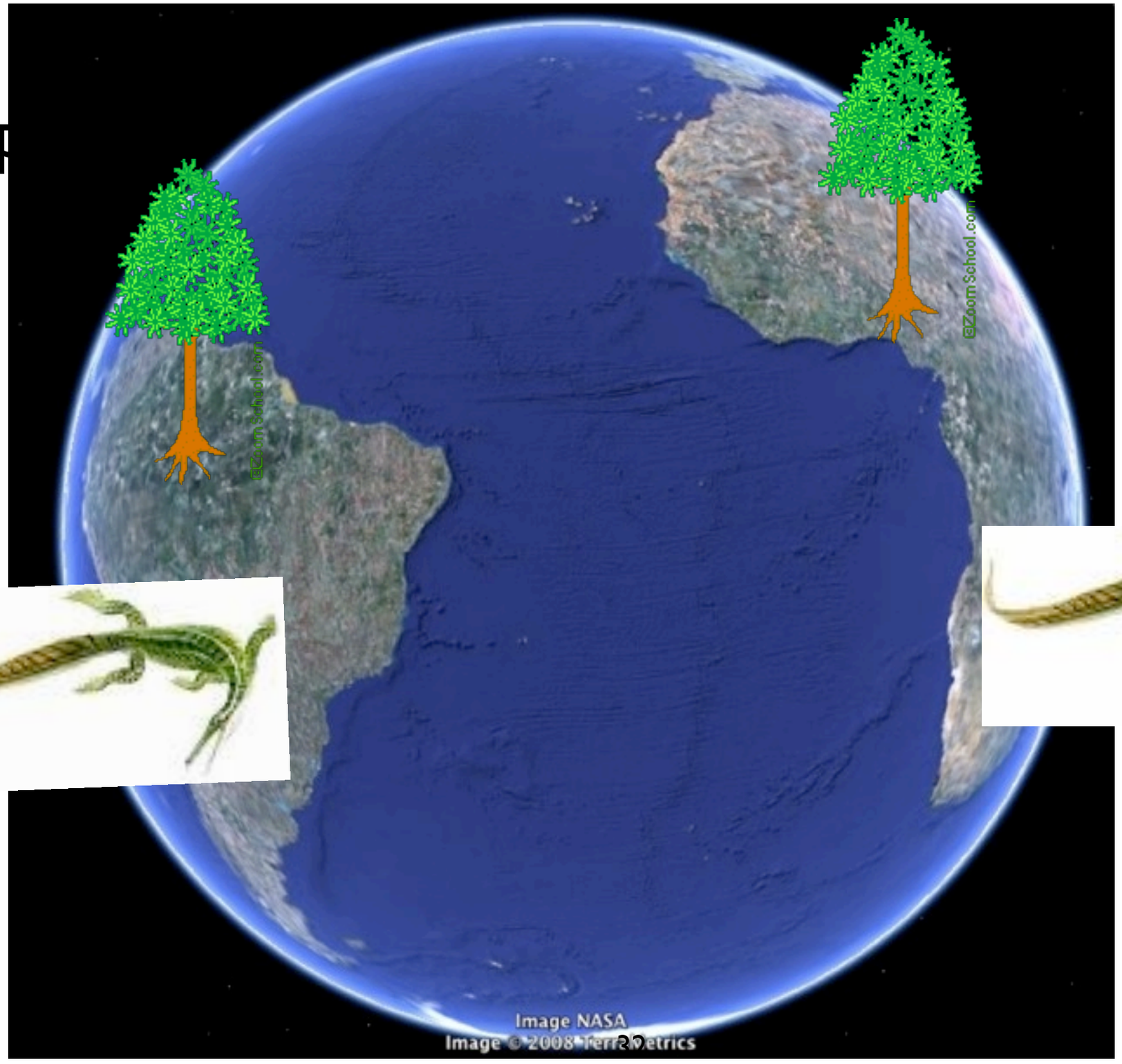
Glossop



Fossil Evidence

Ancient Distribution

Glossop



Mesosaurus

Fossil Evidence

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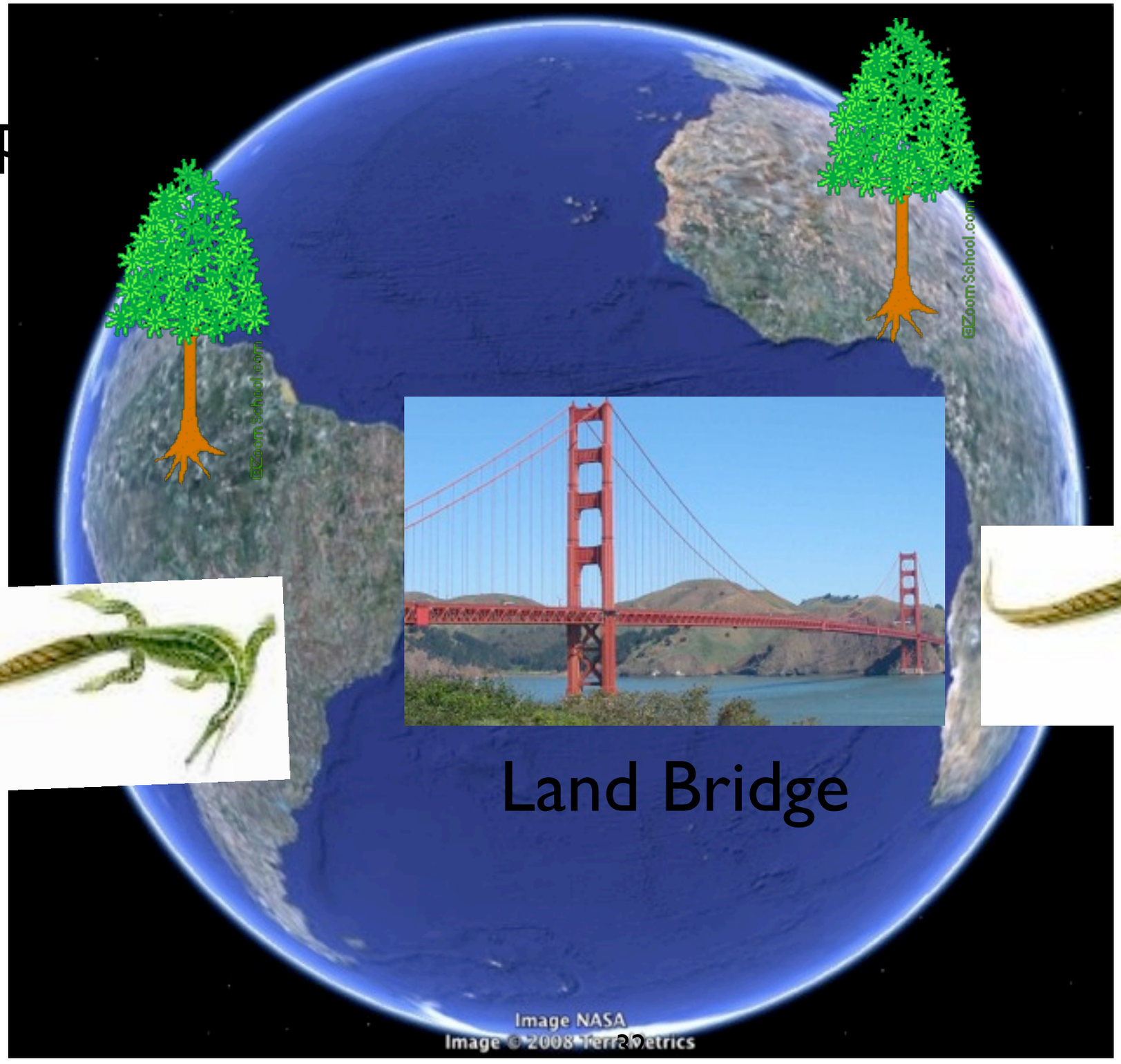


Land Bridge

Mesosaurus

Land Bridge Problem

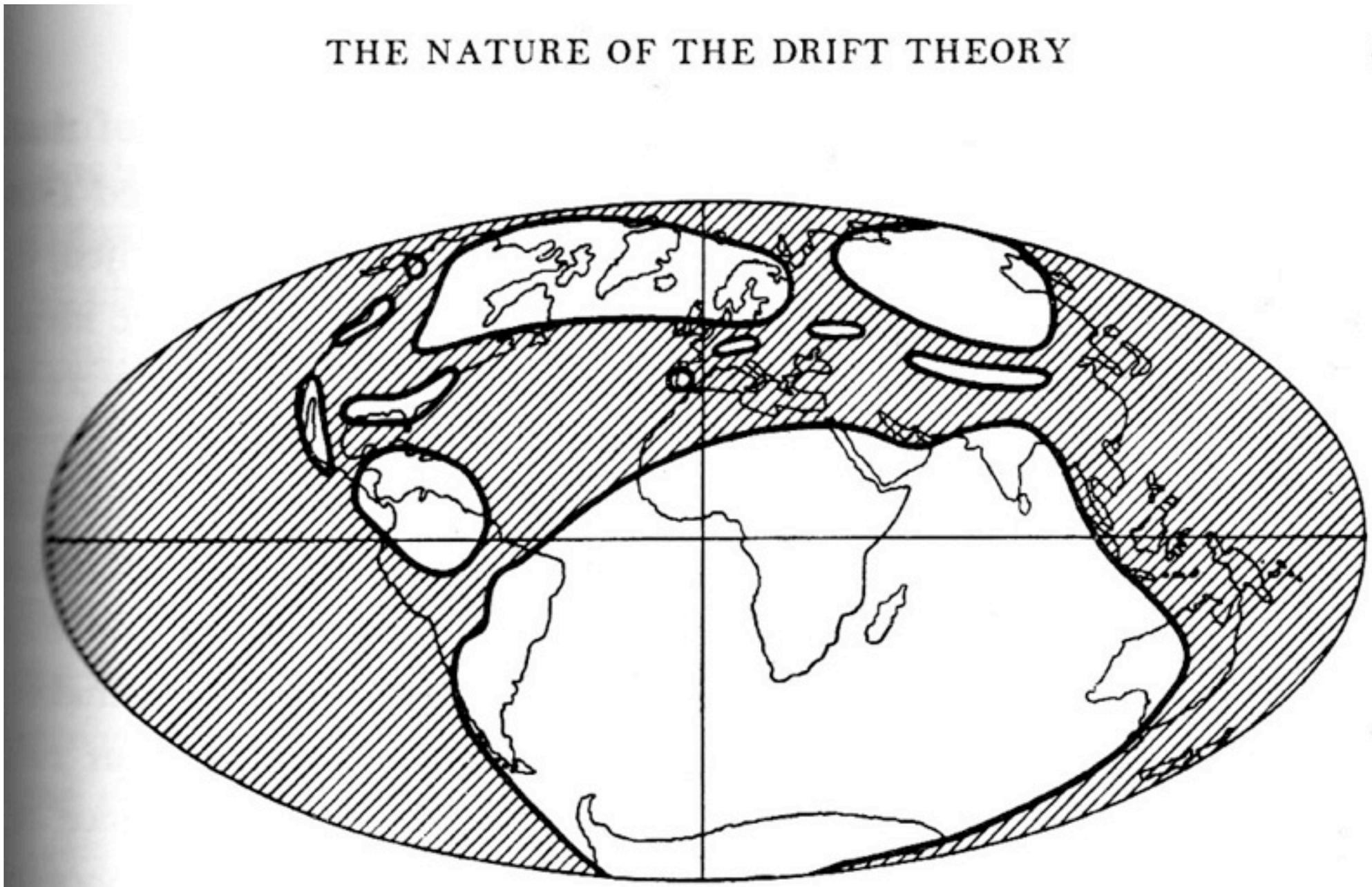
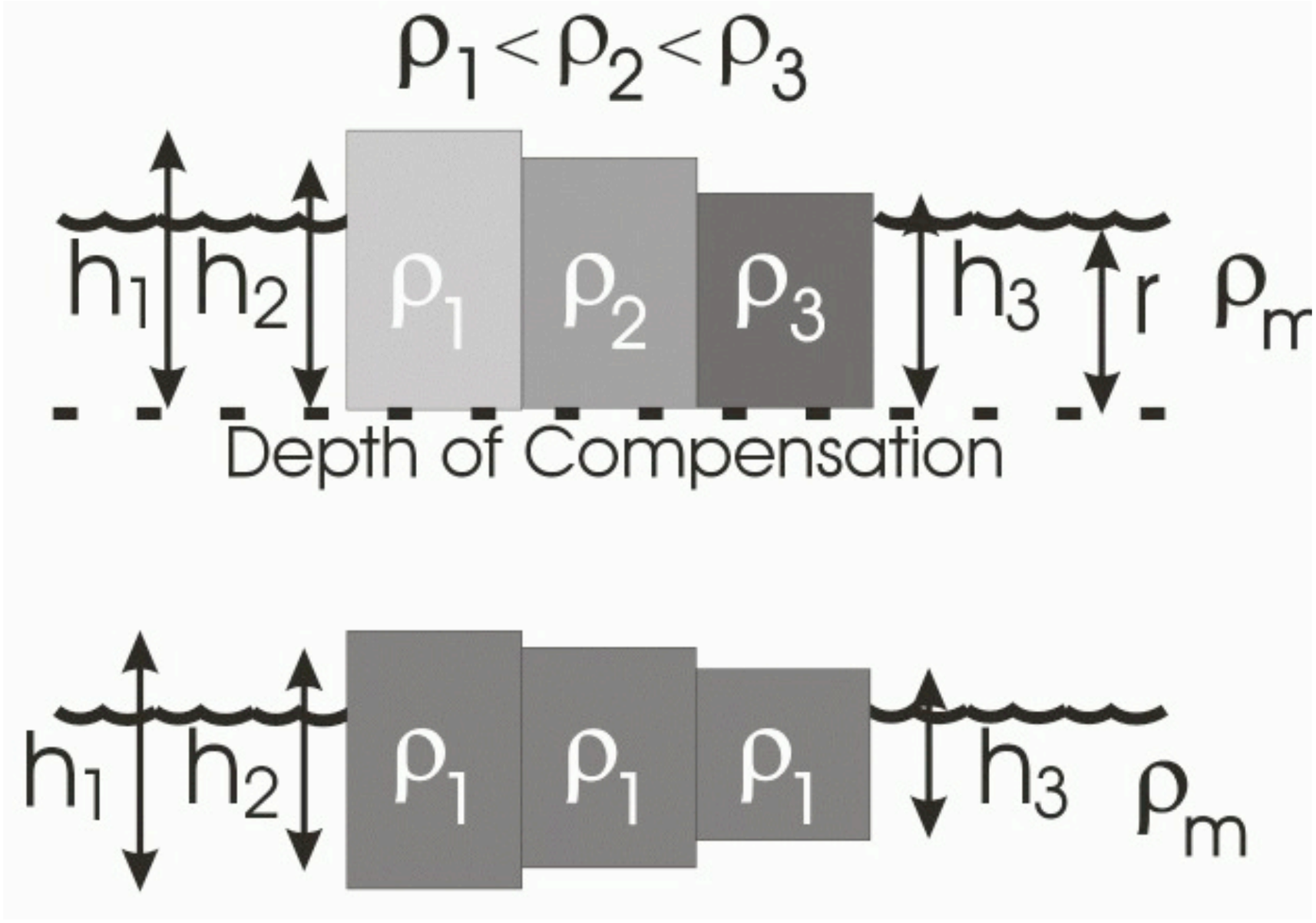


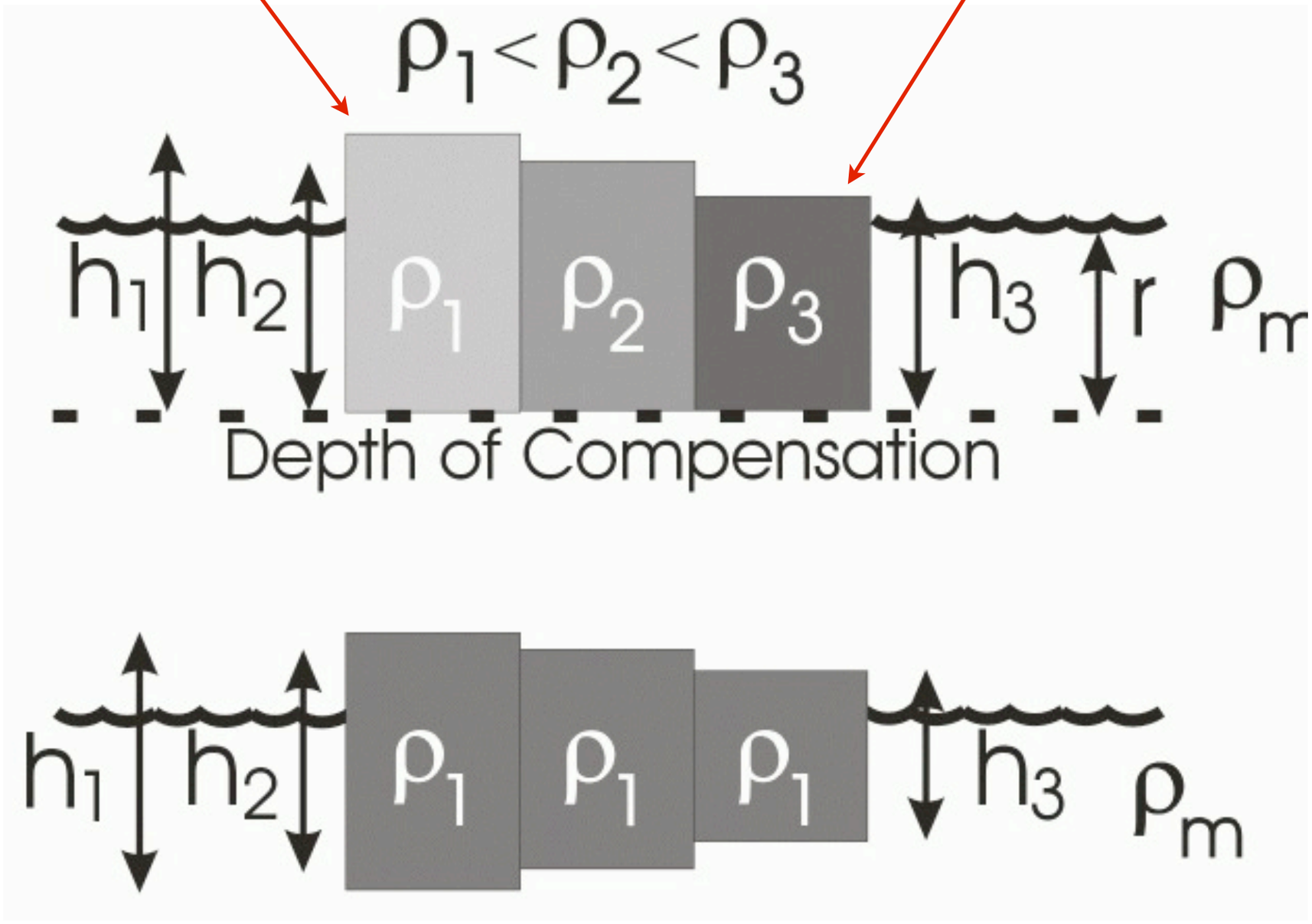
FIG. 2. Distribution of water (hatched) and land in the Carboniferous, according to the usual conception.

Density and Thickness



Density and Thickness

Continental crust **Oceanic crust**

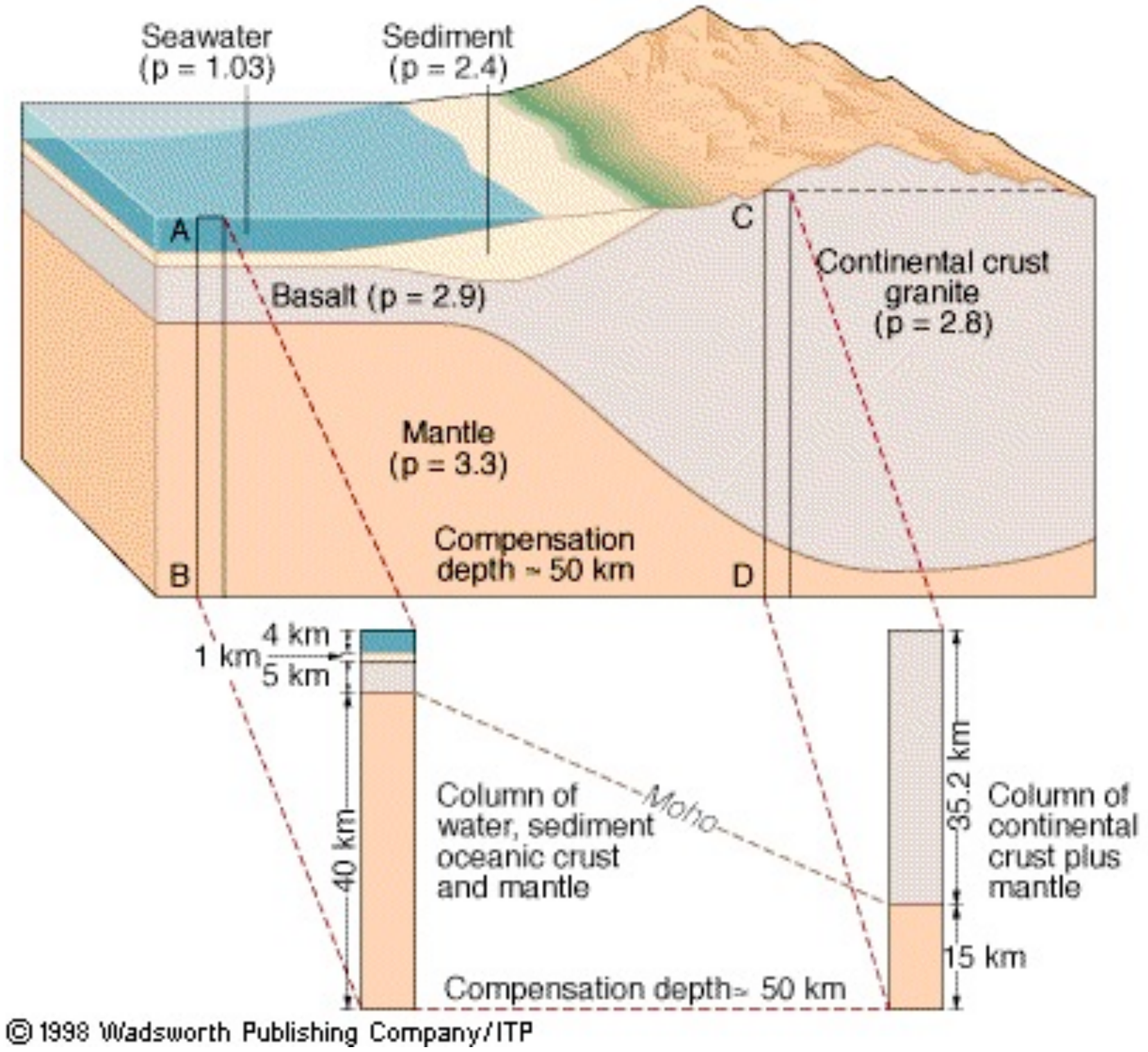


Density and Thickness
Take Home Message

1) The less dense the crust, the more buoyant it is with respect to the mantle and the greater elevation it will "float". Conversely, the more dense the curst, the lower it "floats" and thus will have lower elevation.

2) The thicker the crust, the greater its "floating" elevation and vise versa.

Isostacy Revisited



Land Bridge Problem

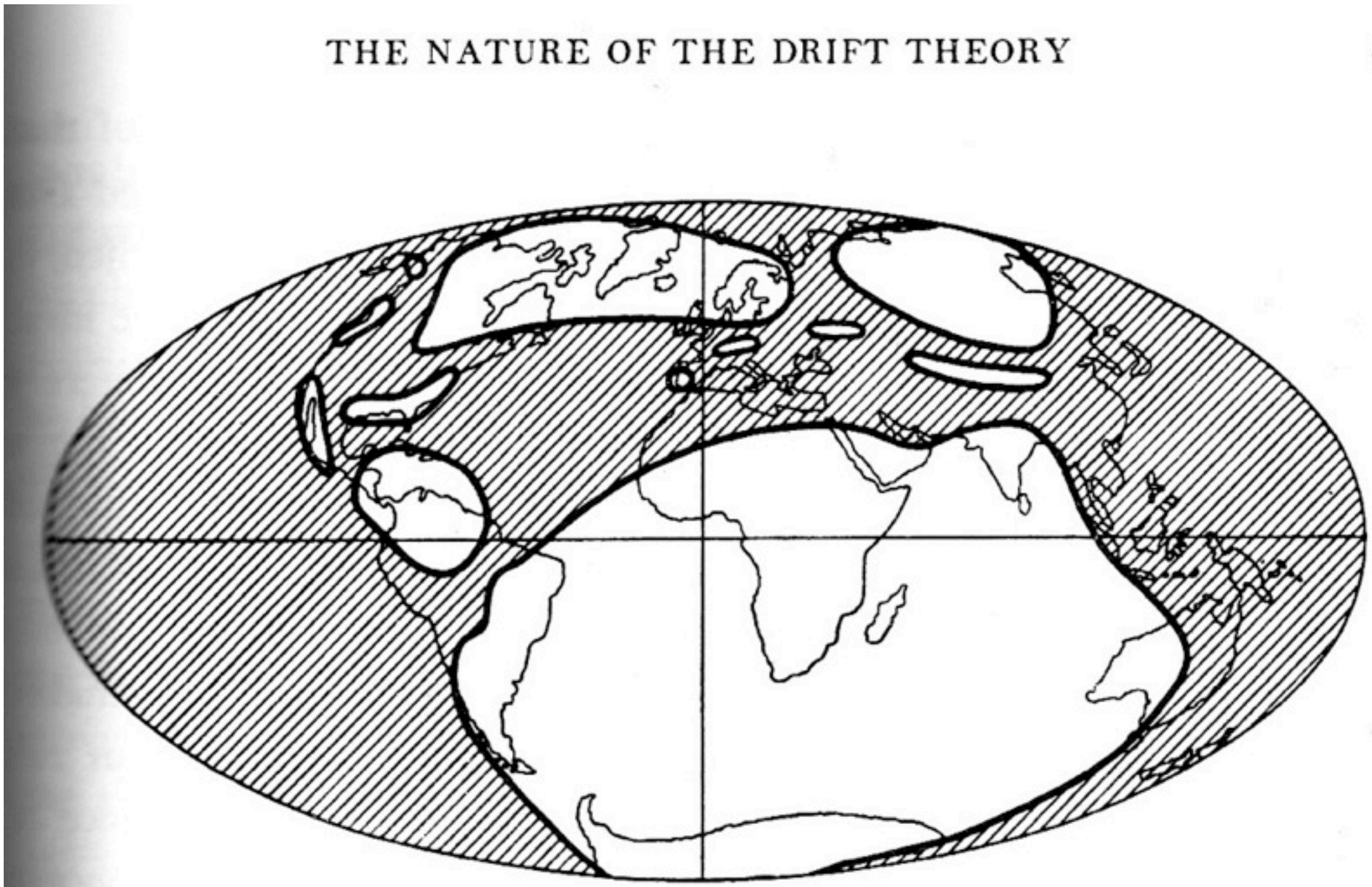
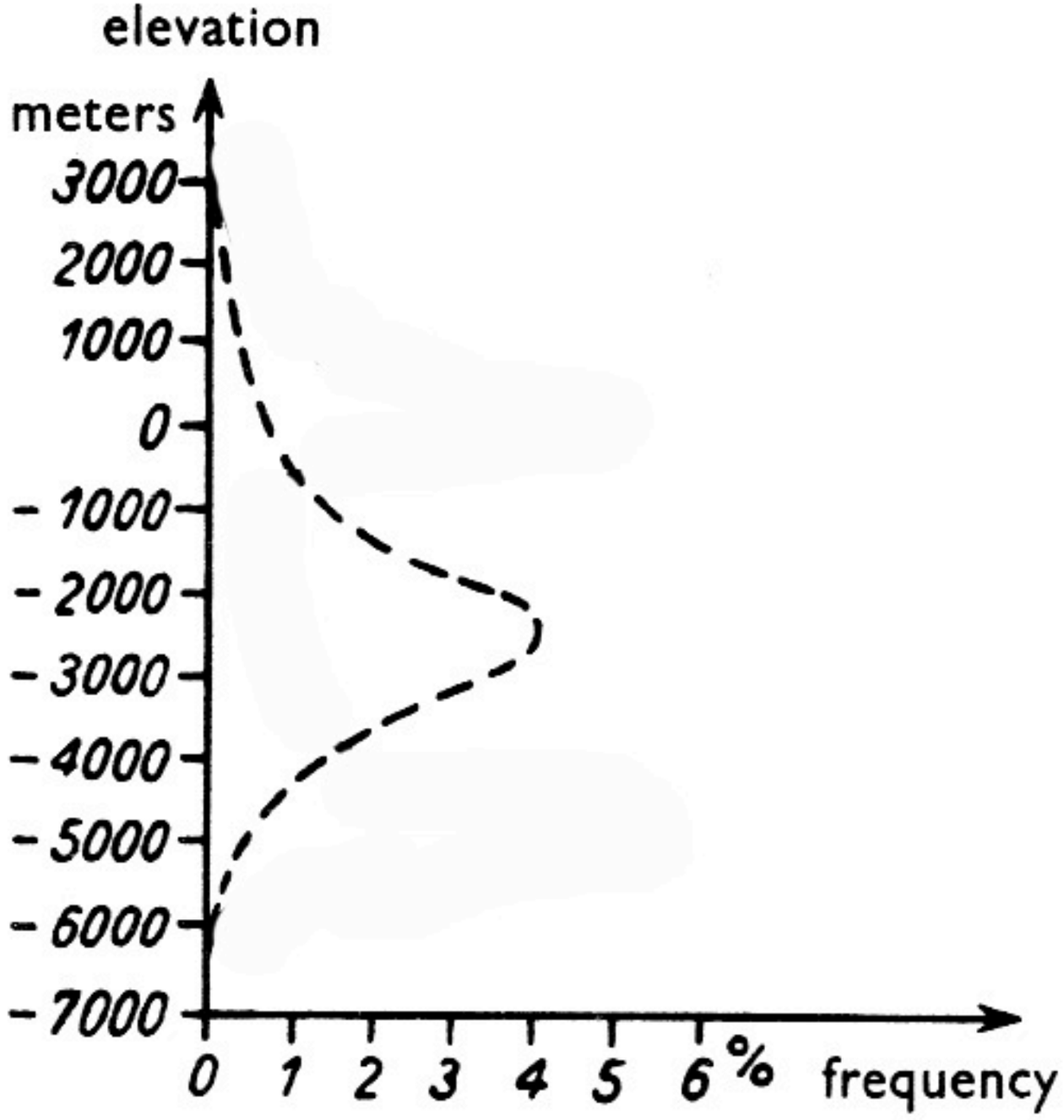


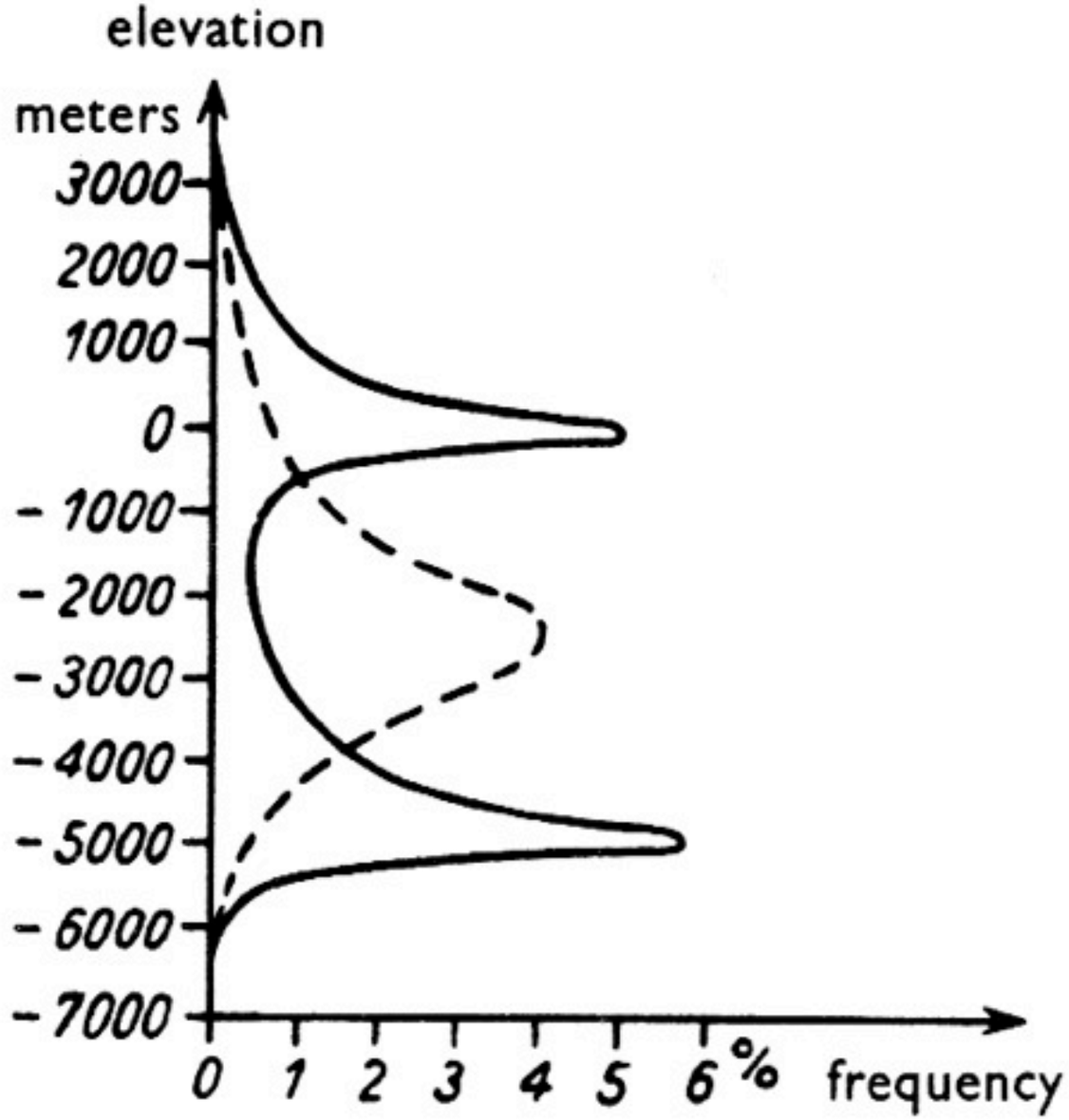
FIG. 2. Distribution of water (hatched) and land in the Carboniferous, according to the usual conception.

If the entire surface of Earth was made of the same stuff such that the oceans basins are just submerged continental crust elevation should be <u>normally distributed</u> as shown below?



Wegener's Solution

However, the elevation of Earths surface is Bimodal (solid line) indicating that the Earth is composed of two distinct types of crust (oceanic and continental), thereby arguing against submerged continents and the existence of land bridges.



Wegener's Solution

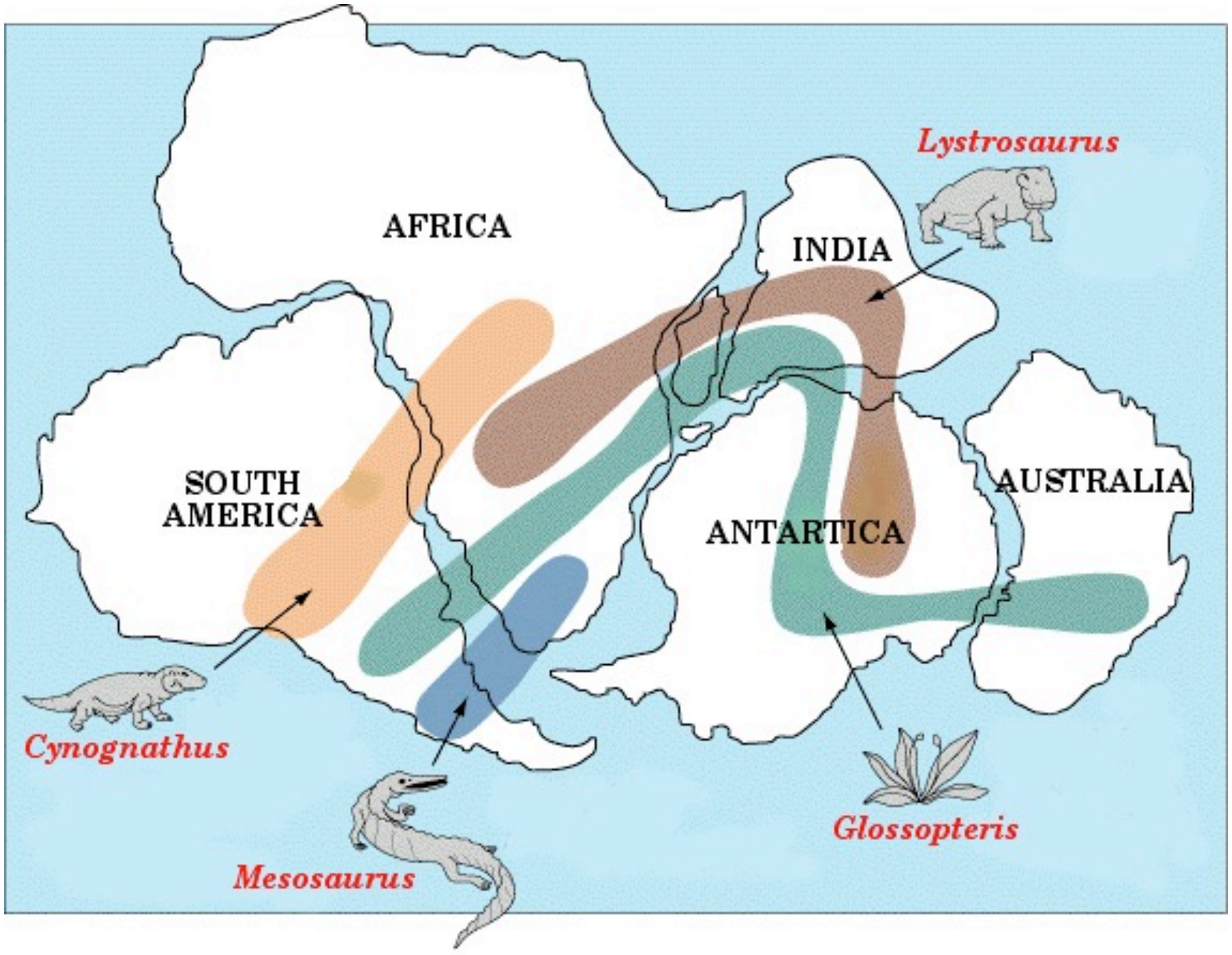


Figure 6: The distribution of the same fossil species across continents that are well separated today.

Alfred Wegener (1880-1930)
"Continental Drift hypothesis"

Last photograph of Wegener (left). Dies in Greenland pursuing is hypothesis

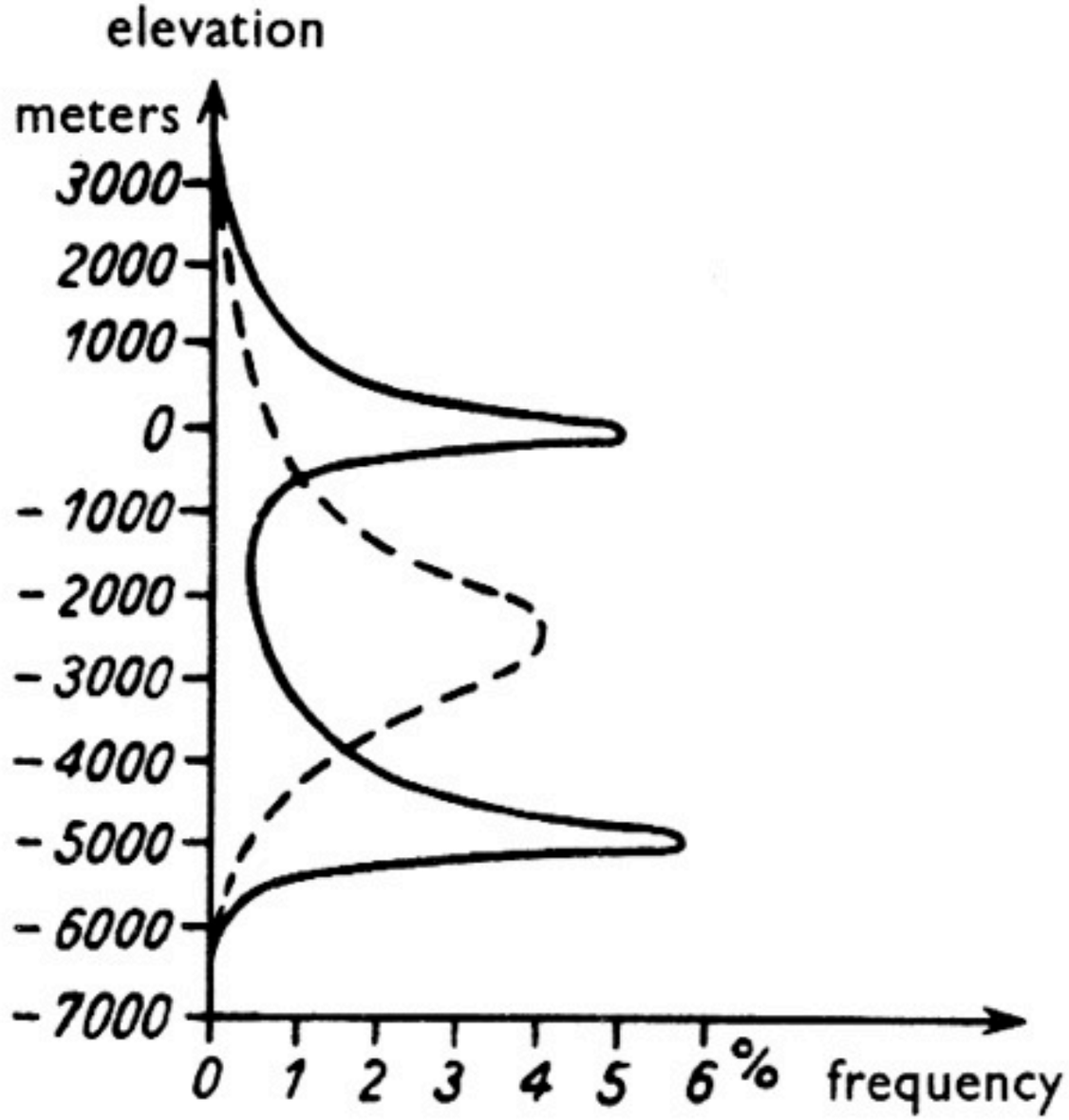
Alfred Wegener (1880-1930)
"Continental Drift hypothesis"

By what Process?

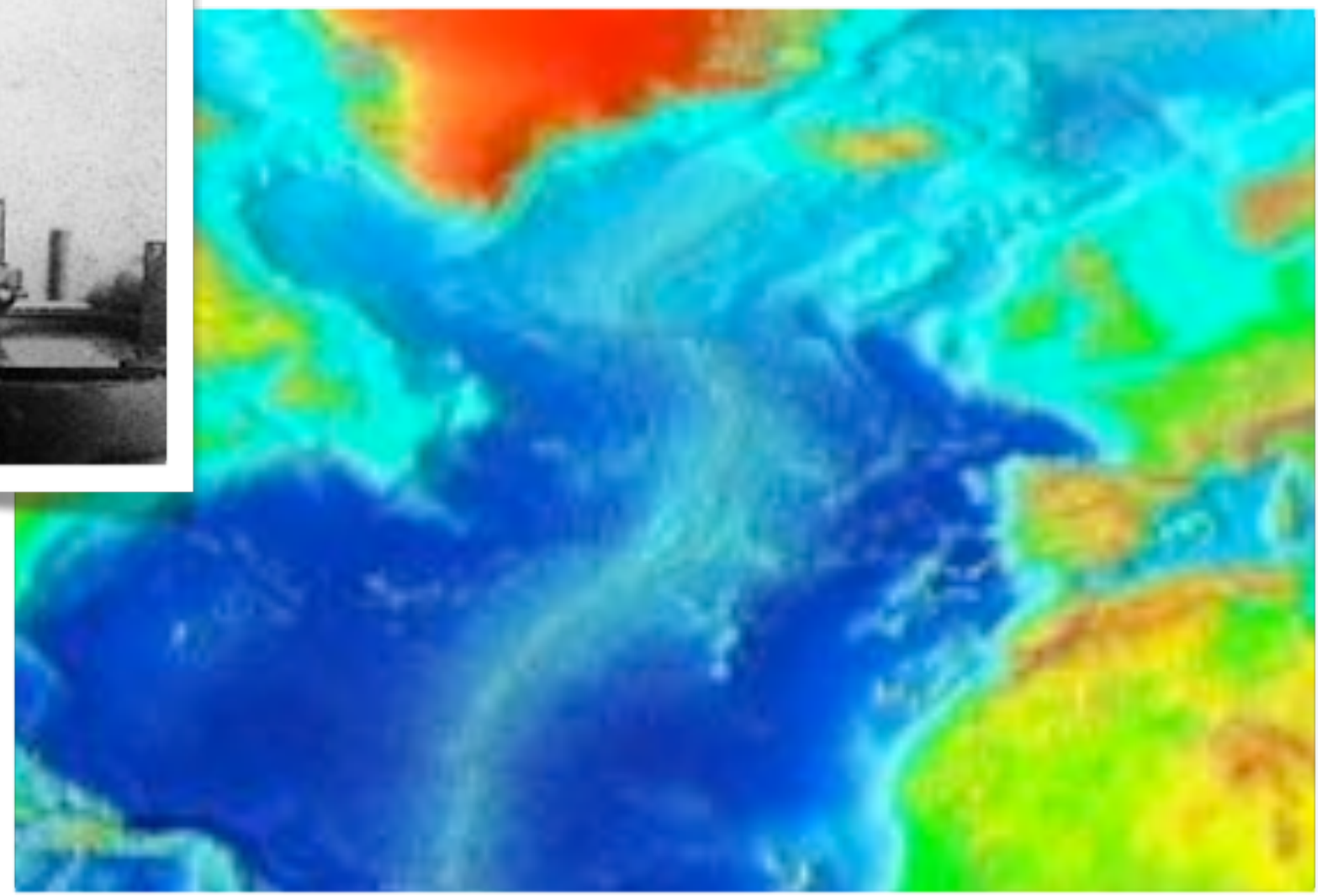
Last photograph of Wegener (left). Dies in Greenland pursuing is hypothesis

Wegener's missing link

In addition to indicating the continents and ocean floor are fundamentally different, the bimodal distribution indicates they form by a very different process.



Harry Hess (1906-1969)
"Sea Floor Spreading hypothesis" (1962)



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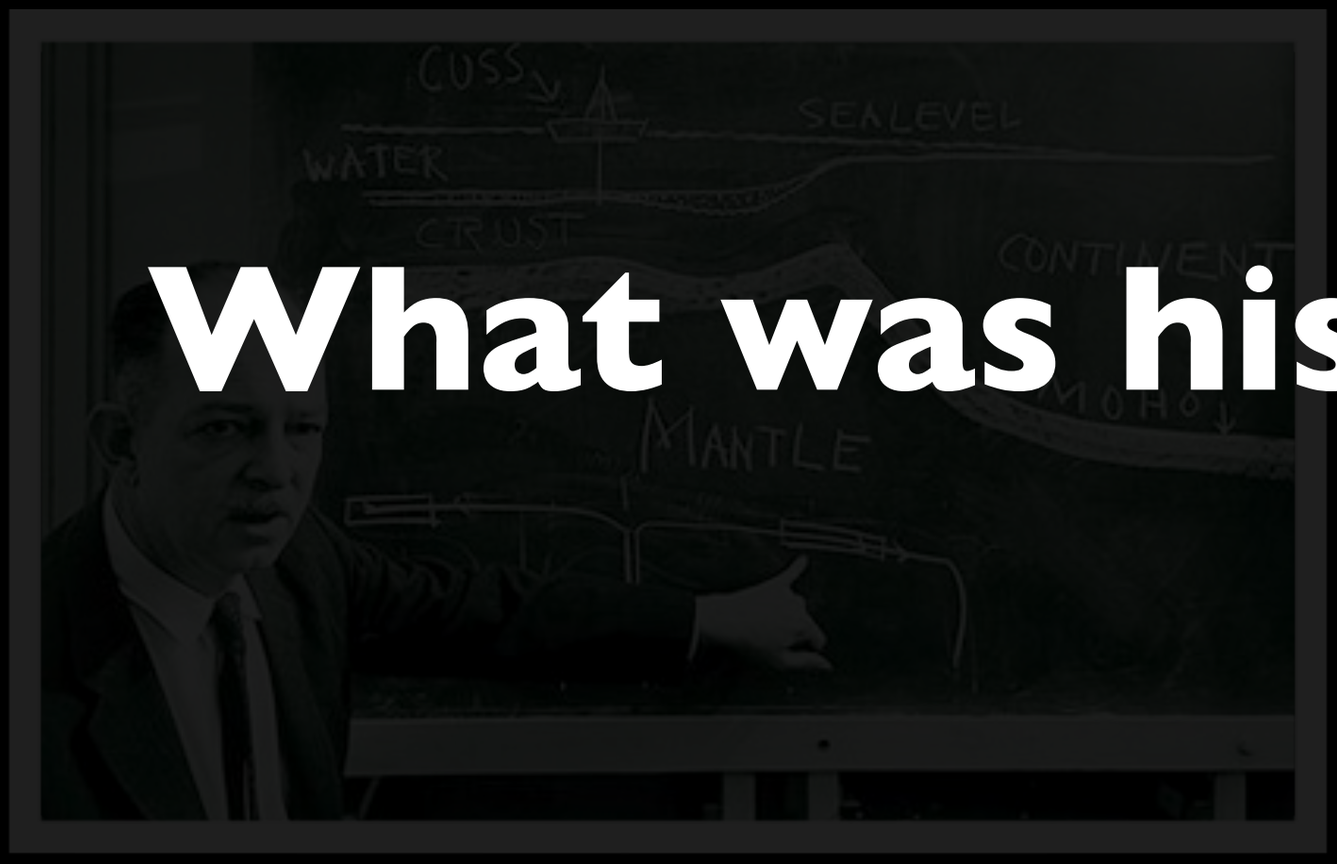
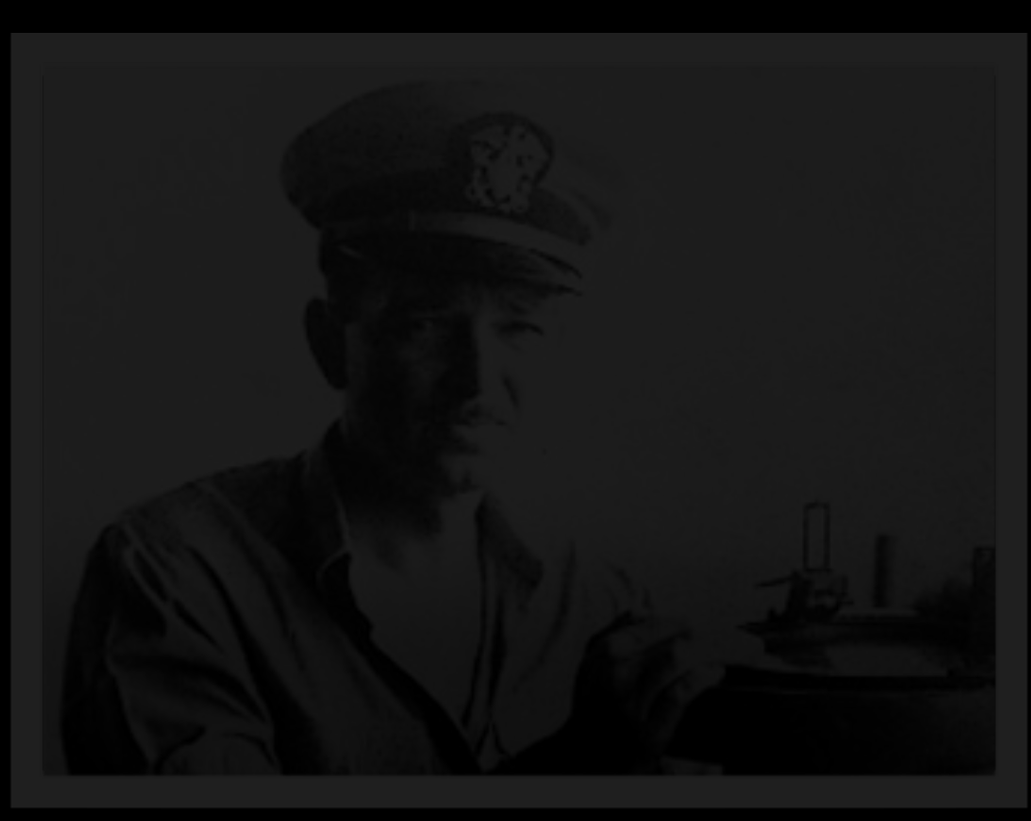


What was his Evidence?



Harry Hess (1906-1969)
"Sea Floor Spreading hypothesis" (1962)

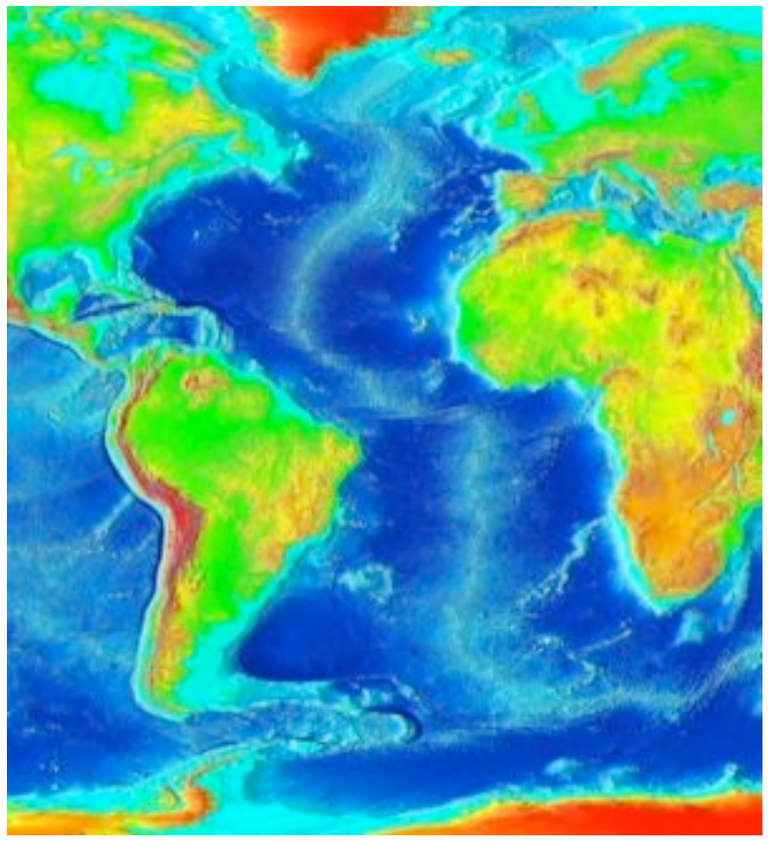
Observations

1) Topography of the Sea floor suggested the the ocean basins got older farther from the ridge (Mid Atlantic Ridge, Guyots)

2) If the Ocean floors are 4.5 Billion years old why is there so little sediment.

3) Why are the oldest fossils found in ocean sediments only 180 Million years old?

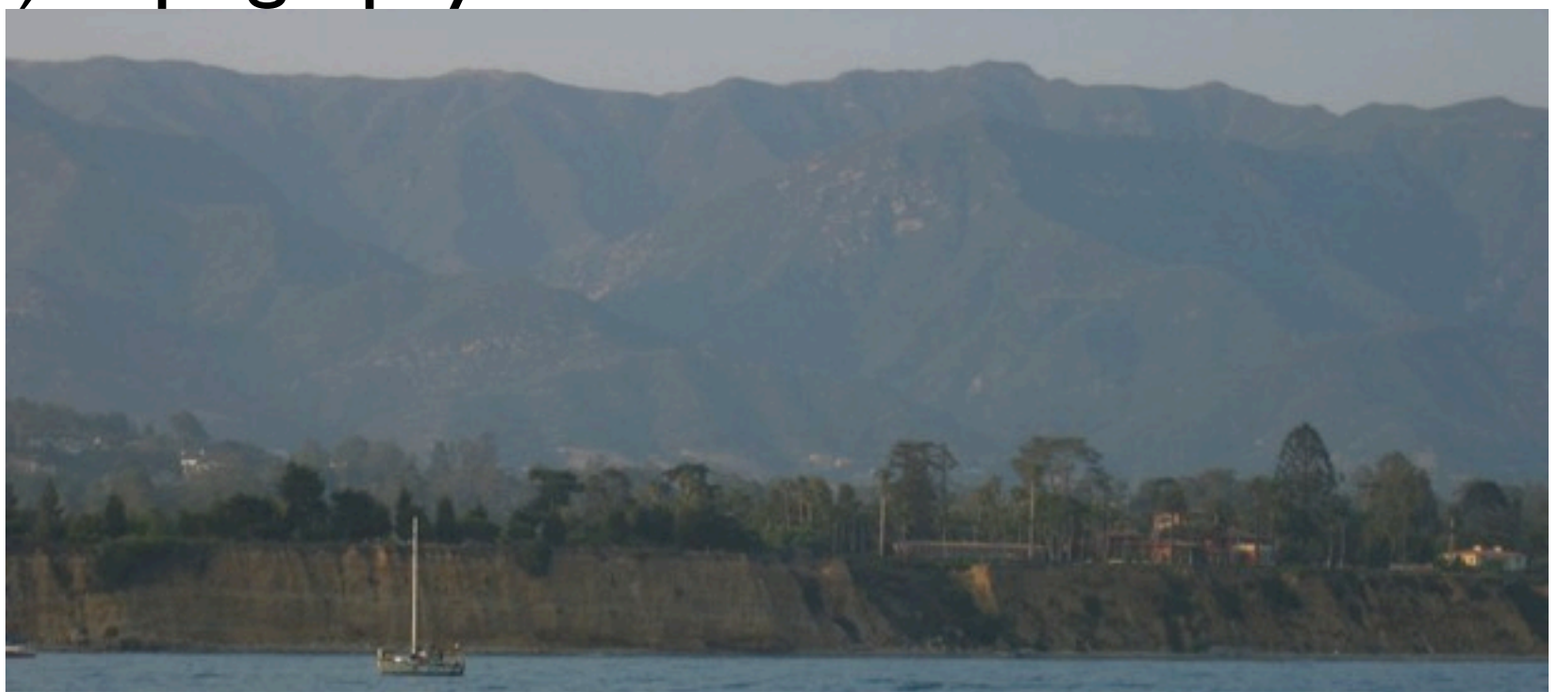
Harry Hess (1906-1969)
"Sea Floor Spreading hypothesis" (1962)



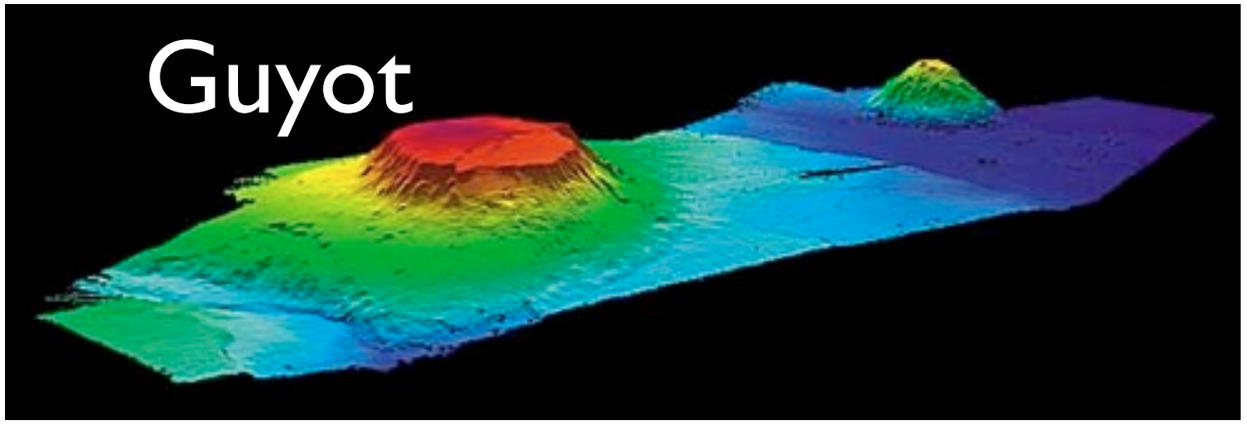
Mid-atlantic ridge

Observations

1) Topography of the Sea floor



Santa Ynez Mts. Santa Barbara ~1500m (5000') tall



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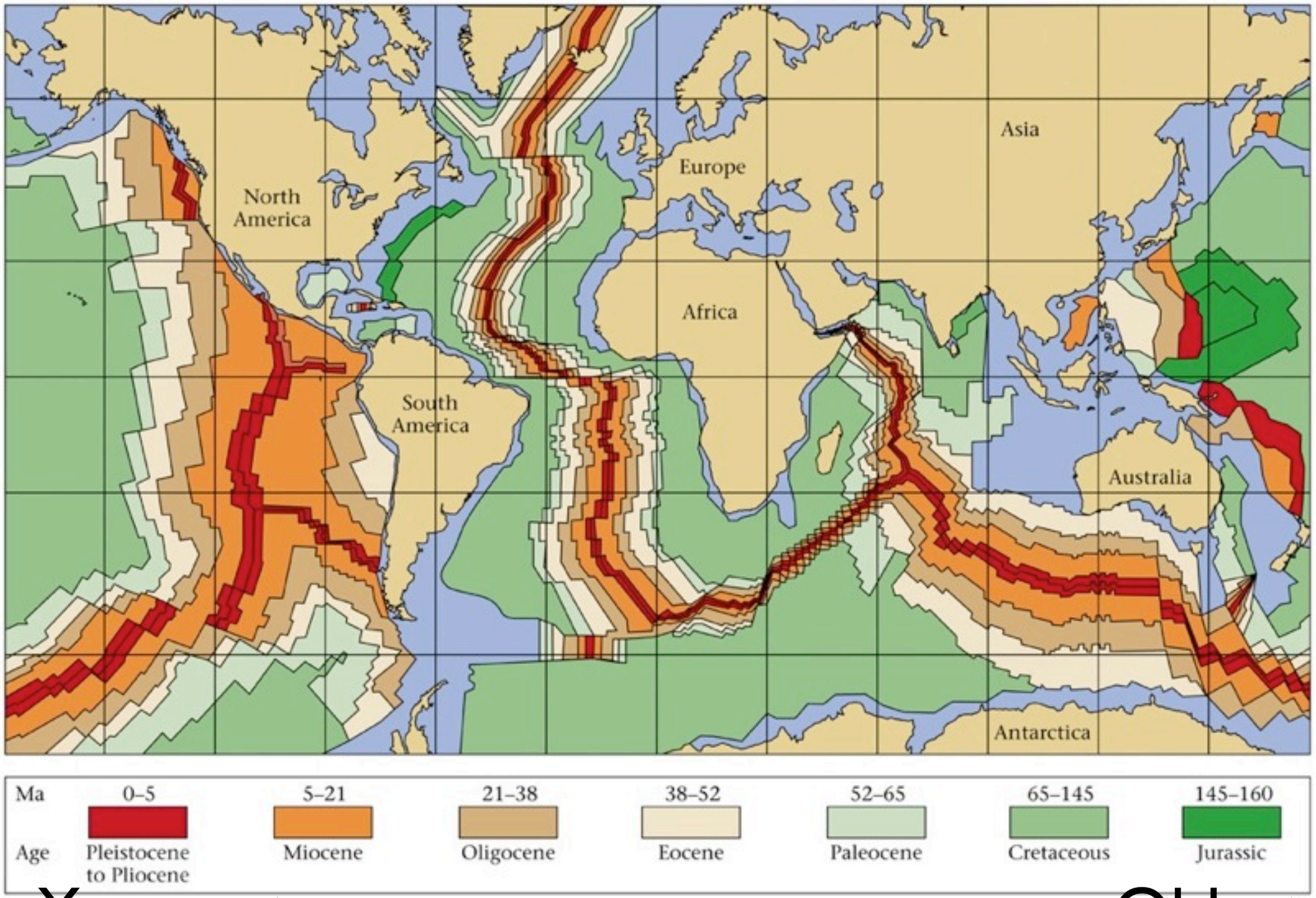
Age of the Sea Floor



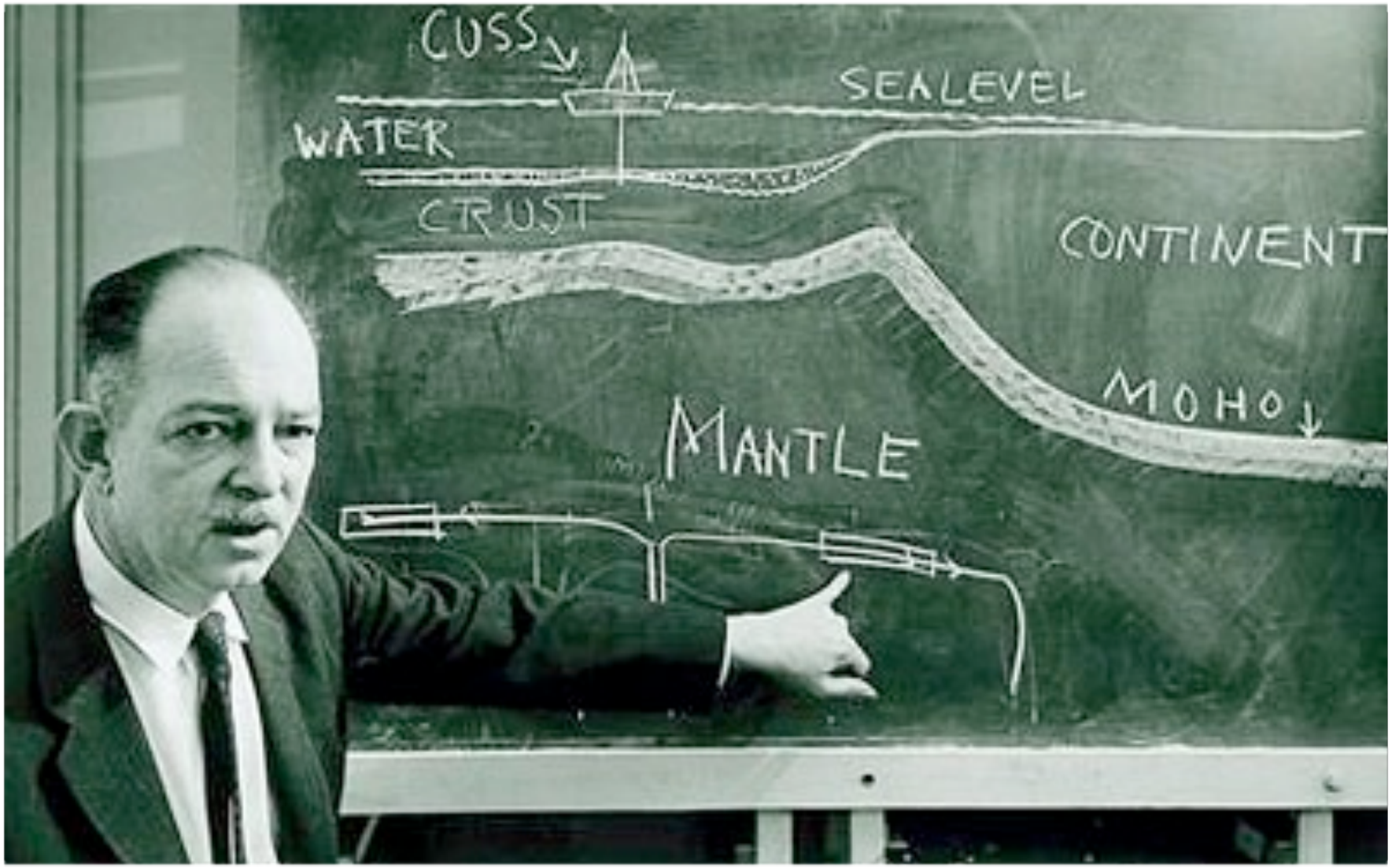
Youngest

Oldest

FIGURE 2.36

Essentials of Geology, 2nd Edition

Harry Hess' Solution
"Sea Floor Spreading hypothesis" (1962)



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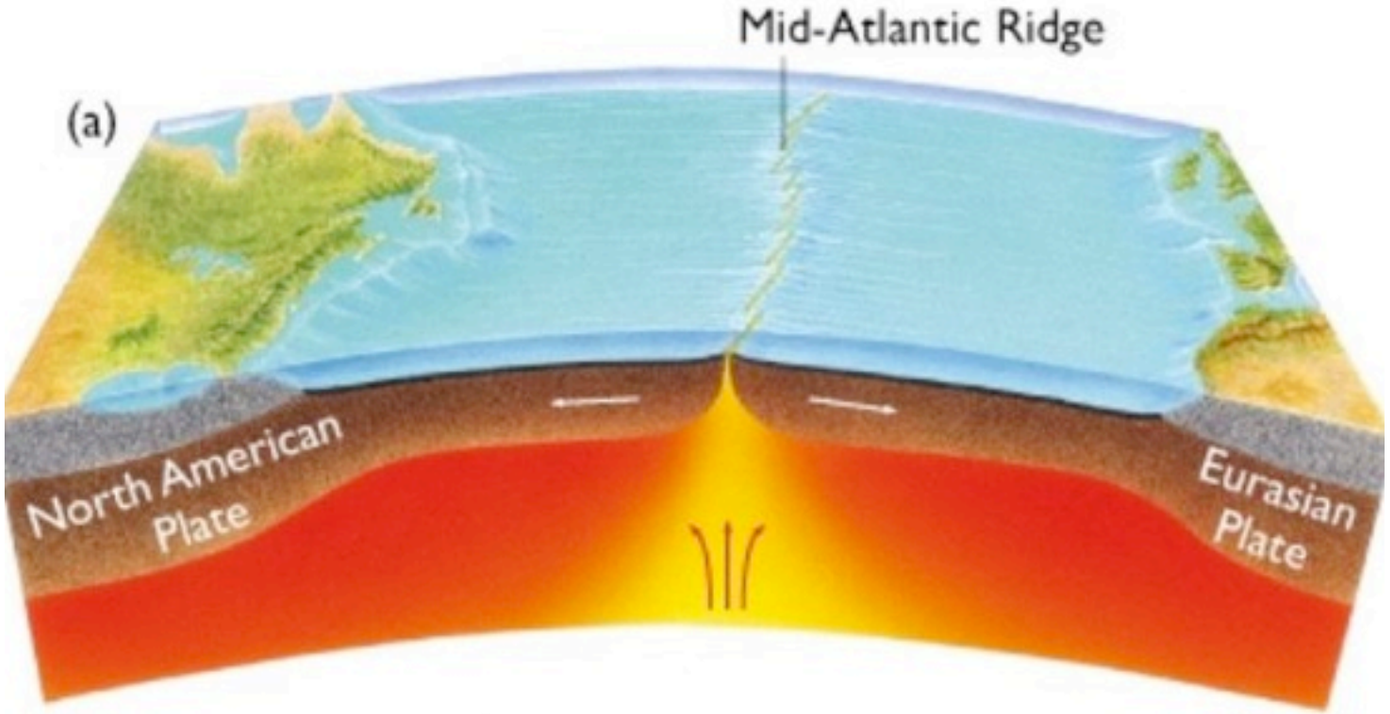
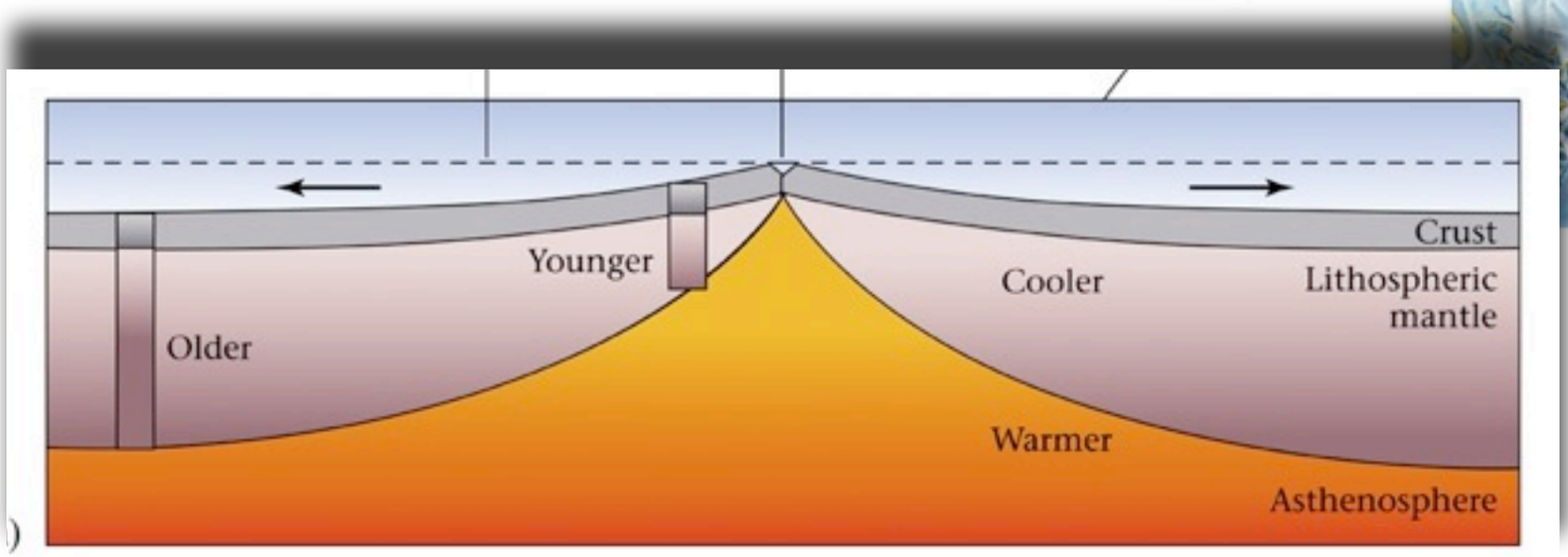
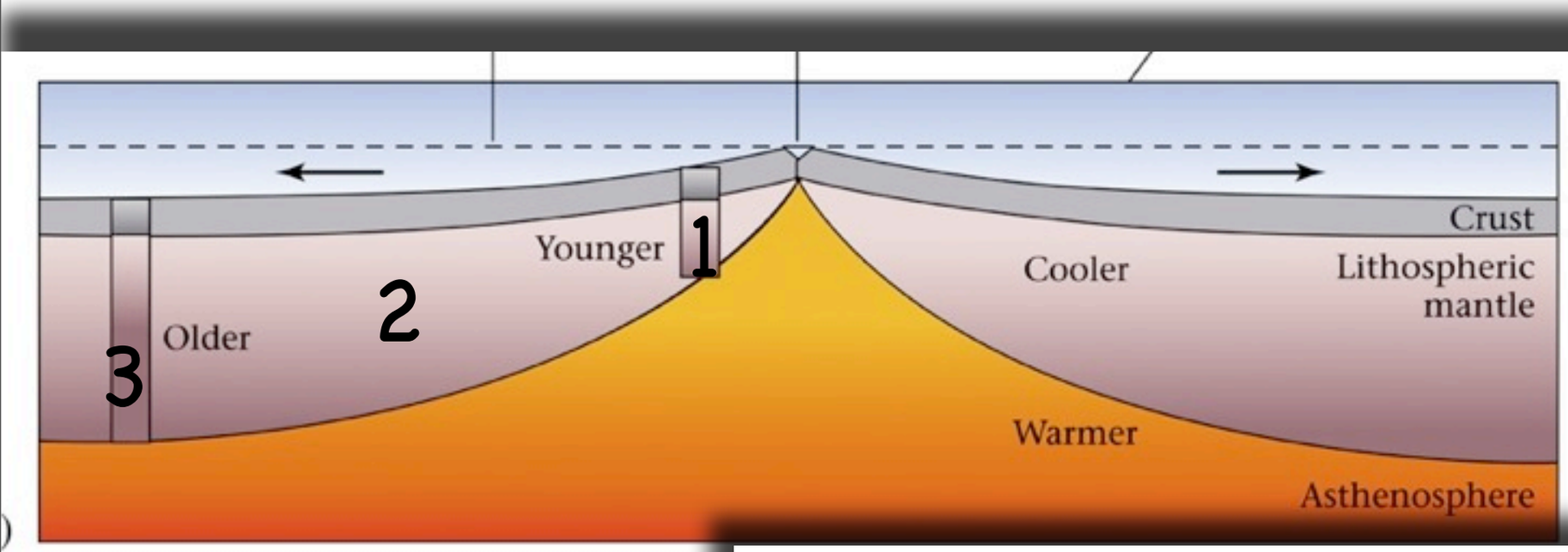
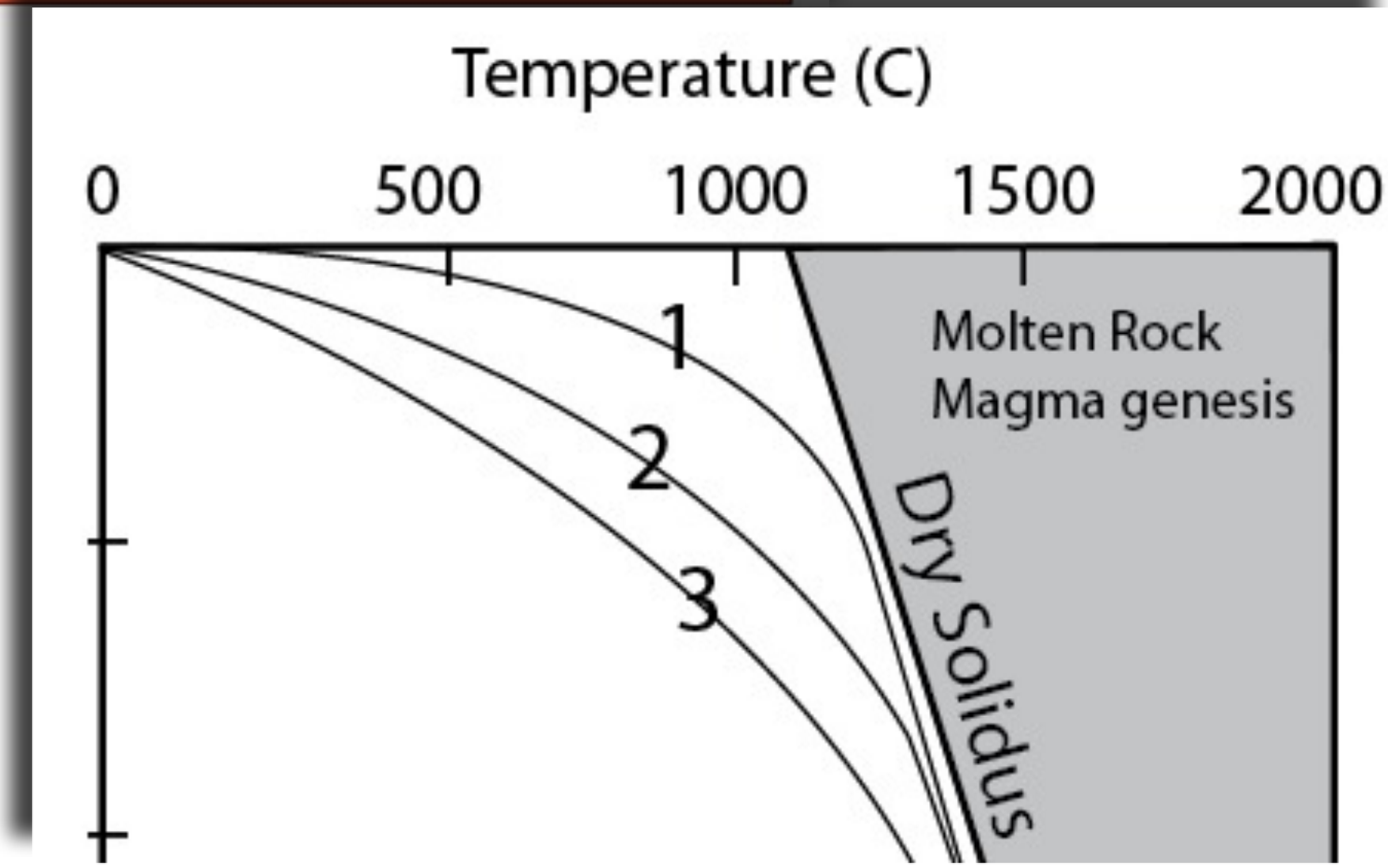




Depressing Geothermal Gradient with Time





Observations

Testing the Hypotheses?

1) Topography of the Sea floor (Mid Atlantic Ridge, Guyots)

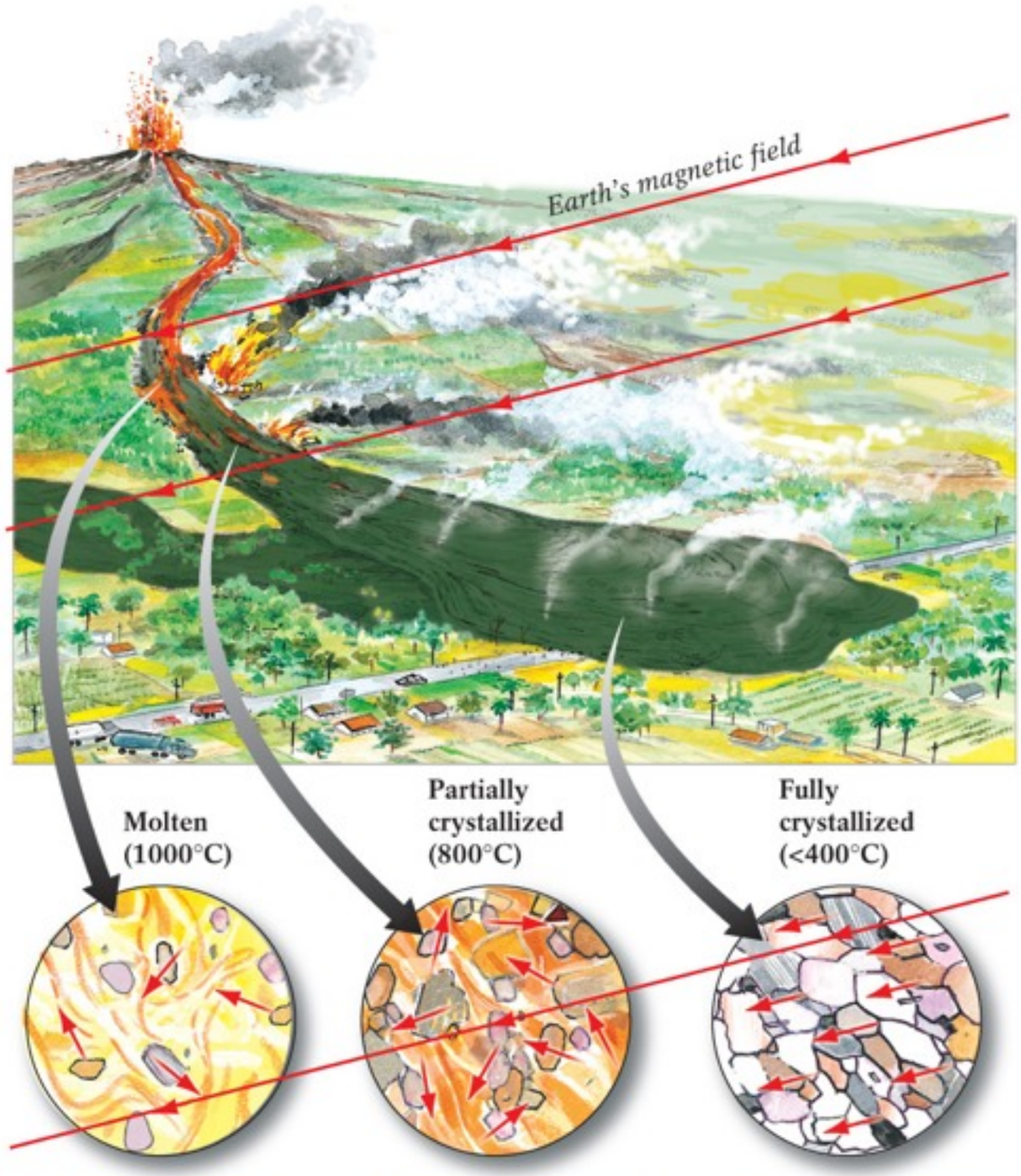
2) If the Ocean Floors are 4.5 Billion years old why is there so little sediment.

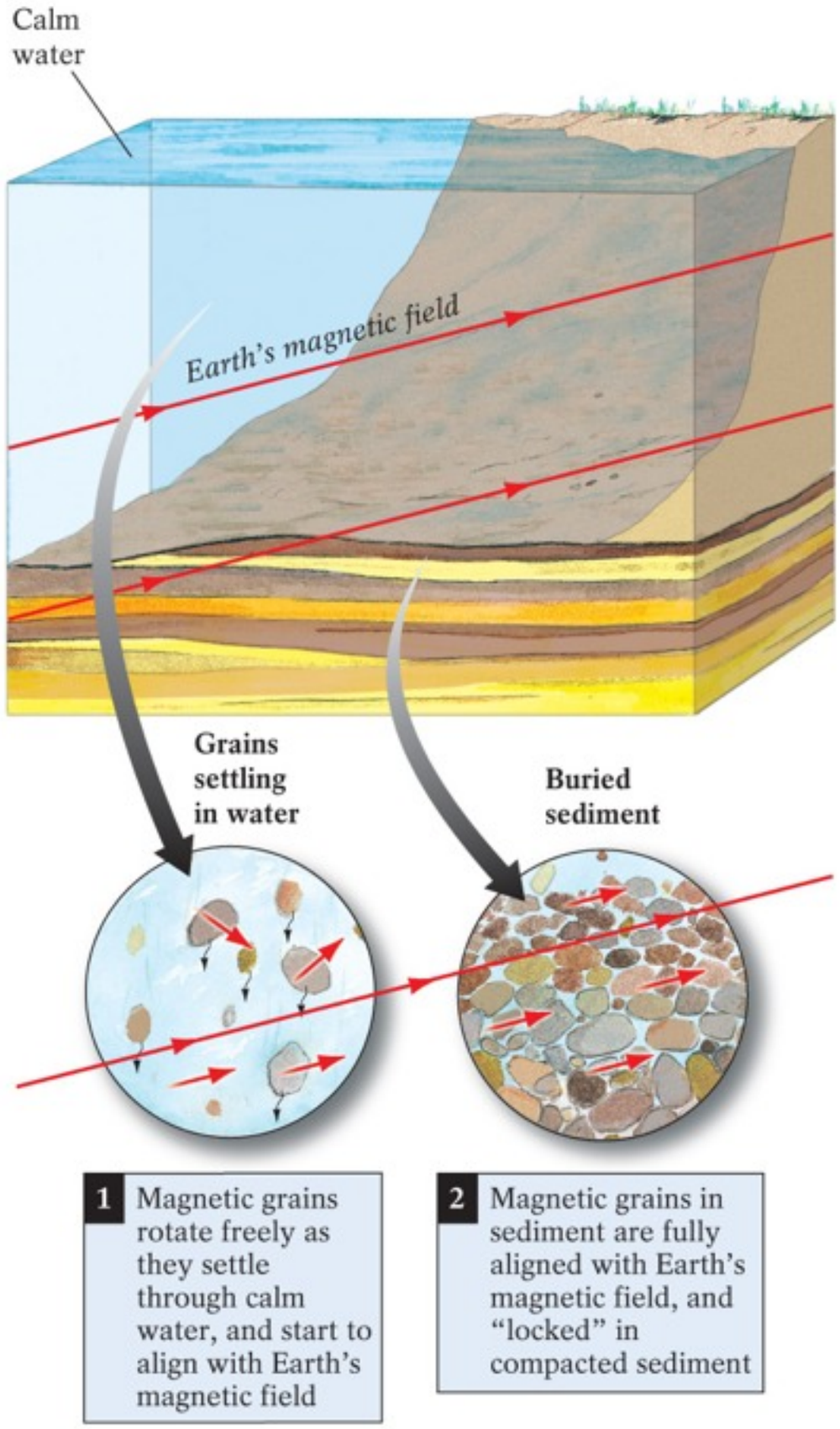
3) Why are the oldest fossils found in ocean sediments only 180 Million years old?

Fred Vine and Drummond Matthews "Vine-Matthews hypothesis"(1963)

Assuming that the oceanic crust is indeed made of basalt intruded in an episodically reversing geomagnetic field, **Drummond H. Matthews** of the University of Cambridge and a research student, **Frederick J. Vine**, postulated in 1963 that the new crust would have a magnetization aligned with the field at the time of its formation. If the magnetic field was normal, as it is today, the magnetization of the crust would be added to that of Earth and produce a positive anomaly. If intrusion had taken place during a period of reverse magnetic polarity, it would subtract from the present field and appear as a negative anomaly. Subsequent to intrusion, each new block created at spreading centre would split and the halves, in moving aside, would generate the observed bilateral magnetic symmetry.

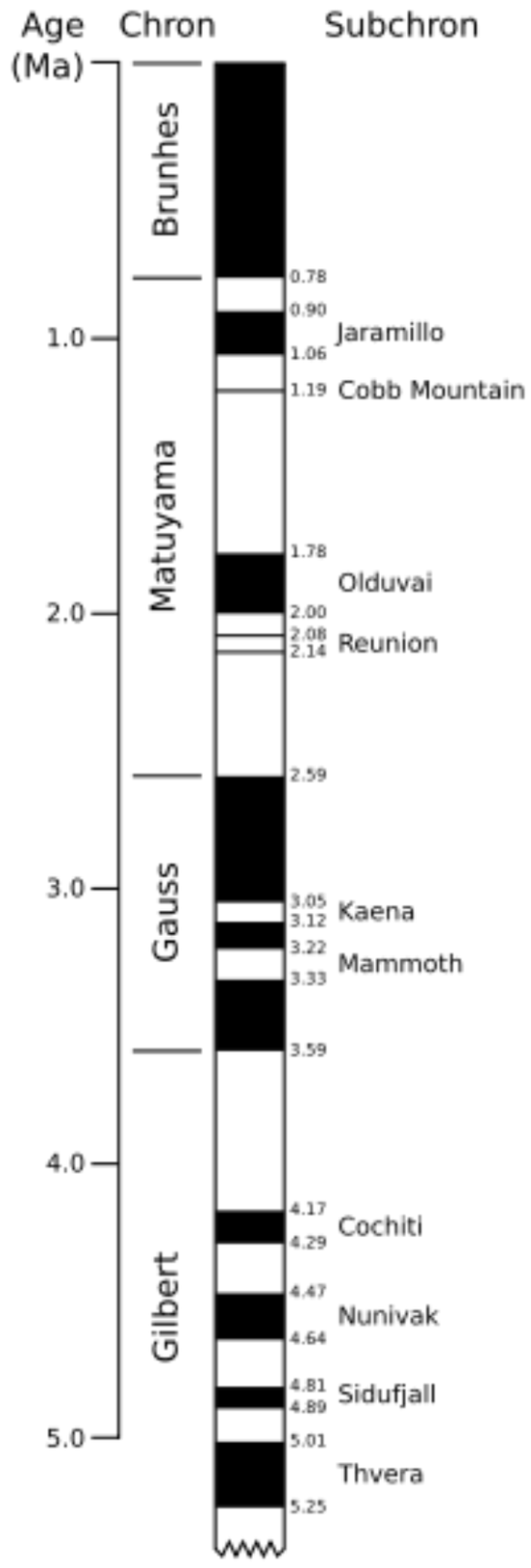
Paleomagnetism





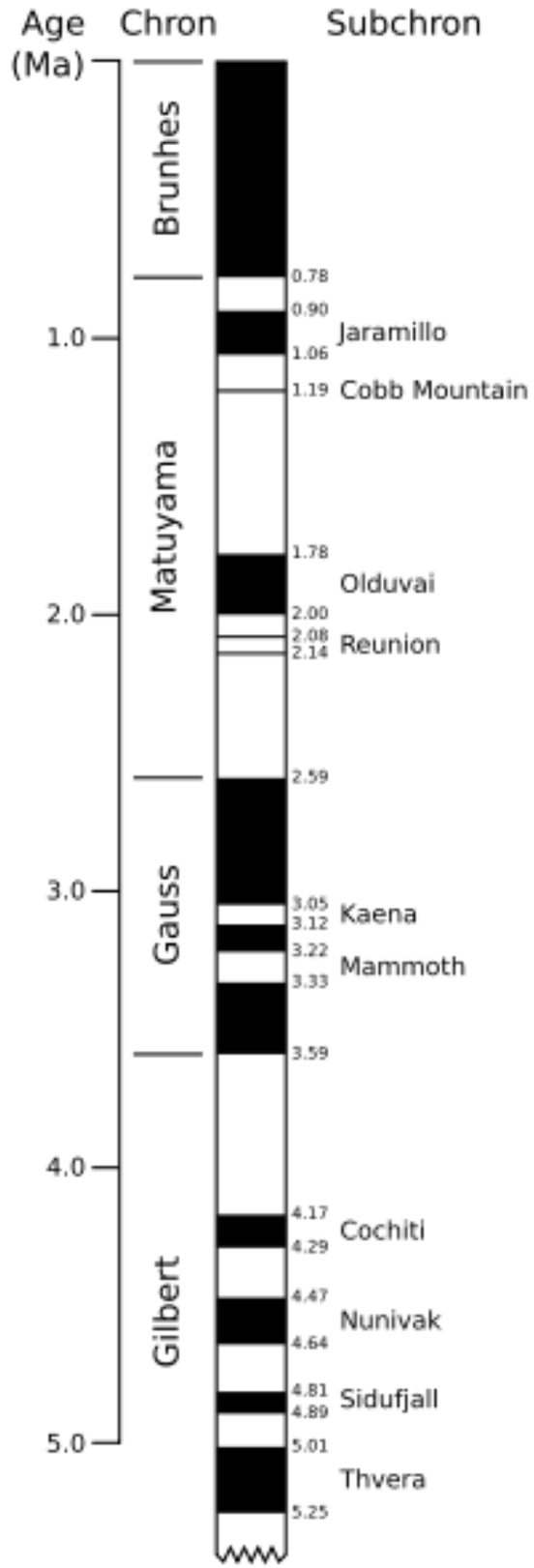
Methods

Mapping magnetic reversals

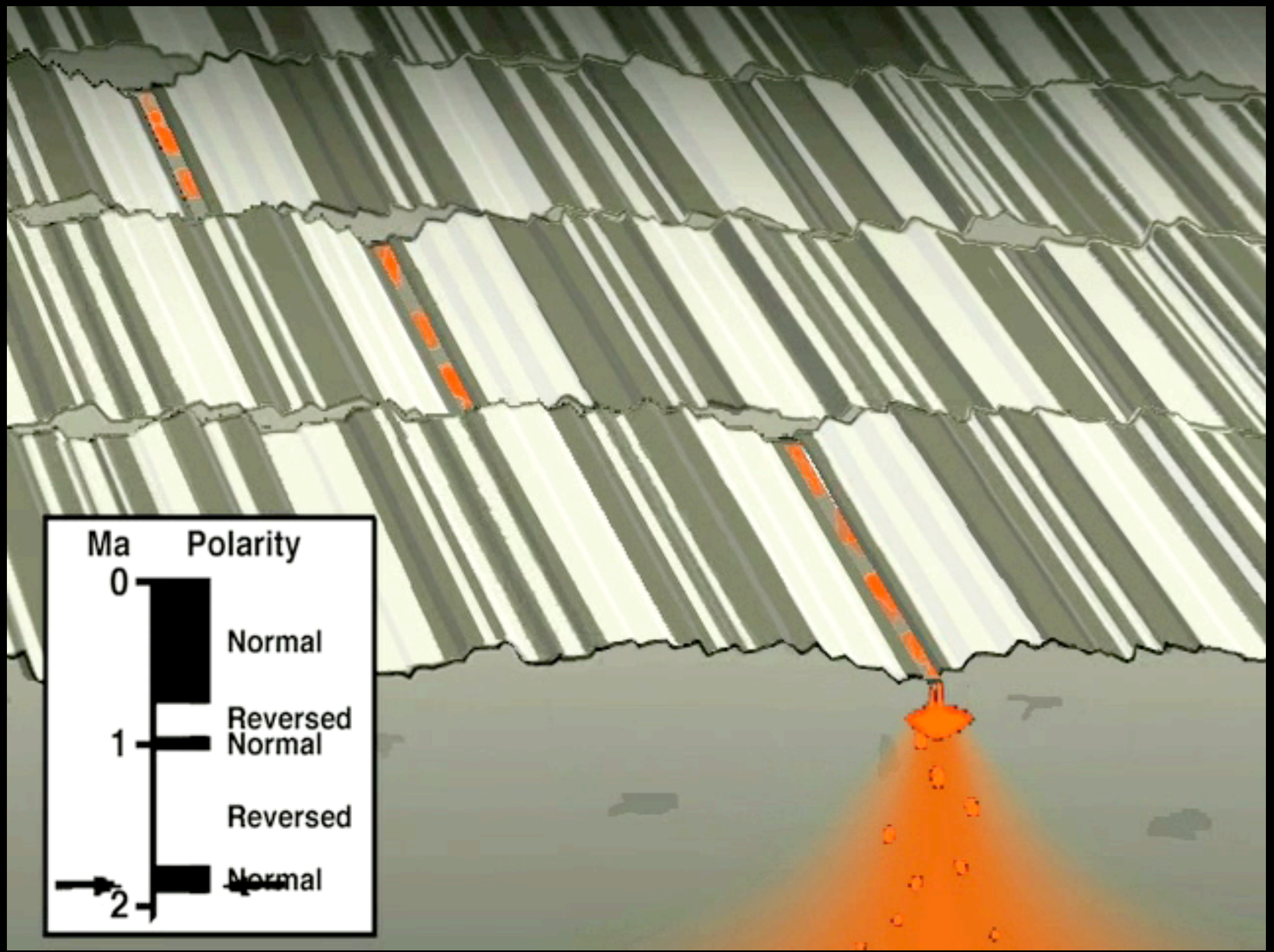


Methods

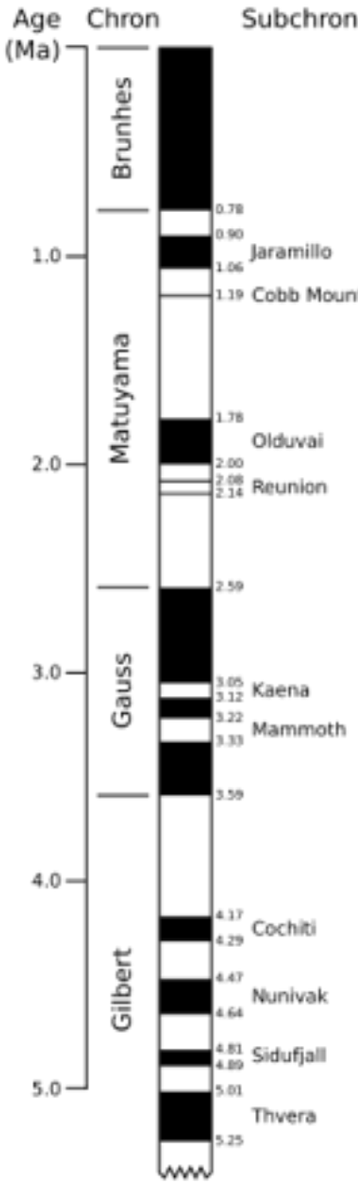
Mapping magnetic reversals

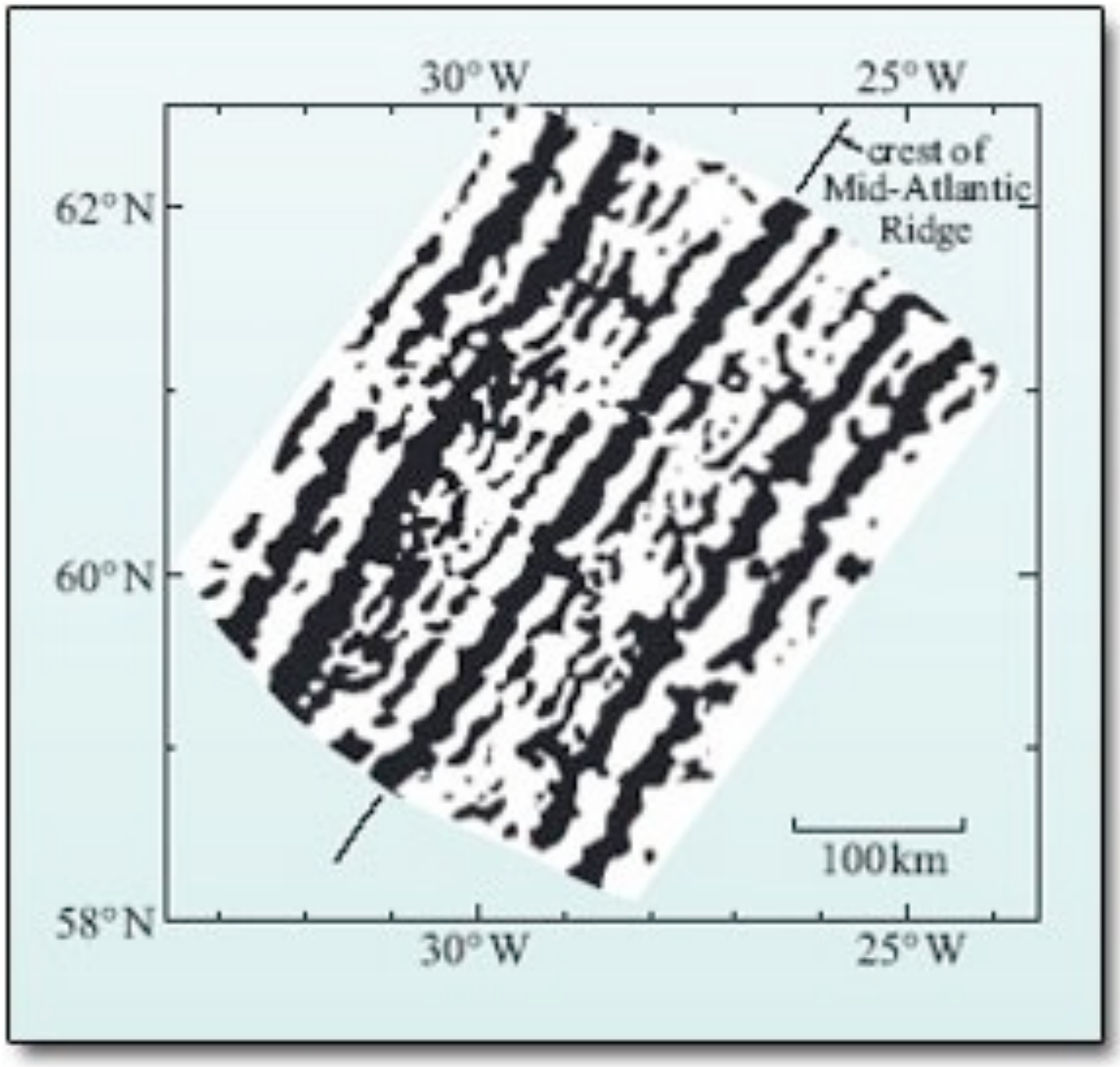


Sea Floor Spreading video



Magnetic Anomaly Map of the Mid Atlantic Ridge





Symmetrical pattern centered on the ridge

Vine-Matthews hypothesis confirmed(1963)

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Sea Floor spreading hypotheses appear to be validated!

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What are the Implications?

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What are the Implications?

1) Mechanism for Continental Drift!

Vine-Matthews hypothesis confirmed(1963)

Sea Floor spreading hypotheses appear to be validated!

What are the Implications?

1) Mechanism for Continental Drift!

2) The Earth is broken into tectonic Plates that are changing relative positions with time!

“Plate Tectonic Theory is born”

Today's Quiz

1) Vocabulary Chapters 13
2) Review of Chapter 1b and 12