PLATE TECTONICS

Elective Sem –IV Lecture 1

By

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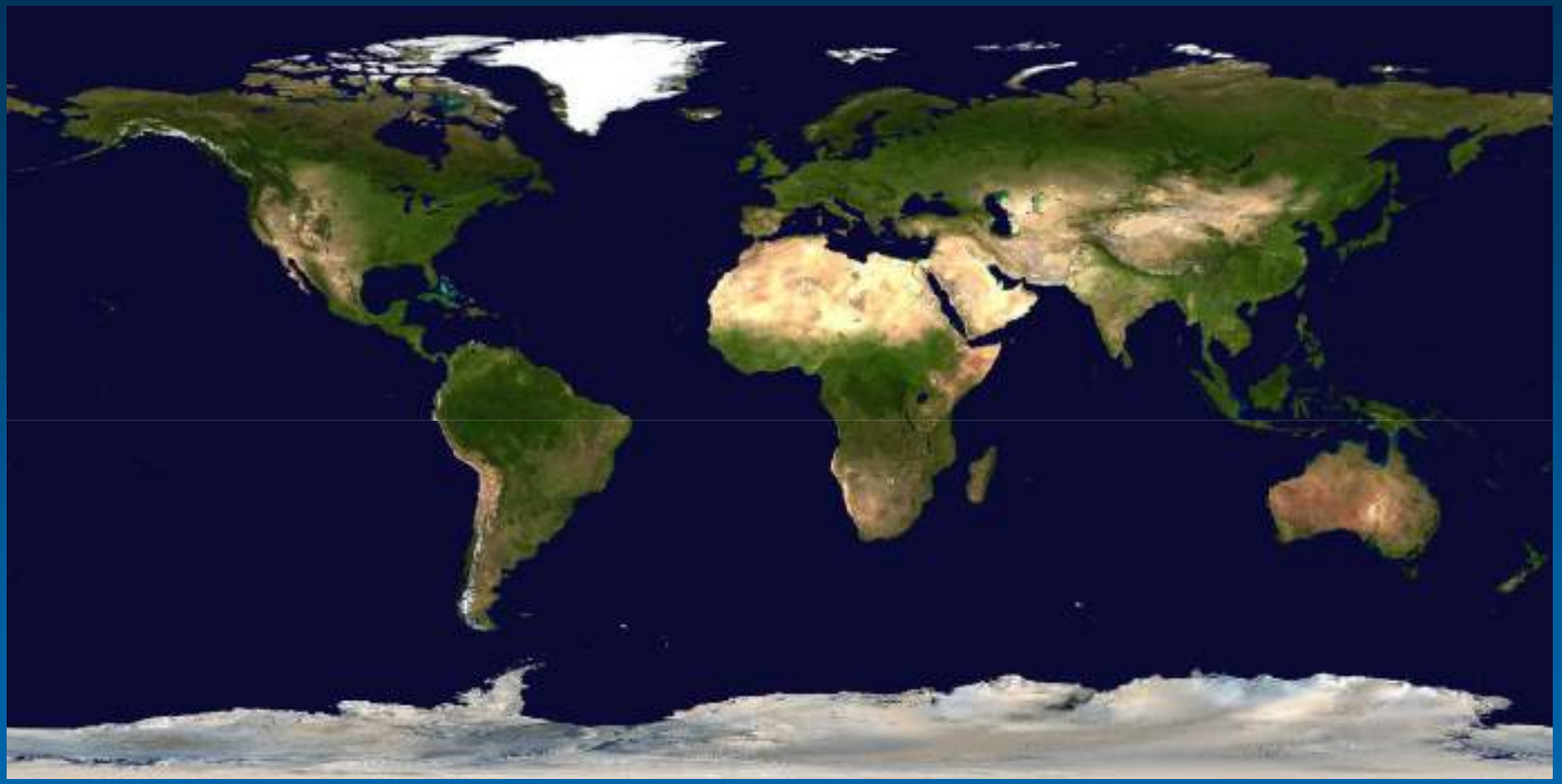
Plate Tectonics Overview

Lecture Overview:

- Have the positions of continents changed through time?
- What is the history of the idea of continental drift?
- How does plate tectonics work?
- How do plates interact at their boundaries?

Map of the World



History of Plate Tectonics

Maps by geographer Antonio Snider-Pellegrini, 1858

Glossopteris – "Seed Fern"

Stars show places where *Glossopteris* fossils have been found.

Glossopteris Flora and Land Bridges?

Was sea level lower during late Paleozoic?

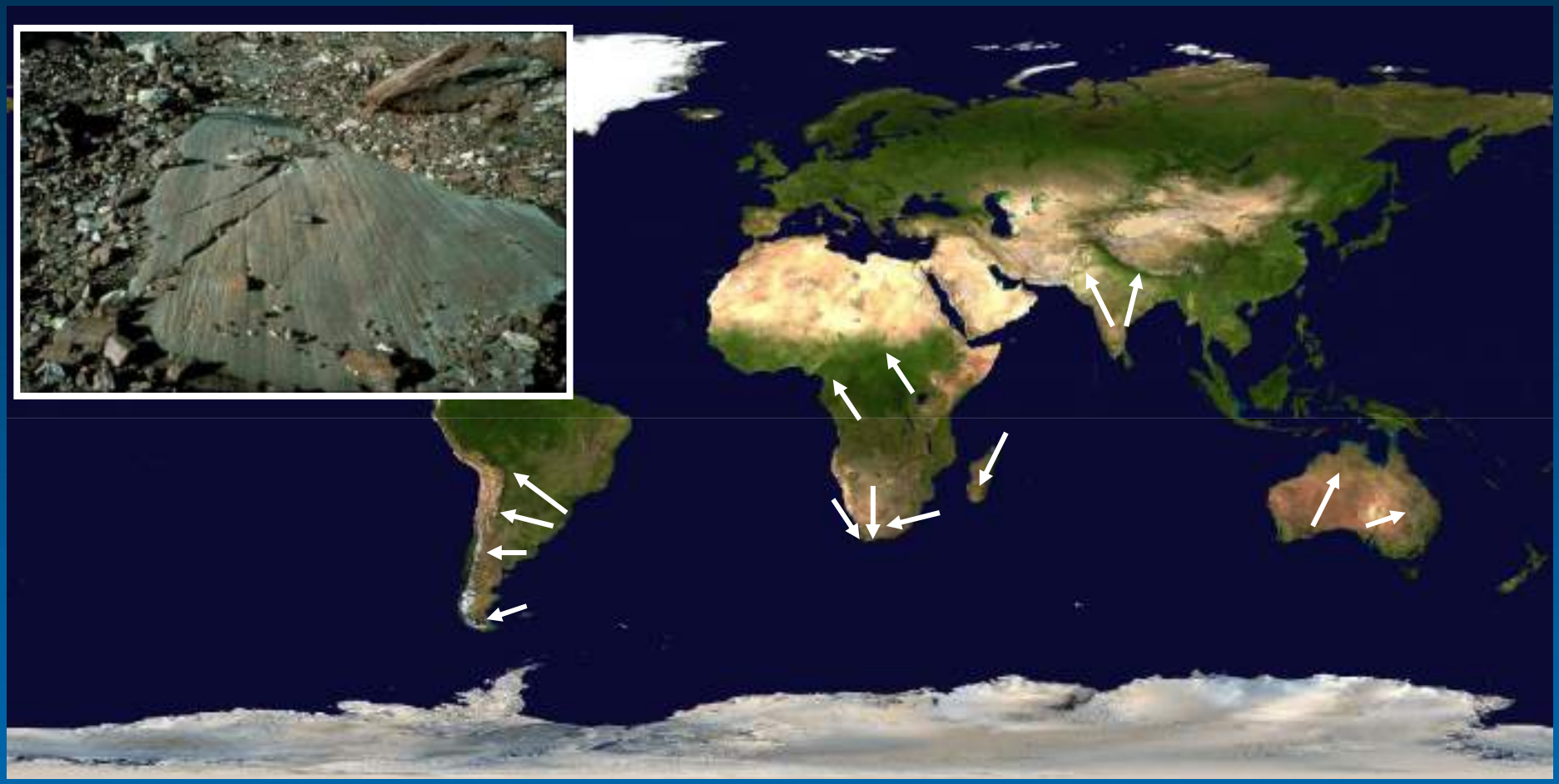
Alfred Wegener (1880-1930)

- German meteorologist who proposed idea of "continental drift": idea that continents moved (and continue to move) horizontally over the surface of the Earth.

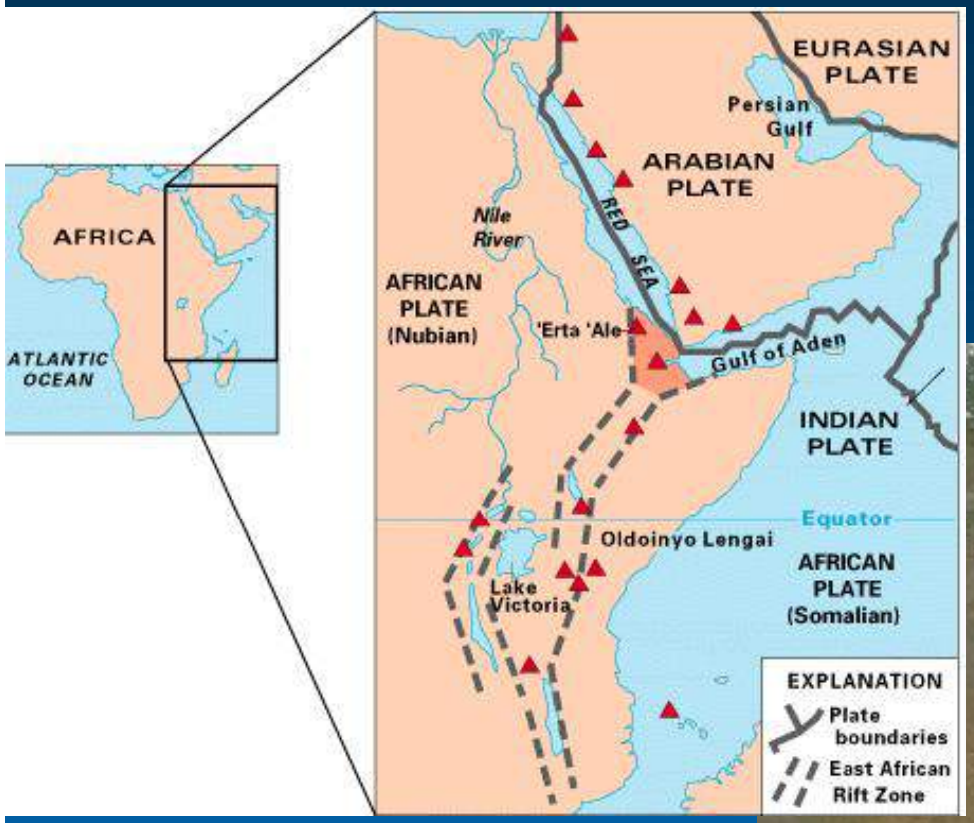
- In 1915 presented evidence for a single supercontinent, which he called Gondwana.

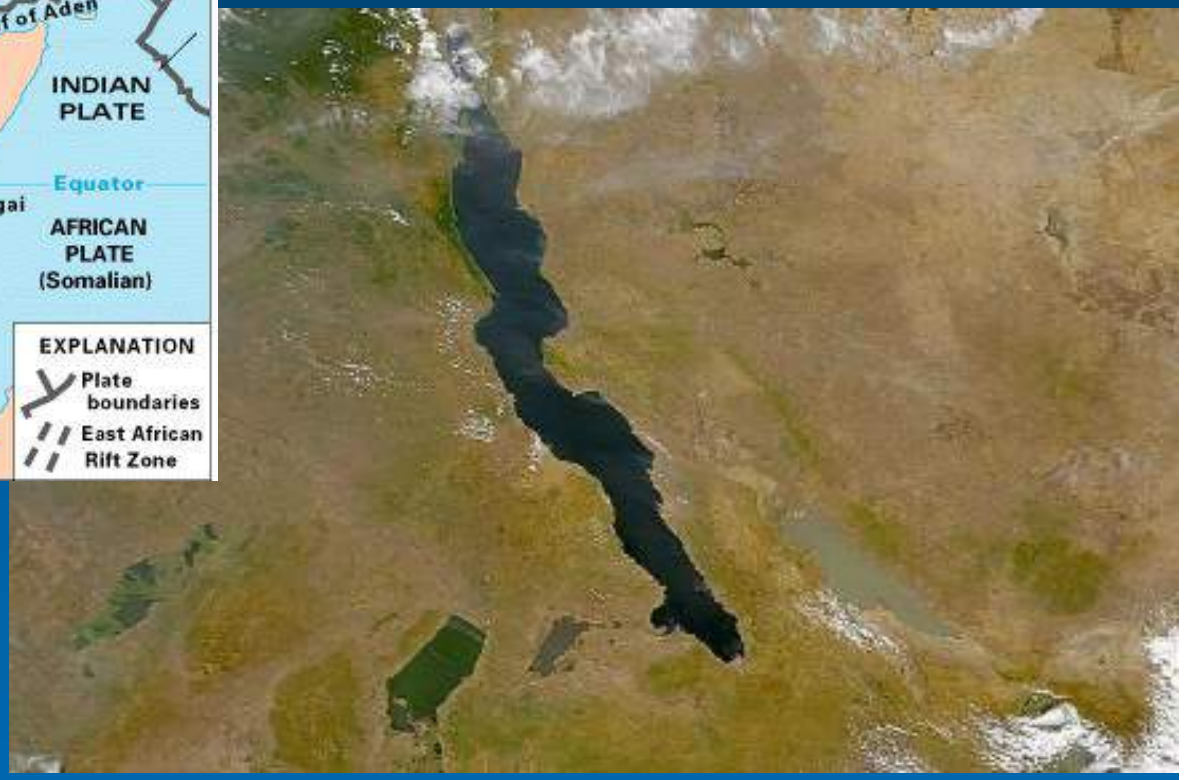
- Early evidence presented by Wegener and other workers (especially Alexander du Toit) in support of continental drift:
  - Continental fit.
  - Rock sequences.
  - Glacial flow directions.
  - Rift valleys.
  - Distributions of fossils.

Glacial Flow Directions

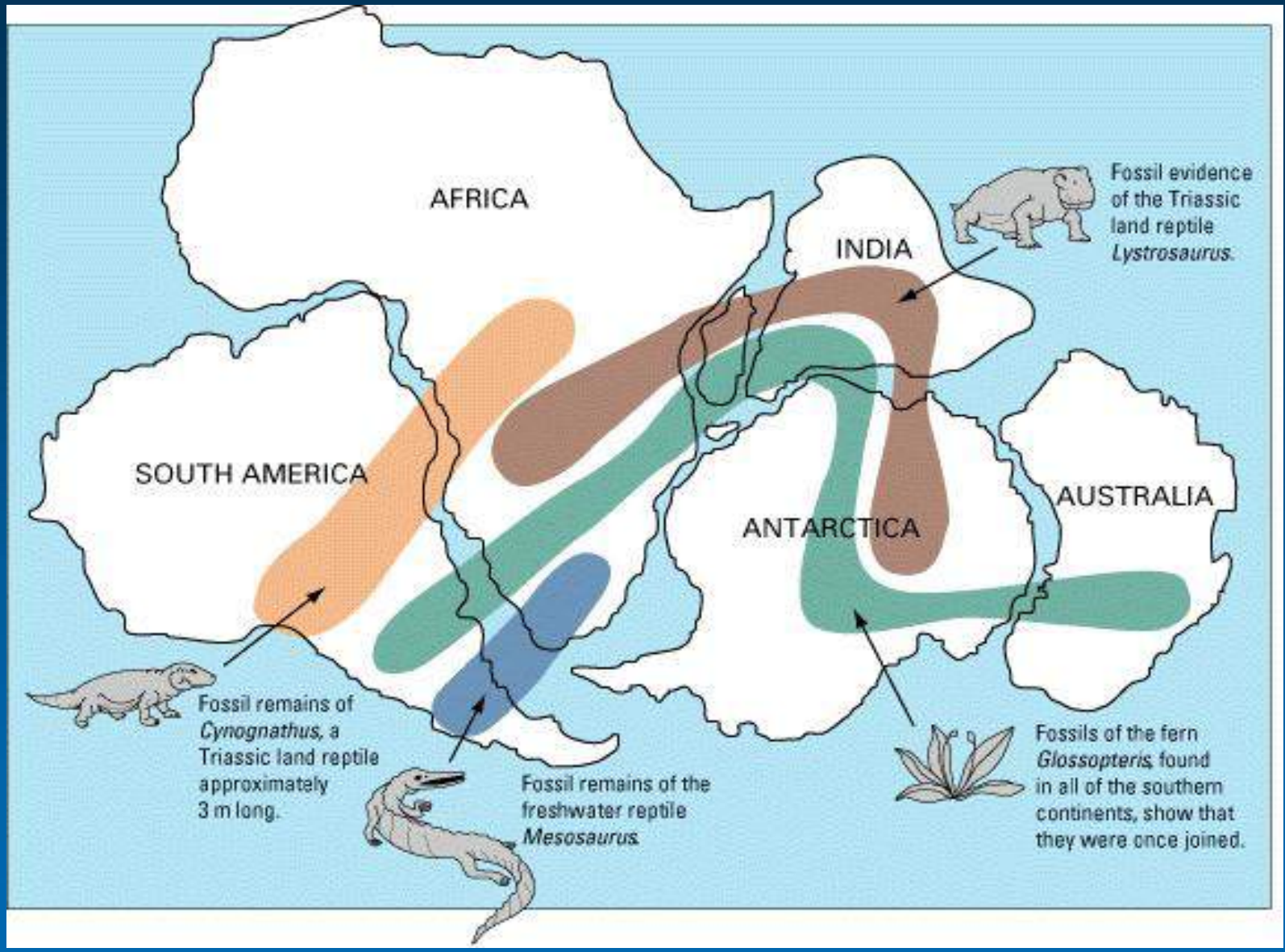


Rift Valleys of Africa





Fossil Evidence



History of Plate Tectonics

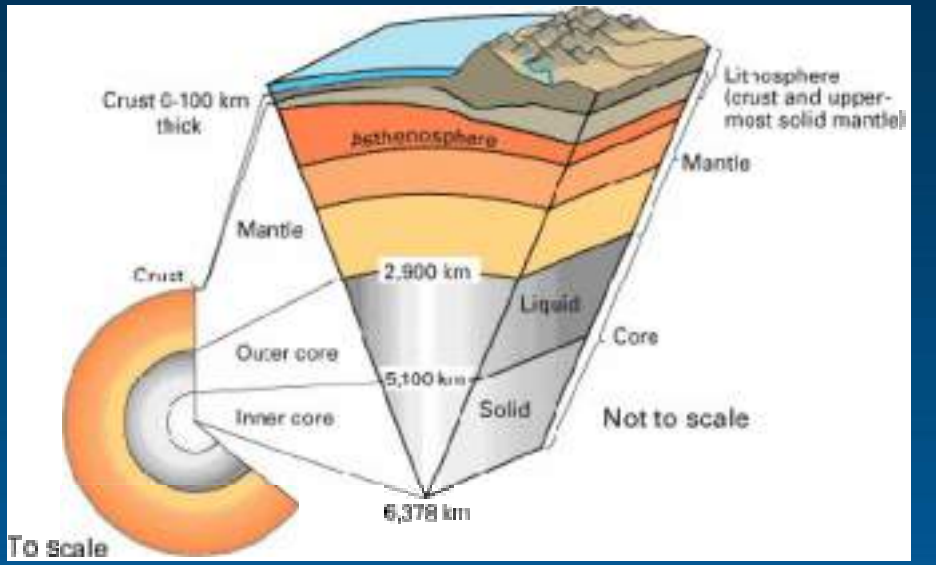
Despite the extensive evidence that the positions of the continents have changed through time, most geologists rejected the idea of continental drift.

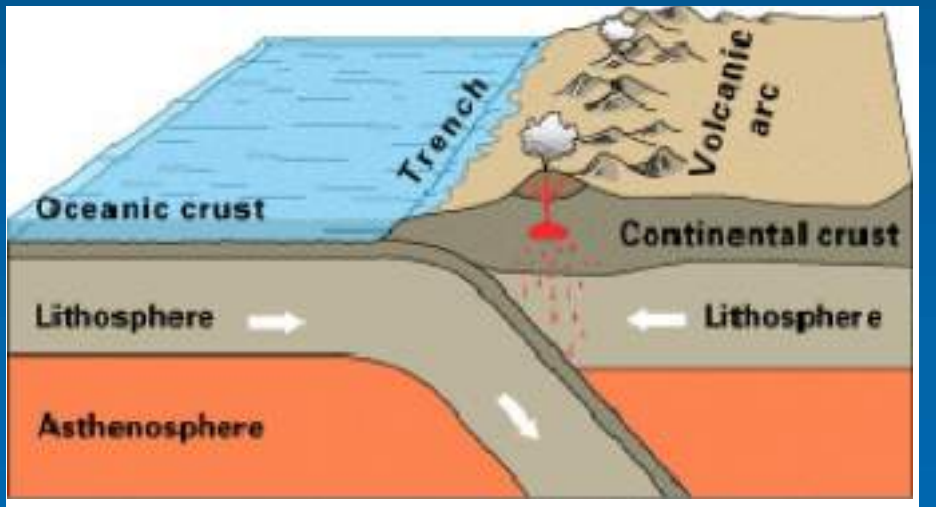
This was because there was no known mechanism that could produce such change.

The role of Oceanic areas was also not discussed.

Interior of the Earth

- Inner core: mostly solid iron
- Outer core: mostly liquid iron
- Mantle: rocky material
- Crust:
  - Oceanic crust
  - Continental crust
- Pressure increases with depth.

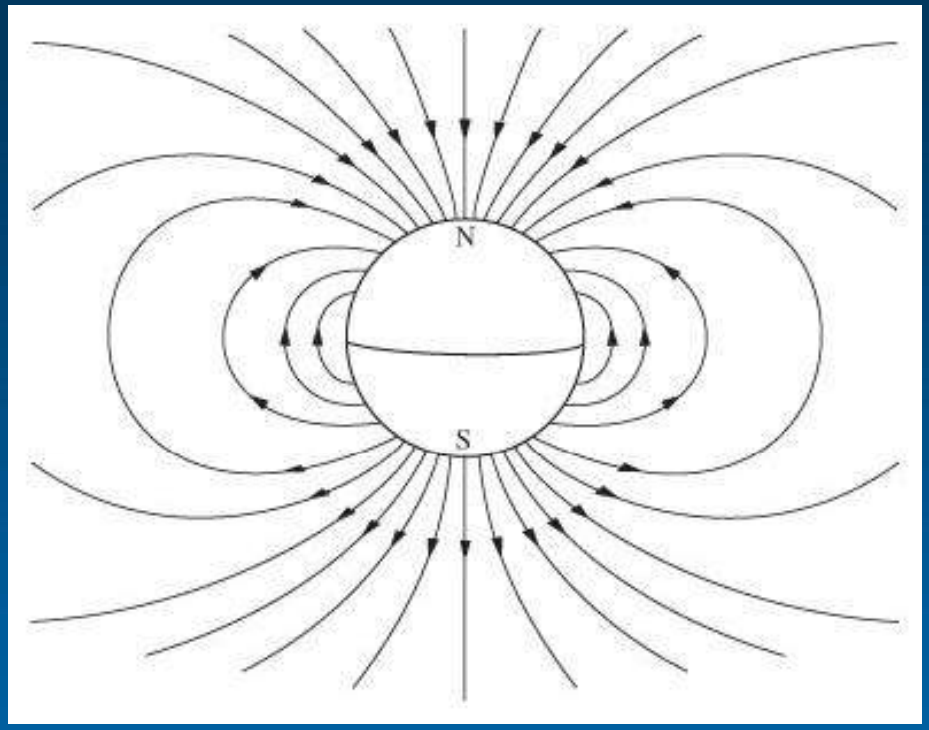




Oceanic-continental convergence

Earth's Magnetism

- Motion of iron-rich outer core creates a magnetic field.
- Earth acts like giant bar magnet with N and S poles.
- Geographic and magnetic poles offset.



Magnetism is Recorded in Rocks

- Some rocks contain iron minerals.
- These minerals align themselves to Earth's magnetic field as the rock forms.
- Iron particles in sedimentary rock align as they fall out of suspension from water.
- Iron particles in magma (igneous rocks) align before the magma cools.
- "Frozen" orientations preserve record of the ancient orientations of Earth's magnetic field.

Study of the Seafloor

The seafloor became much better explored during the 1940-1960's.

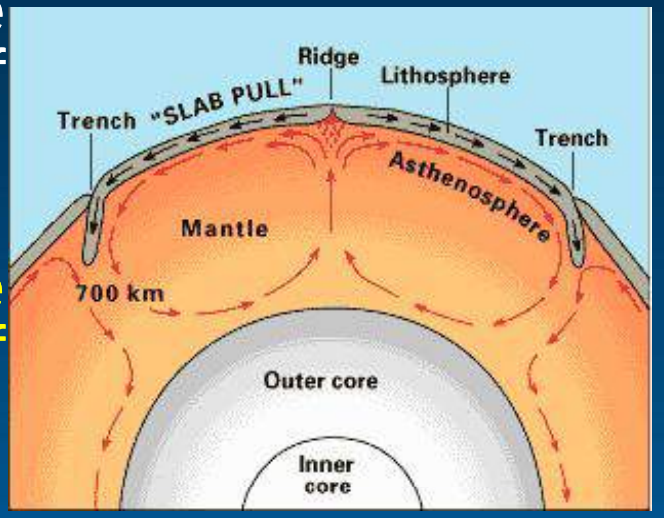
- WWII, sonar.
- Complex topography.
- Mid-oceanic ridges with central furrow.
- Volcanoes often associated with ridges.

Harry H. Hess & Seafloor Spreading

- Hess' Hypothesis of Seafloor Spreading:
- 1962
- Continental and oceanic crust move together.
- New oceanic crust forms from rising magma at mid-continental ridges
- Oceanic crust moves away from ridge as it cools.
- Mechanism: thermal convection.

Thermal Convection

- Thermal convection is thought to be the process driving the movement of plates.



- Earth is hotter (due to radioactive decay - fission) in some portions of the deep mantle than in others.
- This causes the formation of convection cells that drag along overlying lithospheric plates - acts like conveyor belts.
- Think about a container full of boiling water.

Testing Hess' Hypothesis

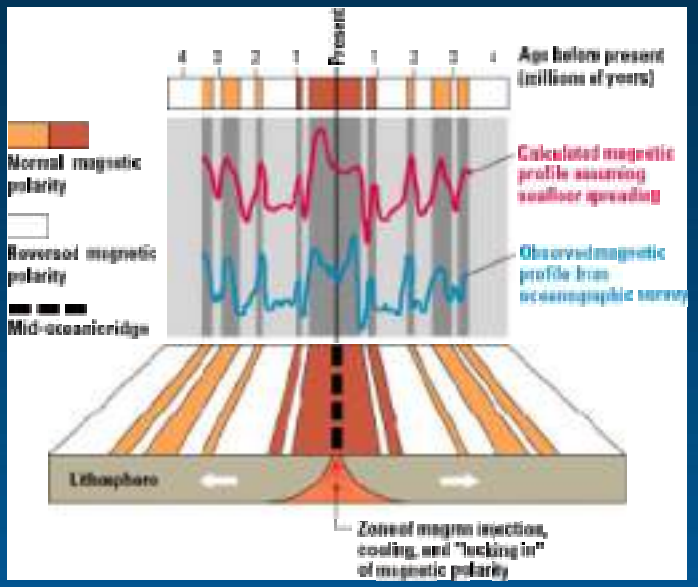
- How could one test Hess' hypothesis of seafloor spreading?
- What pattern should one find on either side of mid-ocean ridge systems if Hess' hypothesis is true?

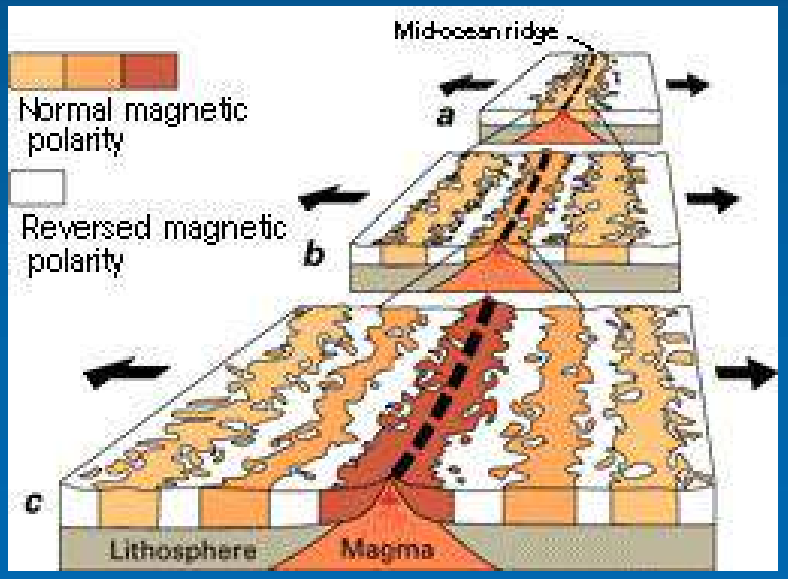
Magnetic Reversals

- The polarity of Earth's magnetic field has "flipped" many times throughout the geologic past.
- The reason(s) why are not at all clear.
- Durations of "normal" and "reversed" polarity highly variable in length.

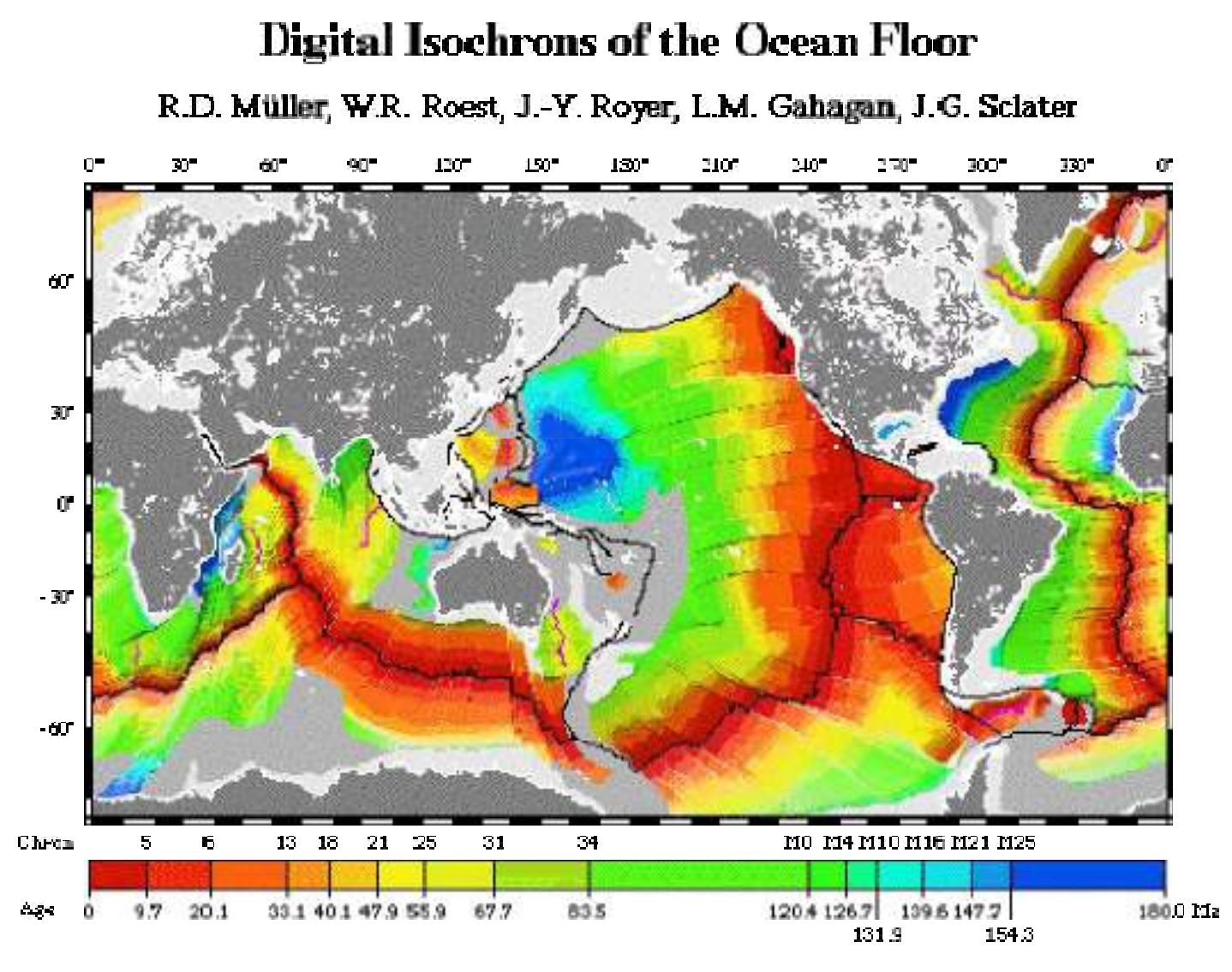
Test of Hess' Hypothesis

- During the early 1960's, it was discovered that changes in Earth's magnetic polarity have been recorded into rocks on the seafloor (oceanic crust) as they cooled.
- Symmetrical banding on each side of mid-oceanic ridge systems.
- Younger rock near ridge, older away.





Ages of the World's Ocean Basins

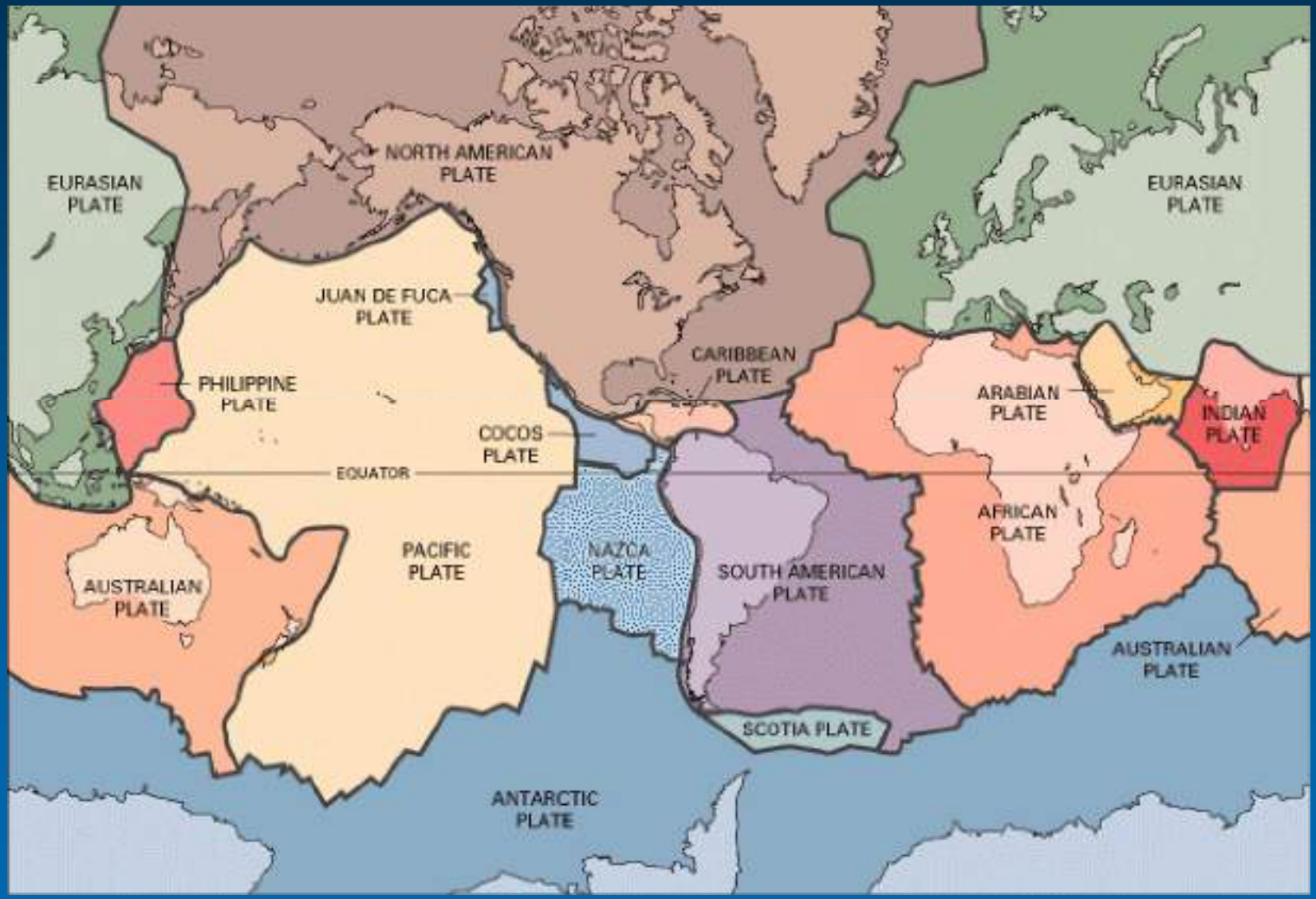


Hess' Hypothesis Was NOT Falsified

Enough support has since been provided for plate tectonics that the idea is now accepted as a unifying theory for geology.

Simple idea with great explanatory power.

Major Plates of the World



Plates Interact at Their Boundaries

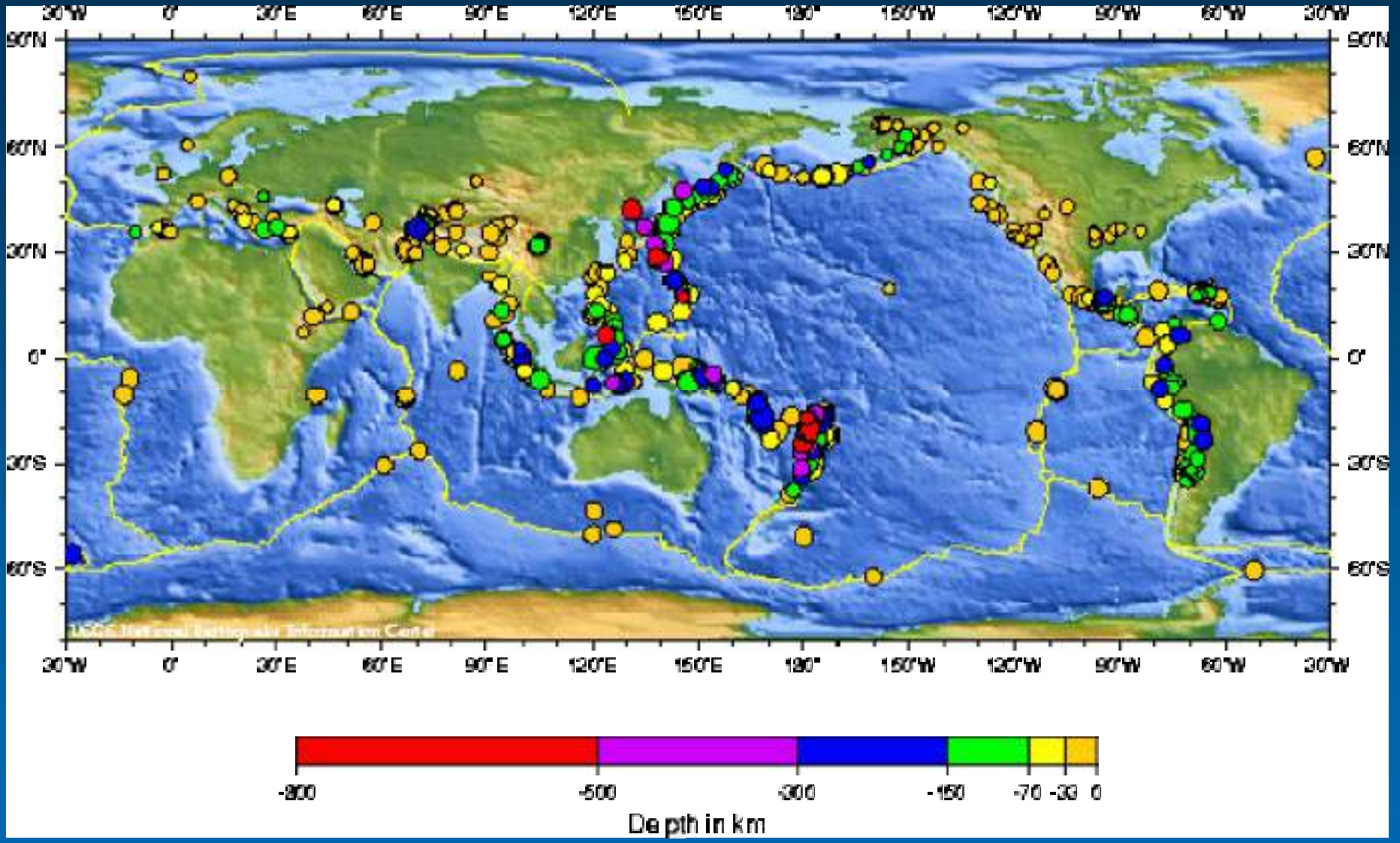


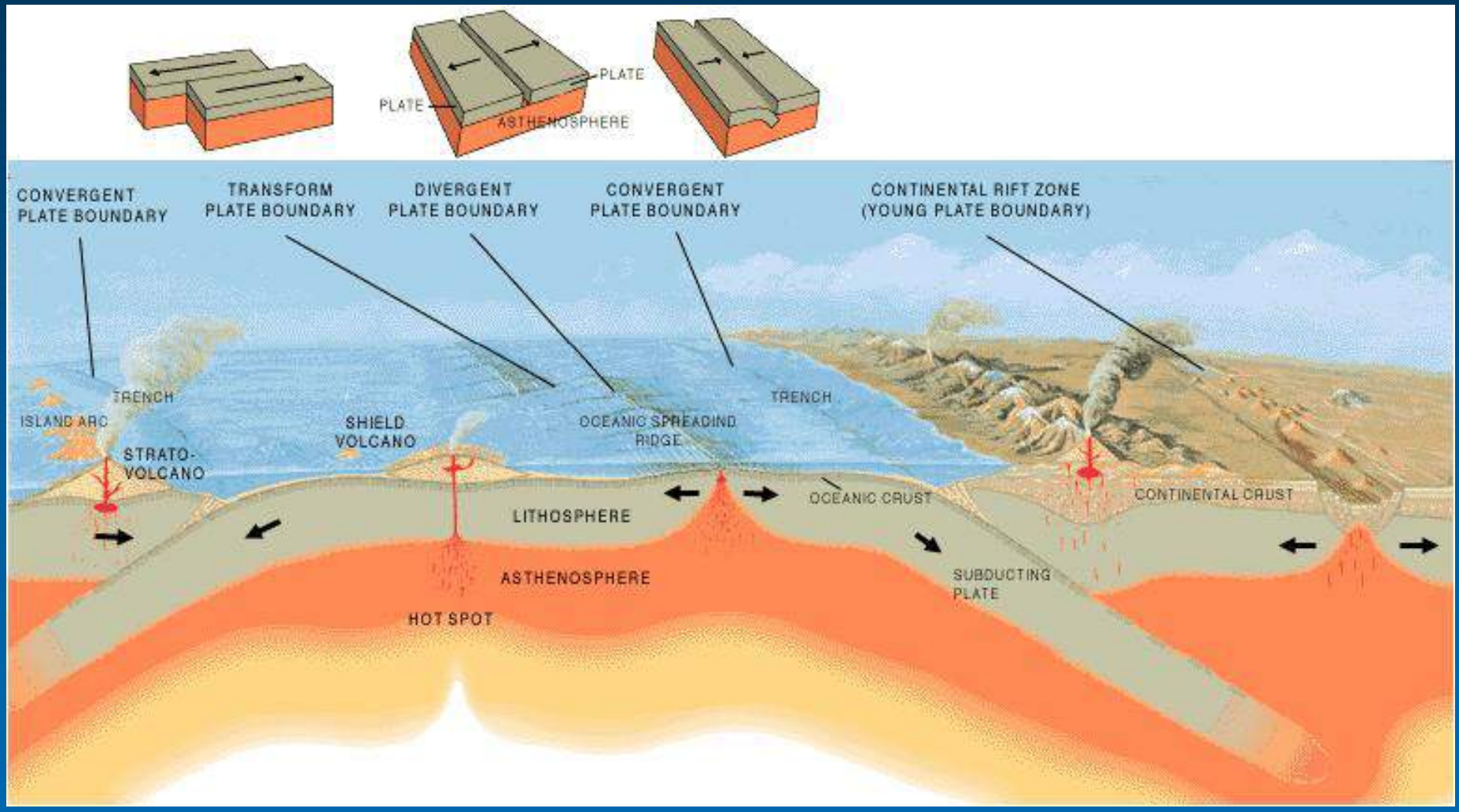
Image from USGS; Earthquakes over last 30 days (http://neic.usgs.gov/neis/qed/)

Different Plate Boundaries

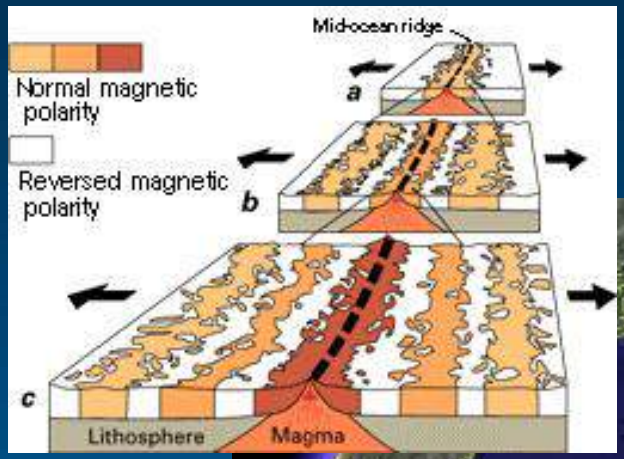
Three major types of plate boundaries:

1. Divergent - plates diverge from each other.
2. Convergent - plates converge toward each other.
   - Oceanic-Continental - oceanic crust (denser) subducts (goes under) beneath continental crust.
   - Continental-Continental - neither body of continental crust subducts (equal density).
3. Transform - plates slide past each other.

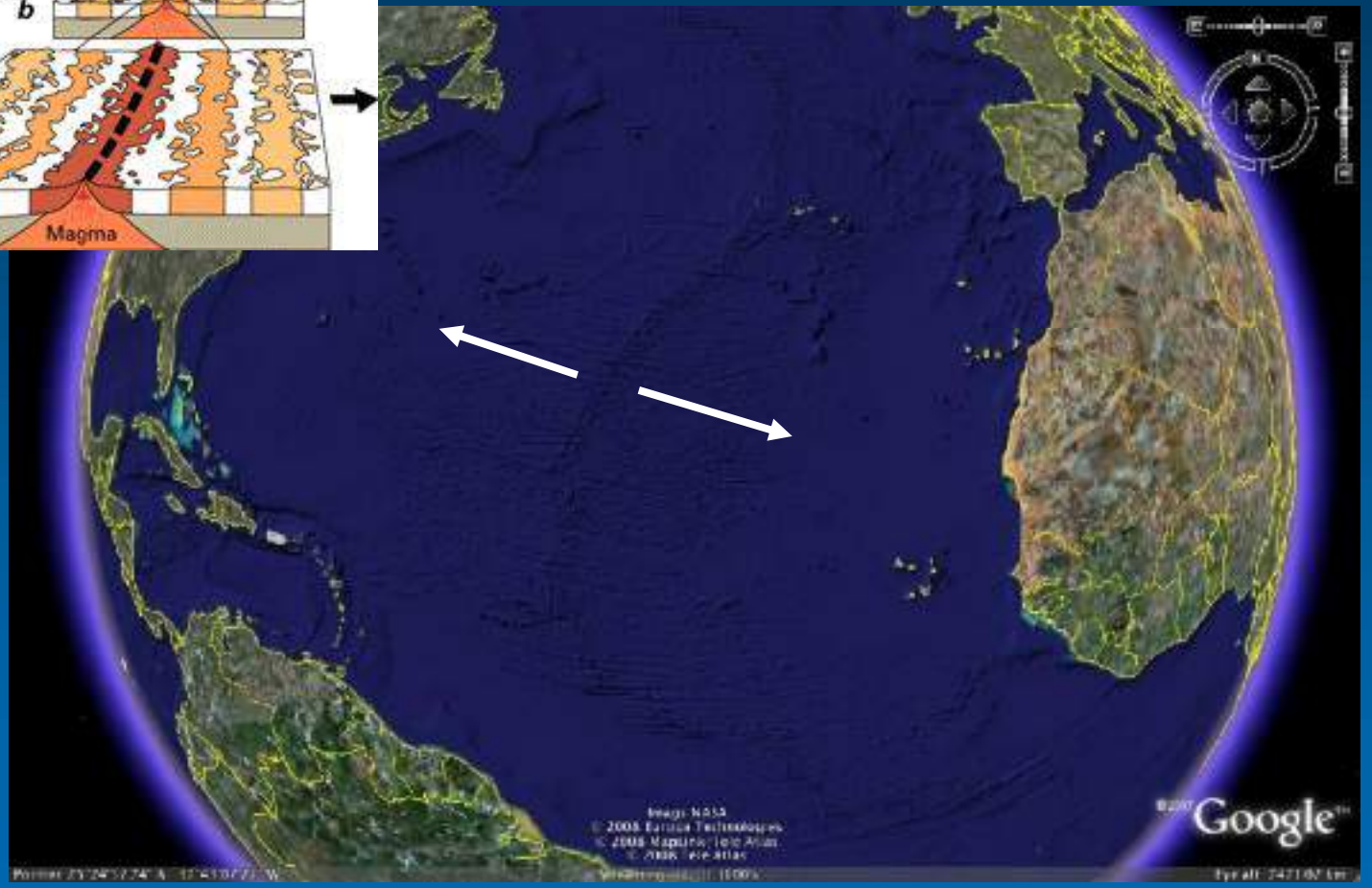
Different Plate Boundaries



Divergent Plate Boundary

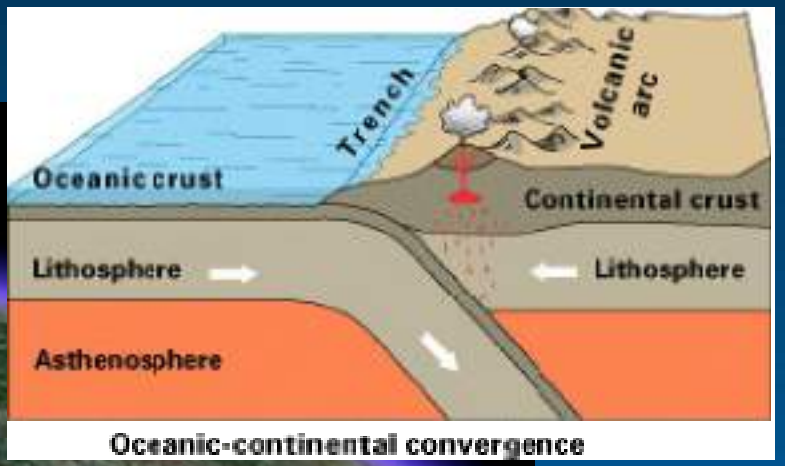


Mid-Atlantic Ridge



Oceanic-Continental Convergent Plate Boundary

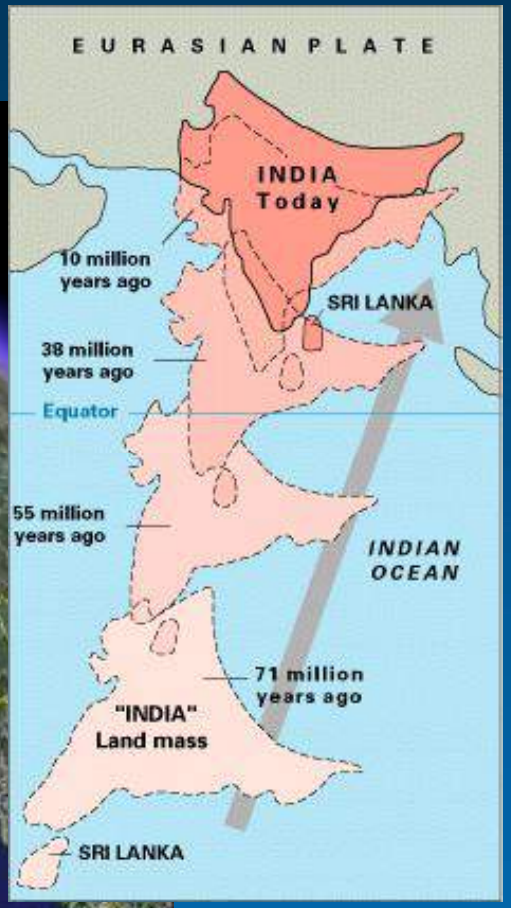
Andes, South America



Oceanic-continental convergence

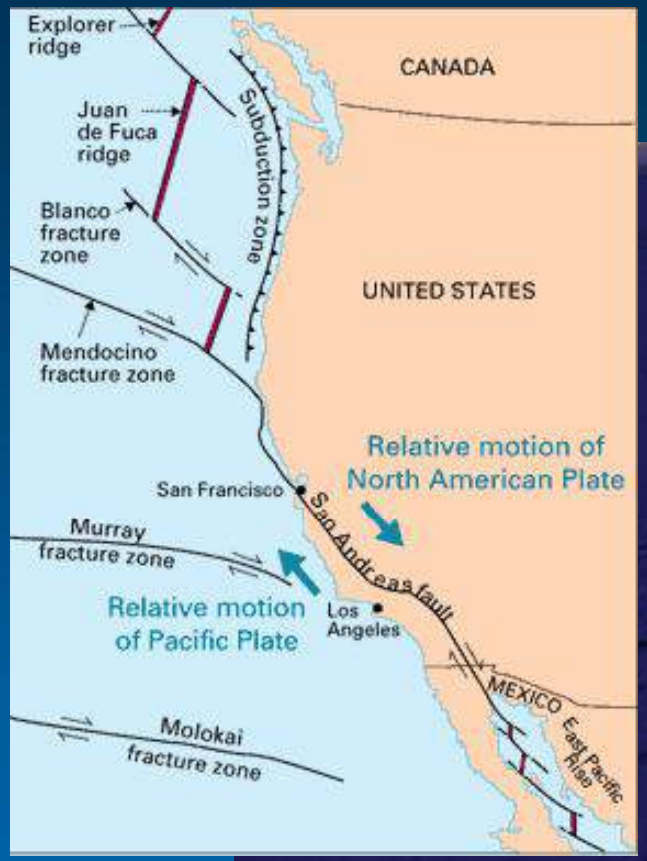
Continental-Continental Convergent Plate Boundary

Himalaya Mountains, Asia

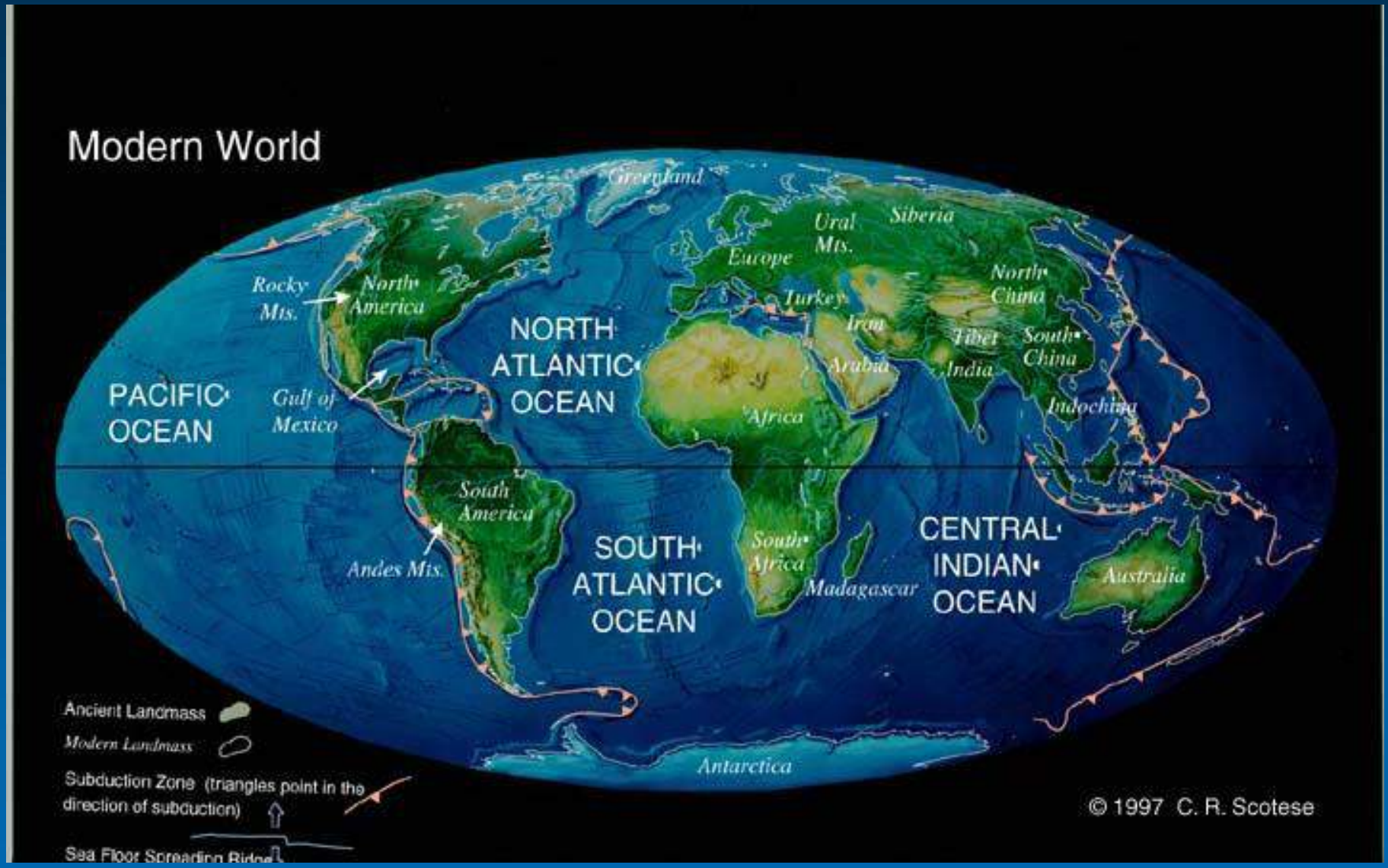


Transform Plate Boundary

Northwestern United States



Earth Today


Modern World
Greenland
Europe
Ural Mts.
Siberia
North China
Rocky Mts.
North America
Turkey
Iran
Arabia
Tibet
India
South China
Indochina
Africa
PACIFIC OCEAN
Gulf of Mexico
NORTH ATLANTIC OCEAN
South America
Andes Mts.
SOUTH ATLANTIC OCEAN
South Africa
Madagascar
CENTRAL INDIAN OCEAN
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge
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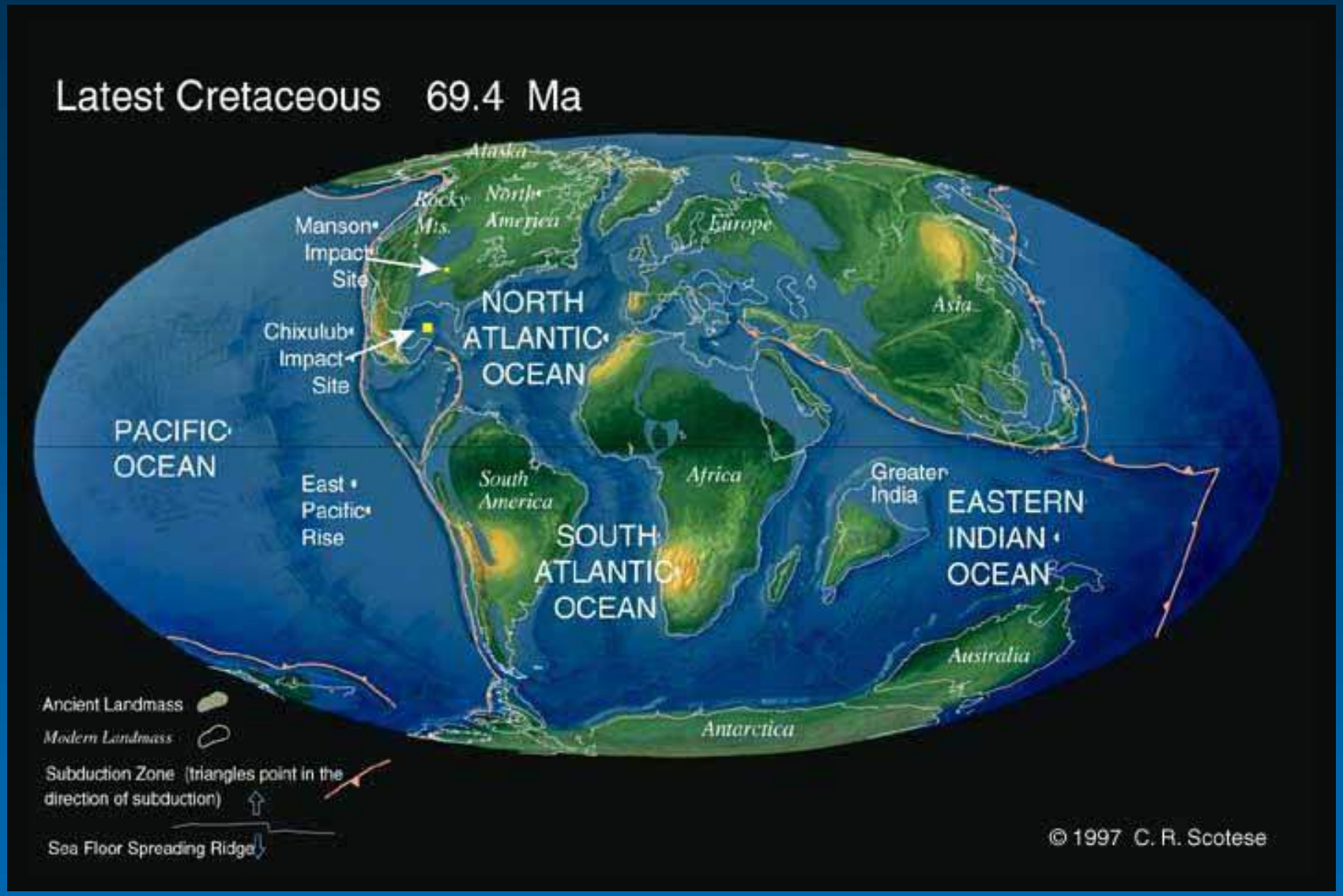
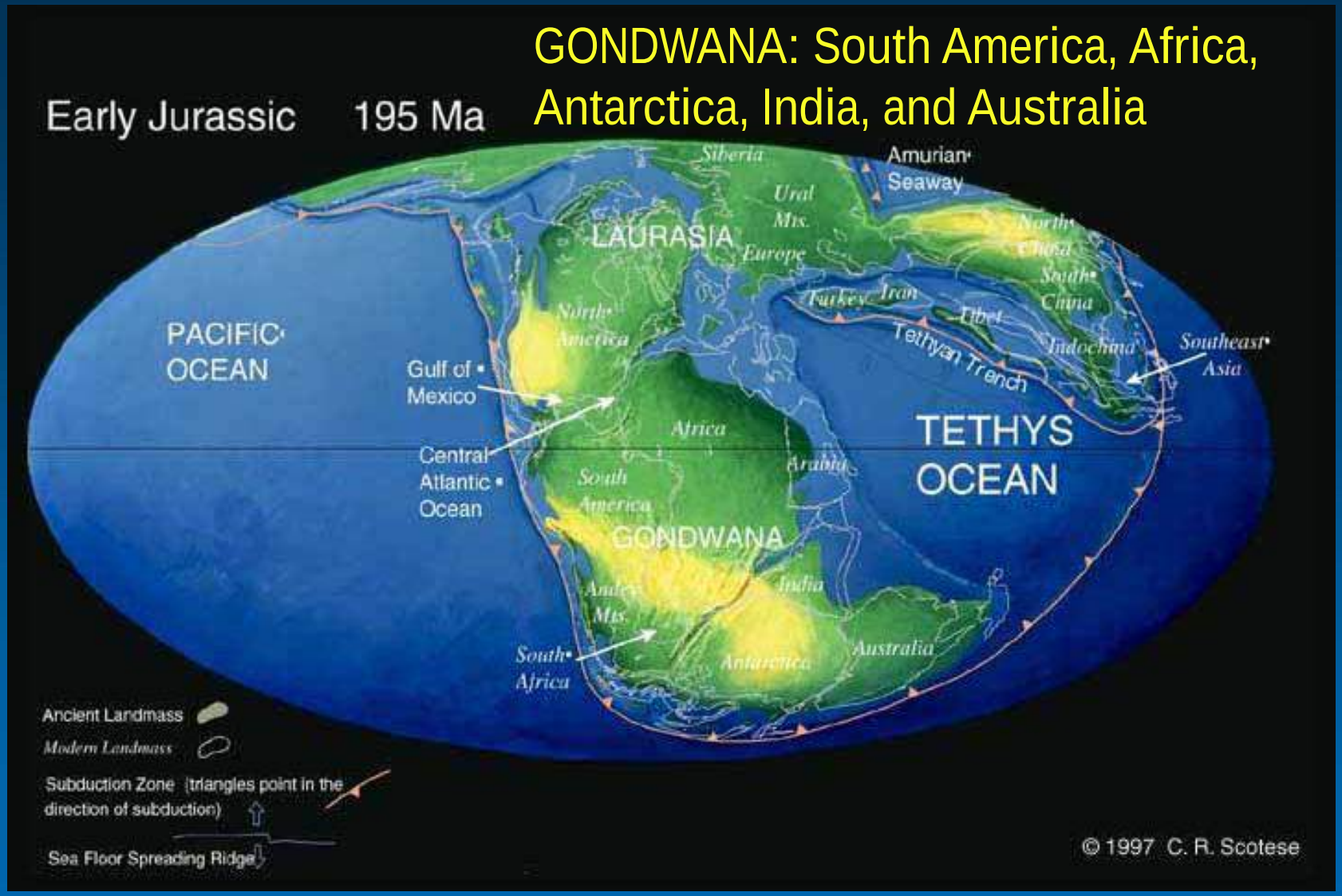
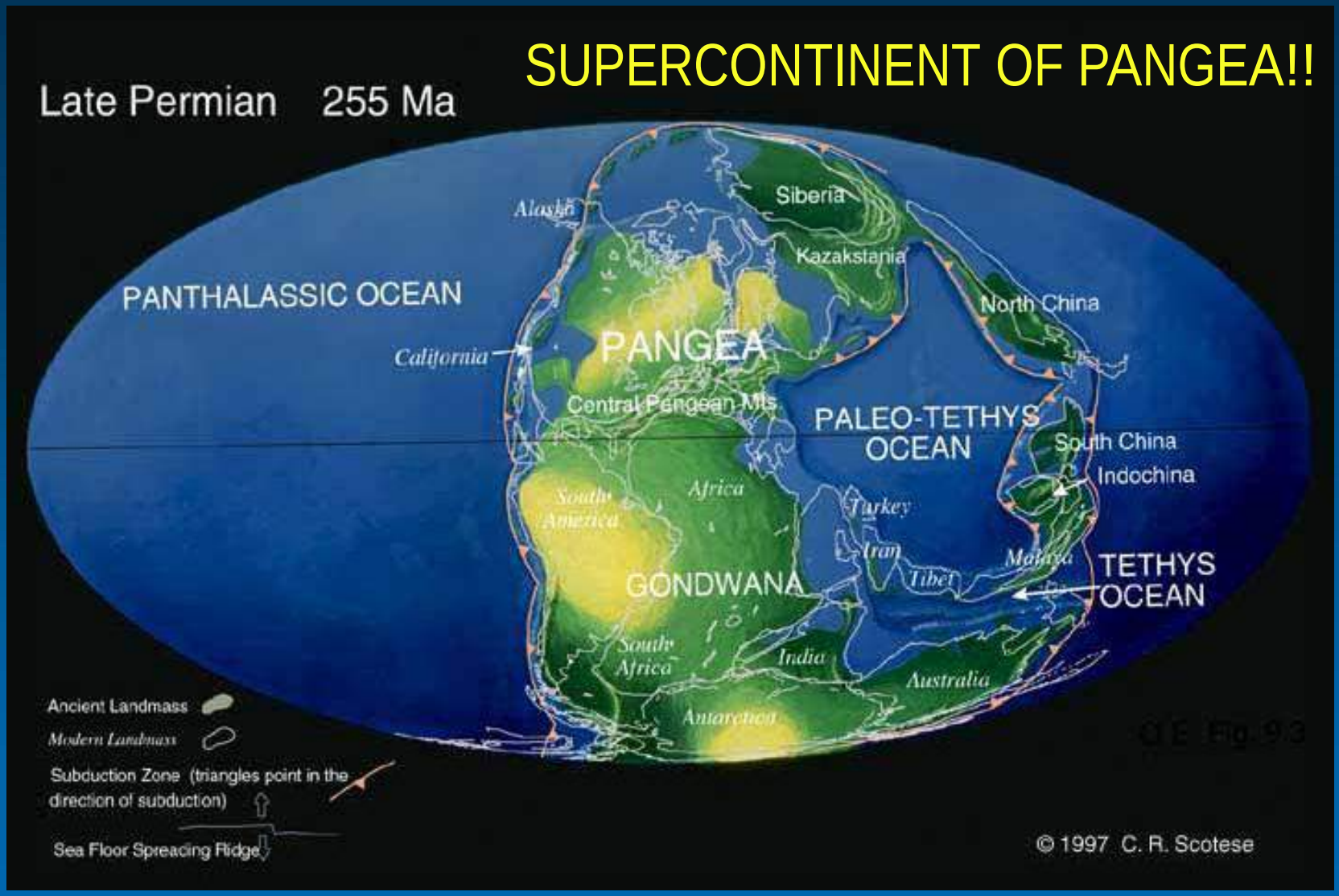
Earth in the Cretaceous



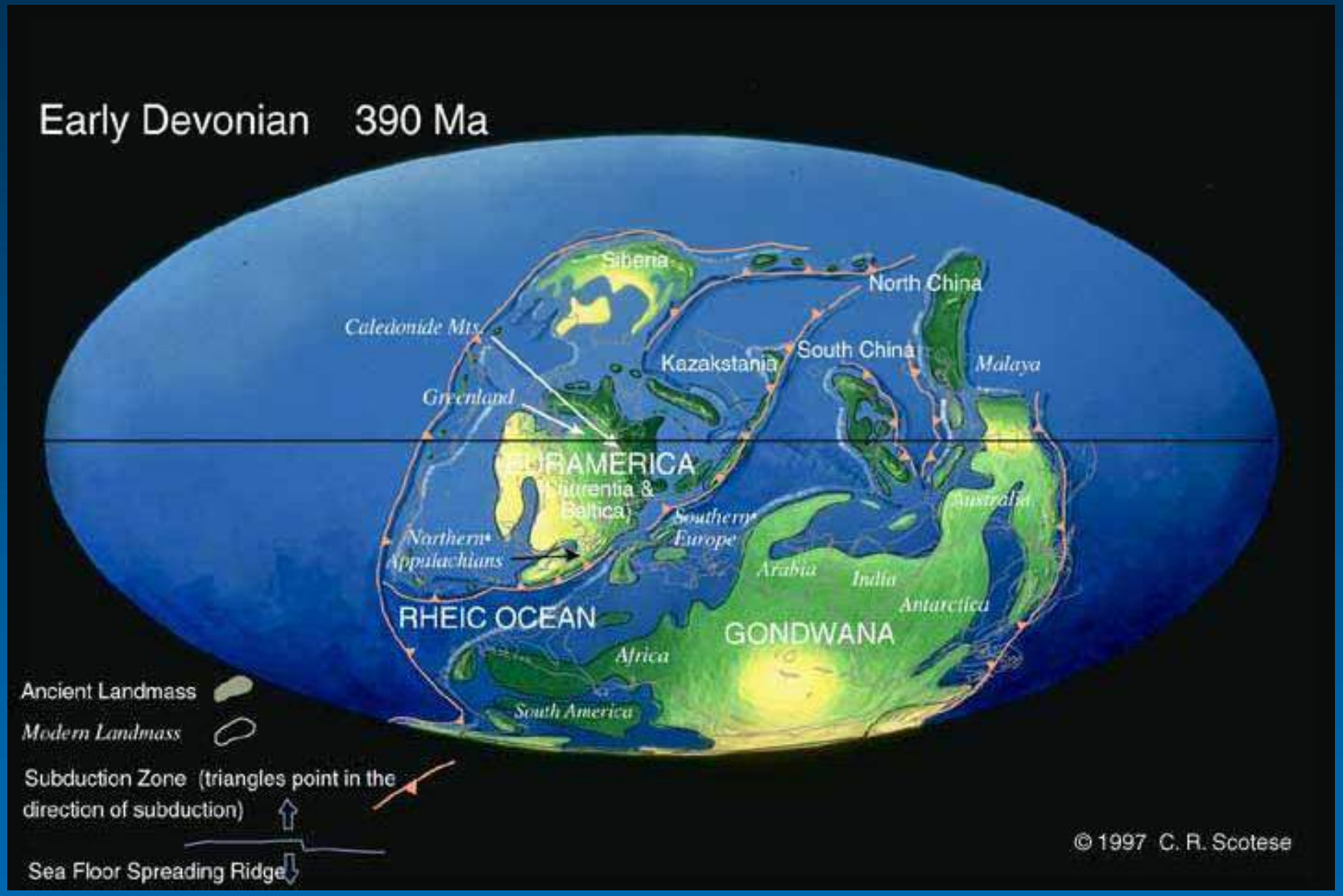
Earth in the Jurassic



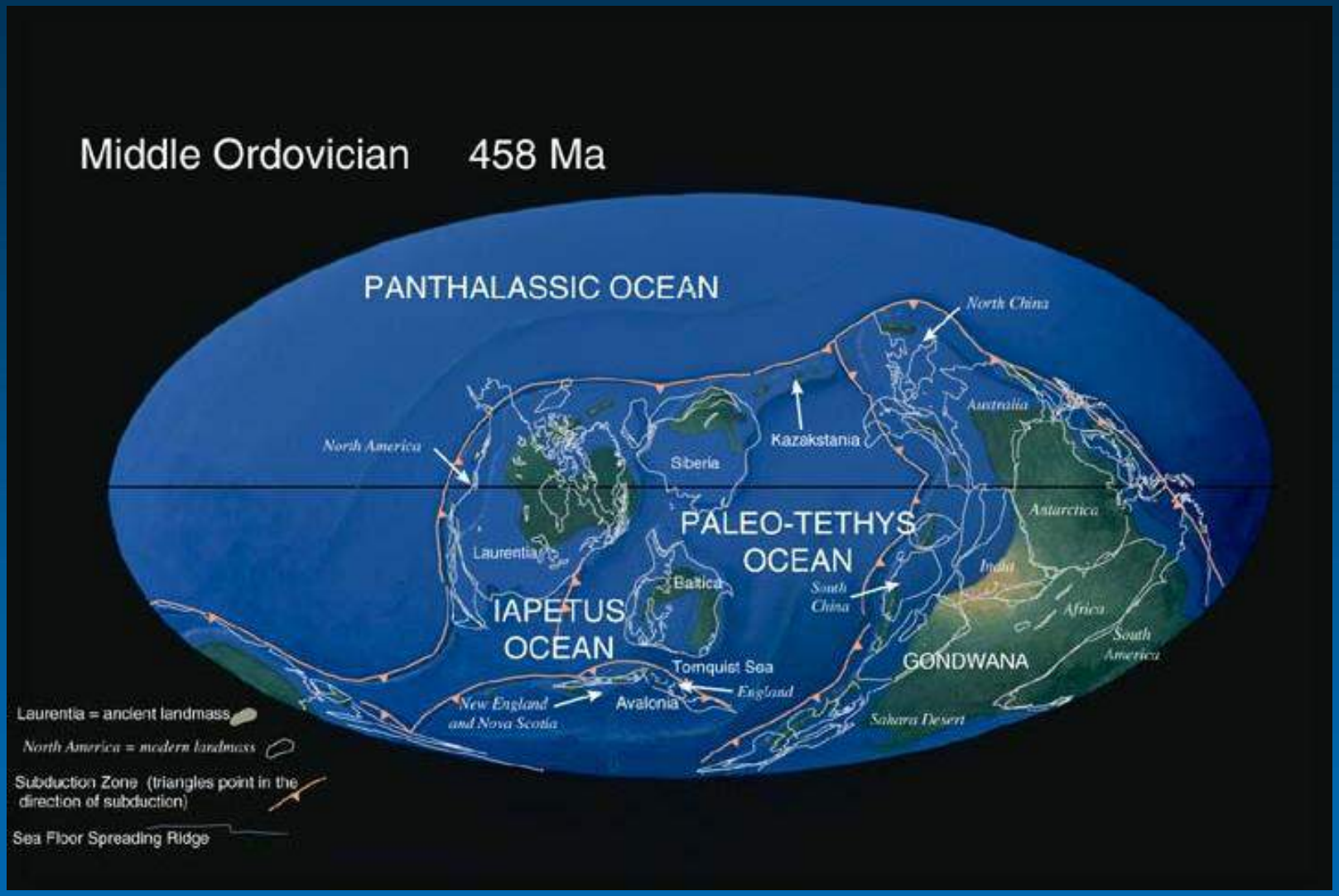
Earth in the Permian



Earth in the Devonian

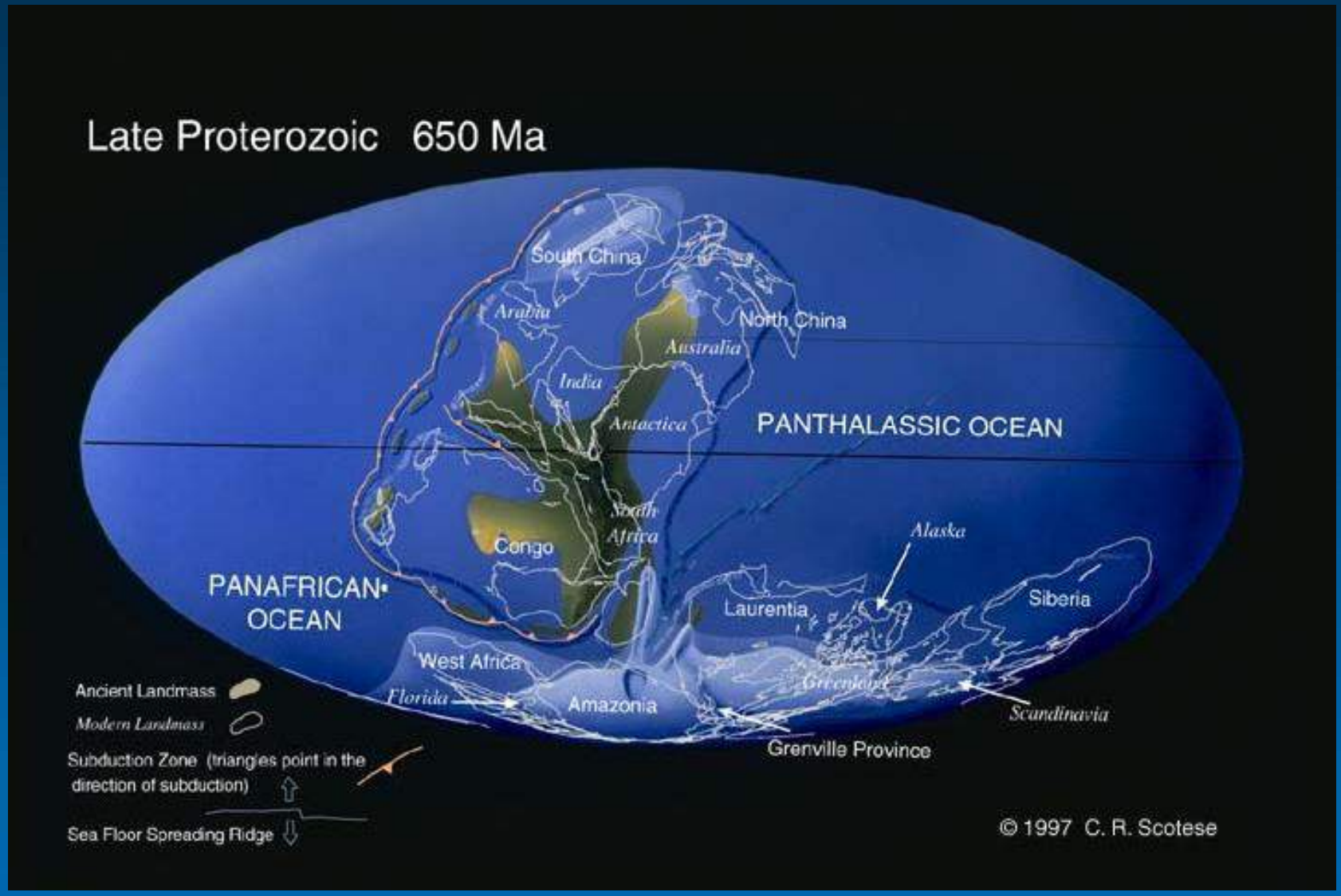


Earth in the Ordovician

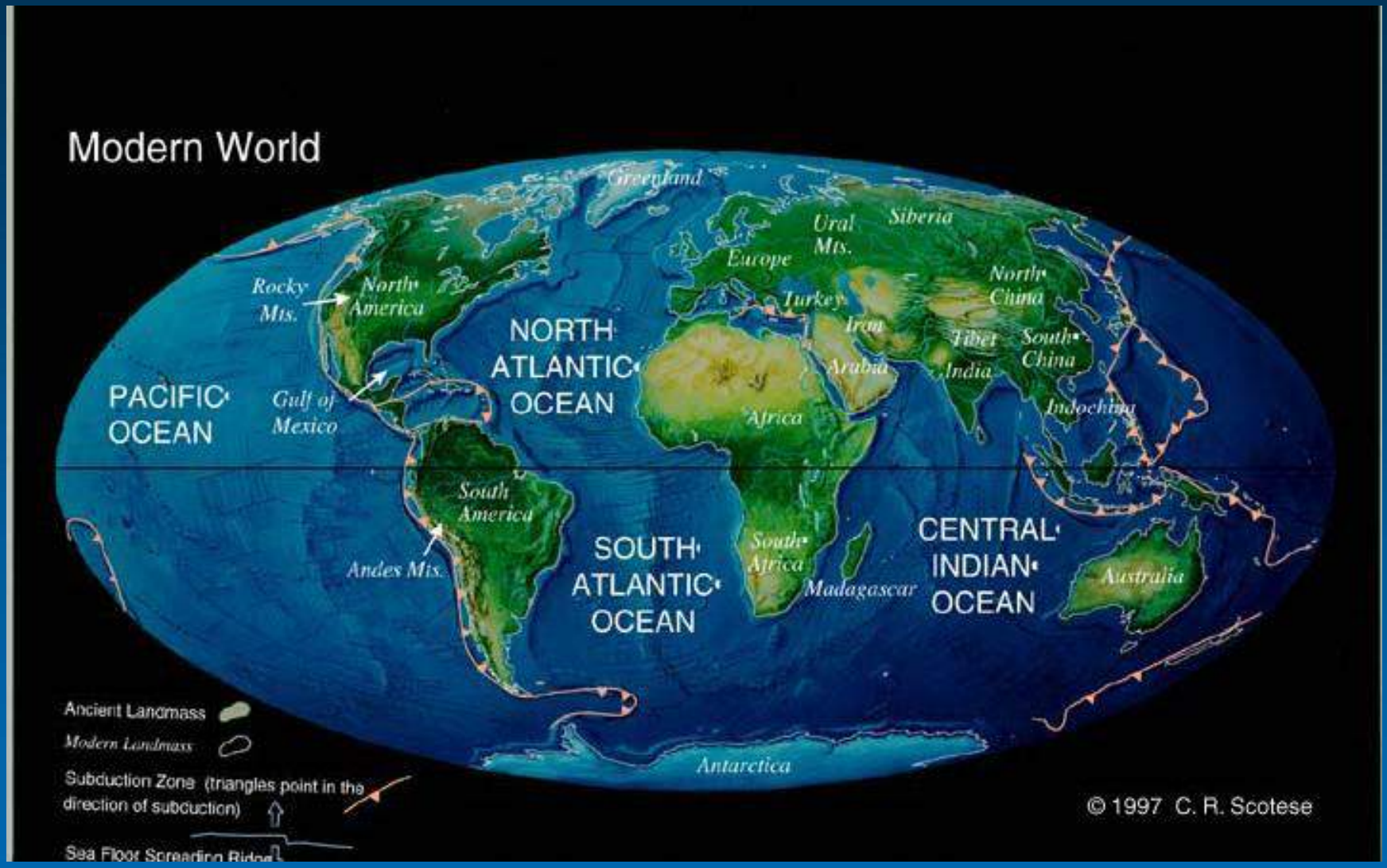


Earth in the Cambrian

Earth in the Late Proterozoic



Earth Today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Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge
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Plate Tectonics

Plate Tectonics: The scientific theory that the surface of the Earth (lithosphere) is divided into plates that move relative to one another and that interact at their boundaries.