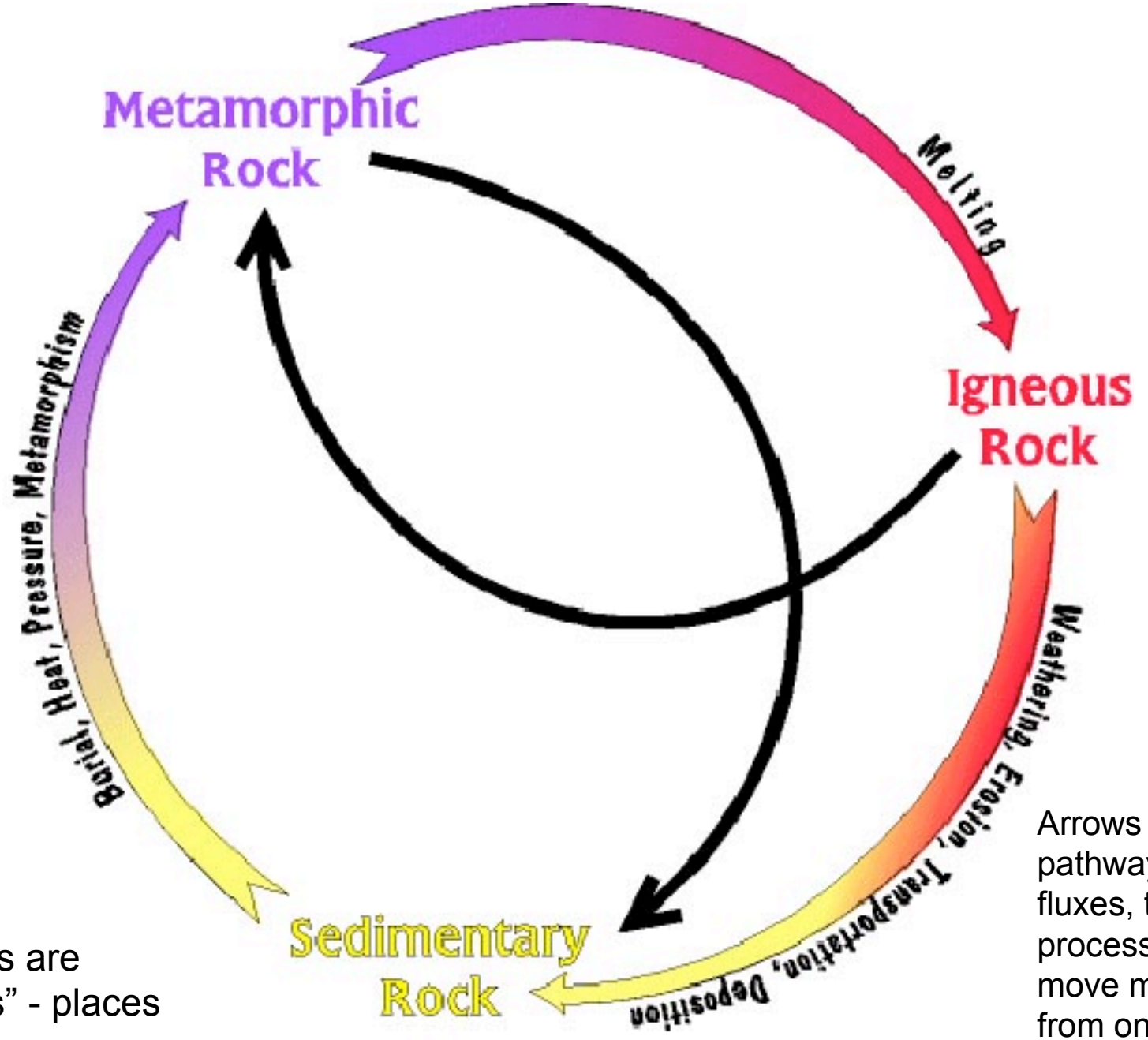
Plate Tectonics and the cycling of Earth materials

Plate tectonics drives the rock cycle: the movement of rocks (and the minerals that comprise them, and the chemical elements that comprise them) from one reservoir to another



I,M.S rocks are "reservoirs" - places where material is temporarily stored

Arrows are pathways, or fluxes, the processes that move material from one reservoir to another

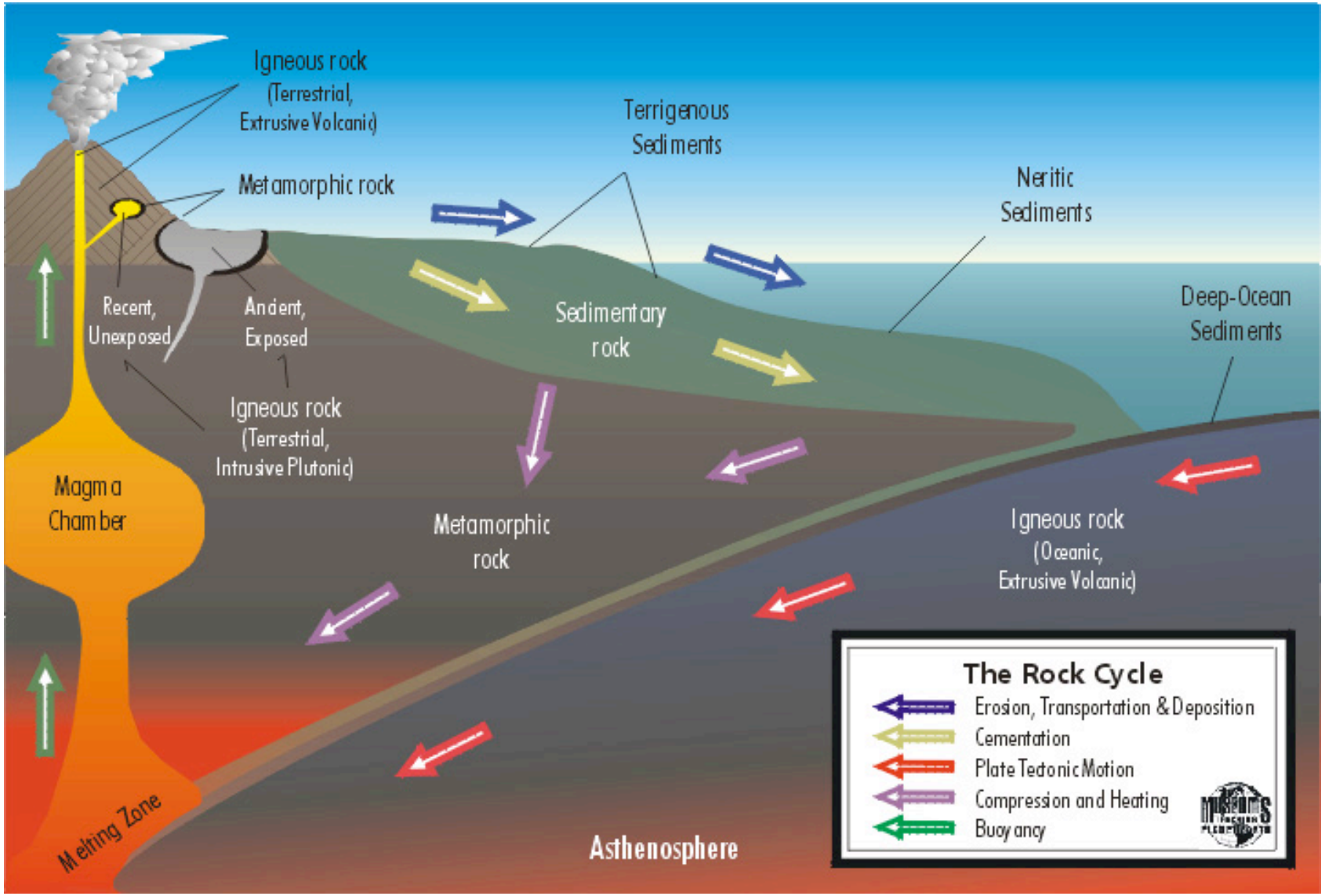
We need to be able to identify these three types of rocks.

Why? They convey information about the geologic history of a region.

What types of environments are characterized by the processes that produce igneous rocks?

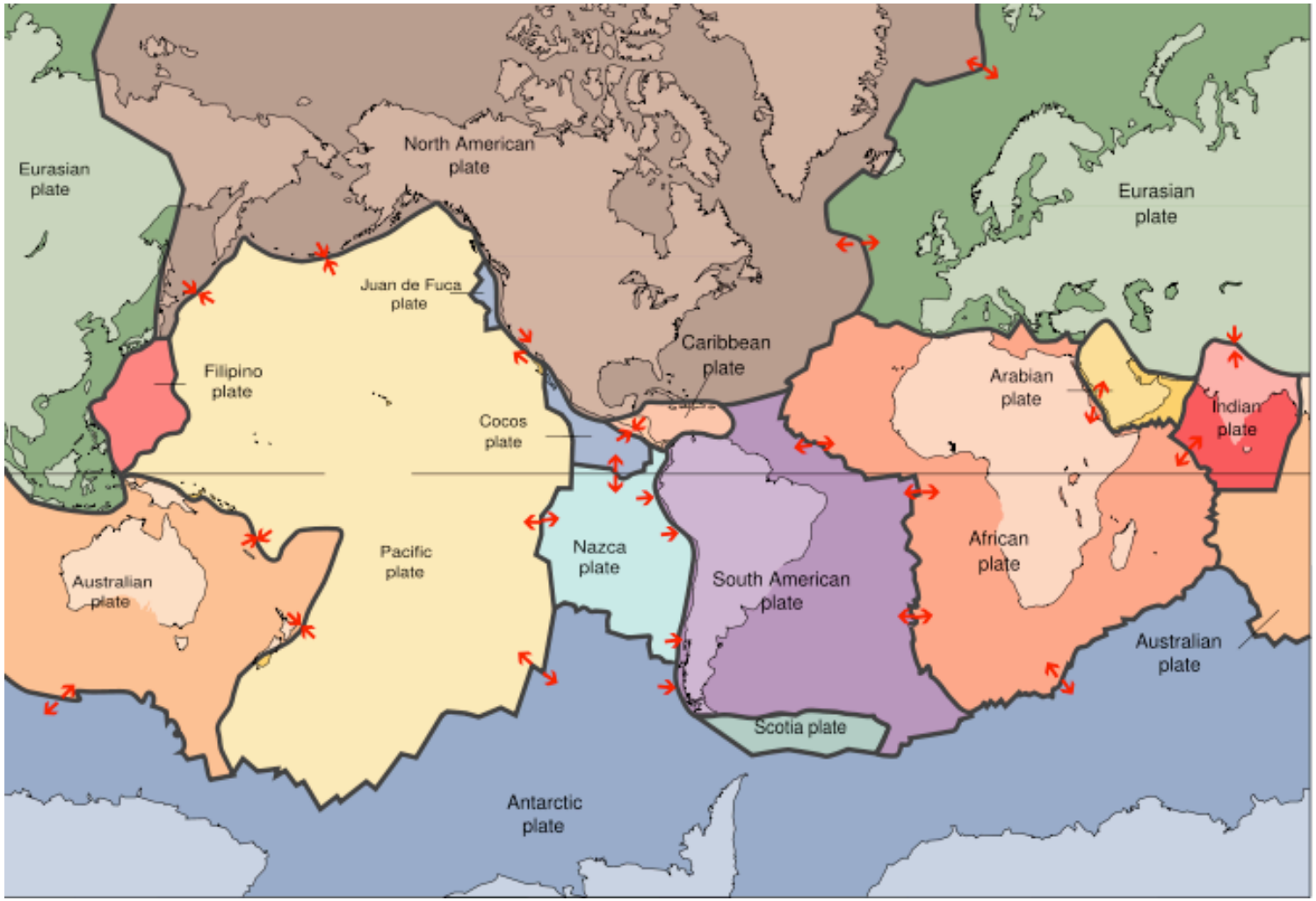
What types of environments are preserved by the accumulation of sediment?

What types of environments are characterized by the tremendous heat and pressure that produces metamorphic rocks?



How the rock cycle integrates into plate tectonics.

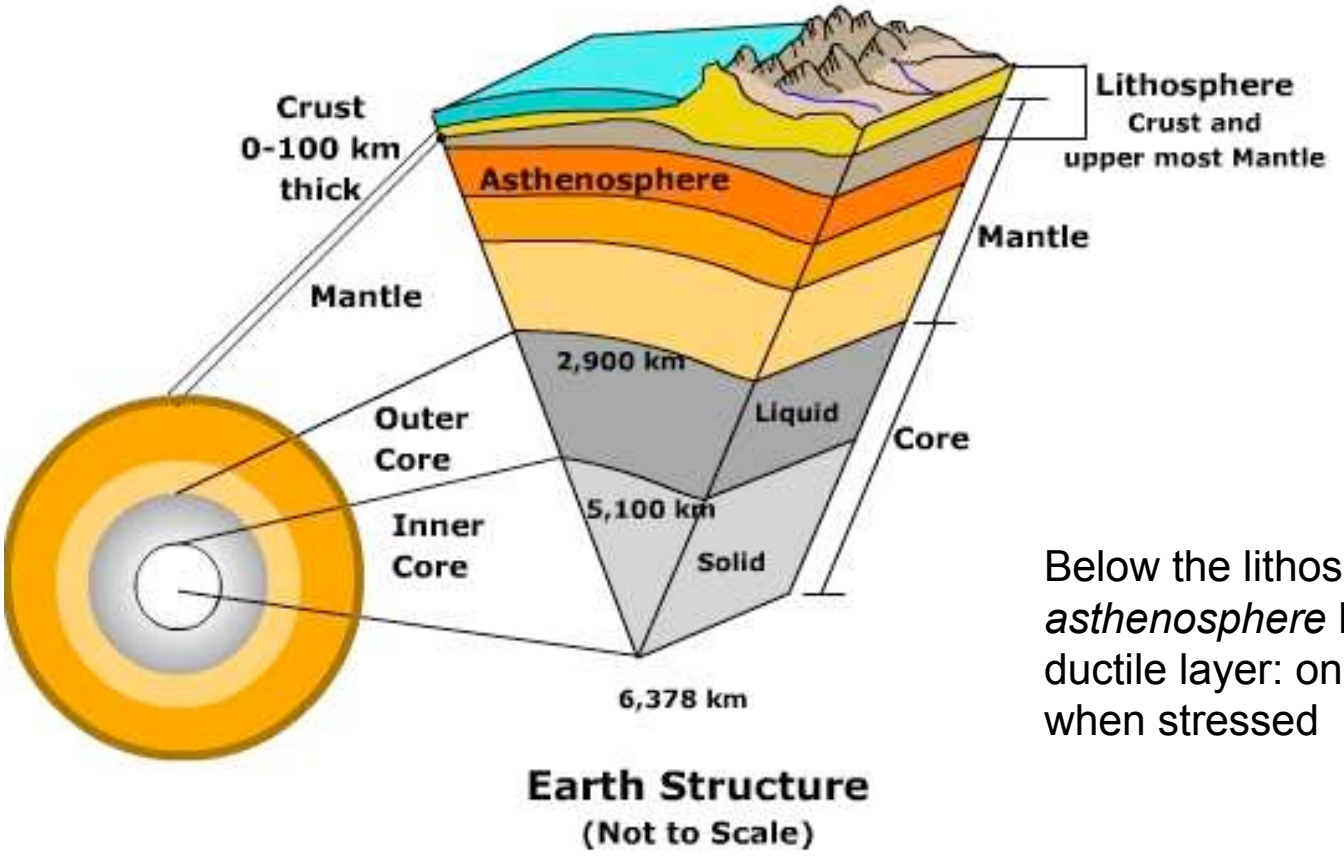
In order to understand the concept that plate tectonics drives the rock cycle, we need to understand what the theory of plate tectonics says about how the earth works



The major plates in *today's* Earth (there have been different plates in the Earth's past!)

What is a "plate"?

The “plate” of plate tectonics is short for “lithospheric plate” - - the outermost shell of the Earth that behaves as a rigid substance. What does it mean to behave as a rigid substance?



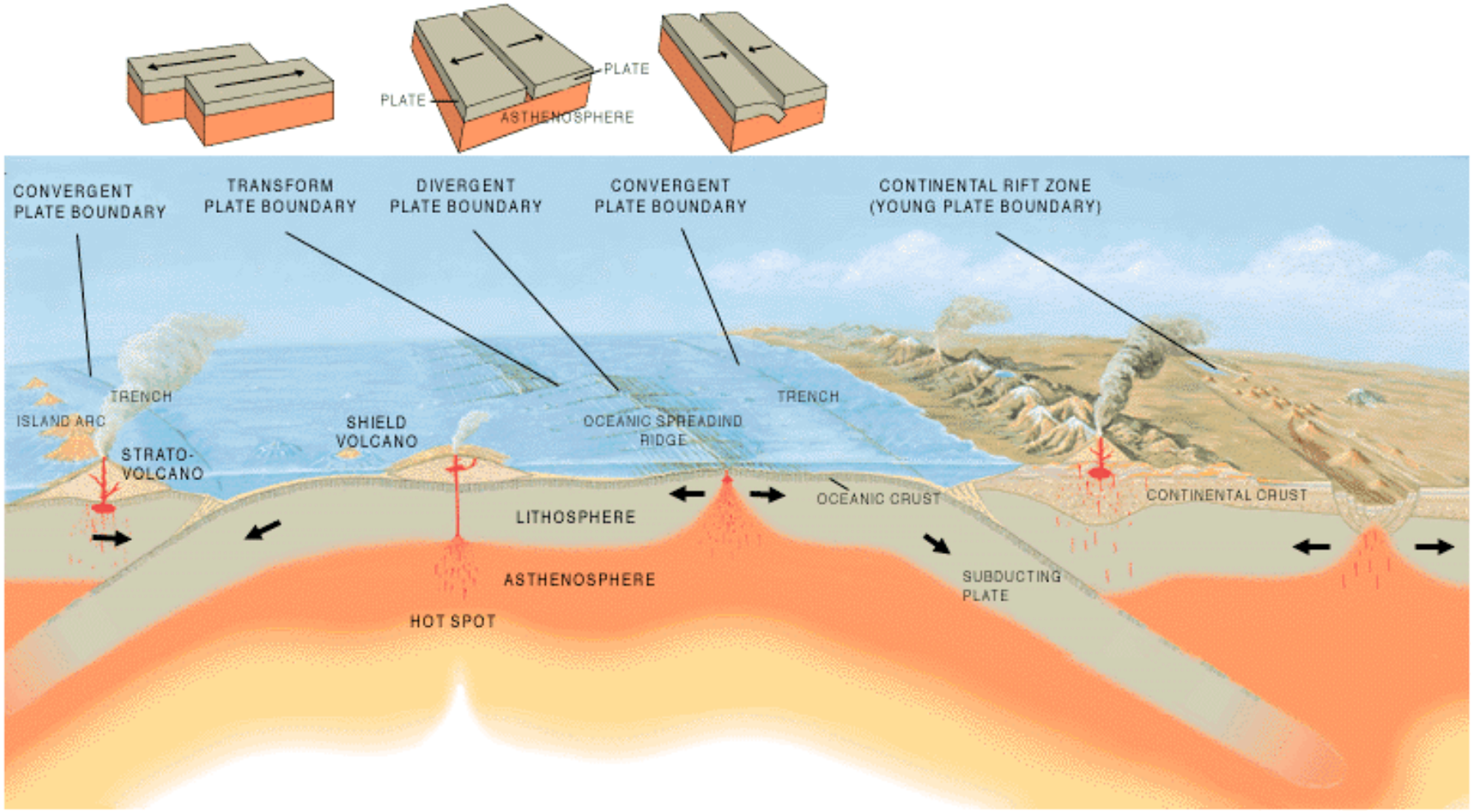
Earth Structure
(Not to Scale)

The lithosphere is ~150 km thick. It consists of the crust + the uppermost mantle.

Below the lithosphere the *asthenosphere* behaves as a ductile layer: one that flows when stressed

It means that when the substance undergoes stress, <u>it breaks</u>
(a non-rigid, or ductile, substance <u>flows</u> when stressed; for example, ice flows; what we call a glacier)

Since the plates are rigid, brittle 150km thick slabs of the earth, there is a lot of “action”at the edges where they abut other plates



We recognize 3 types of plate boundaries, or edges. Different geologic processes occur at each of these.

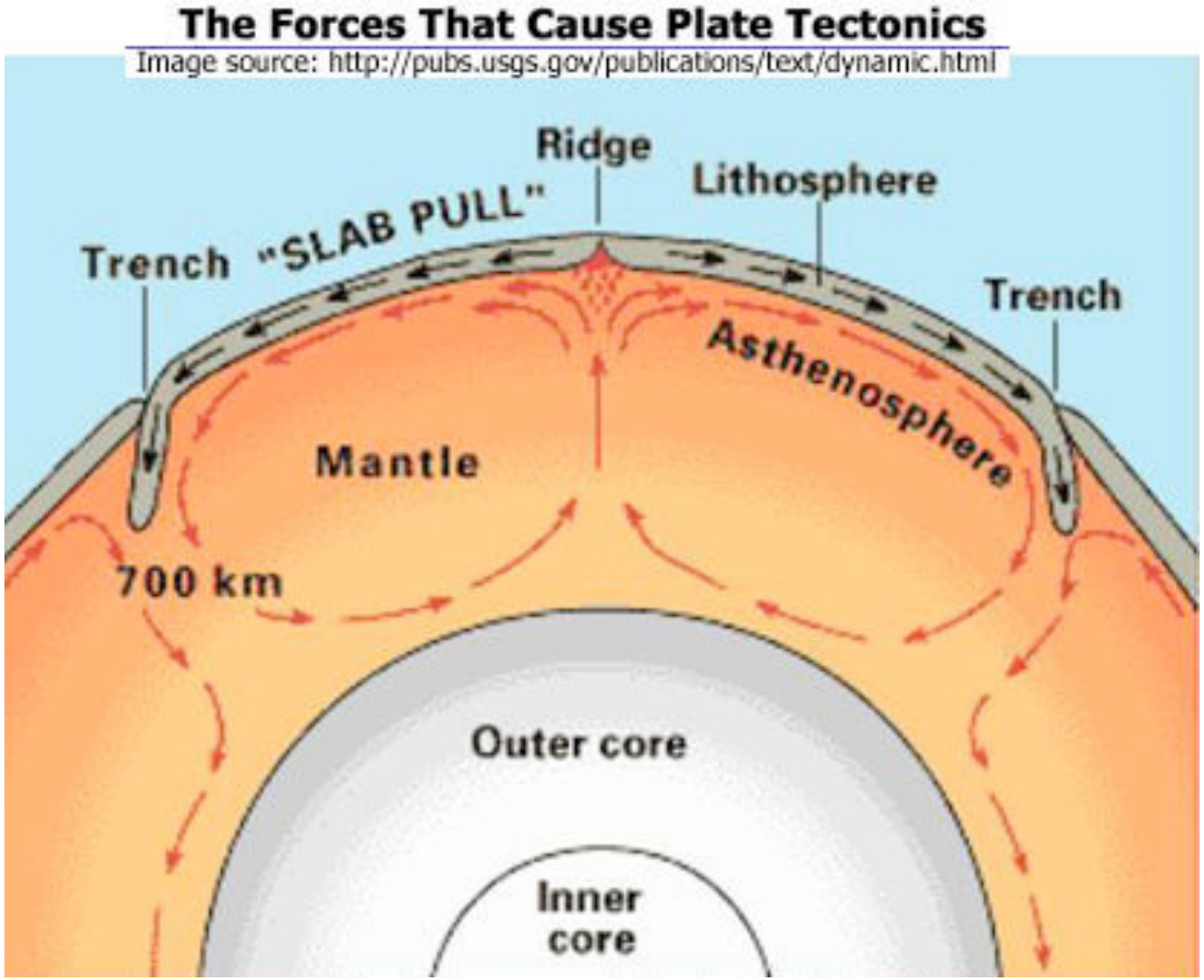
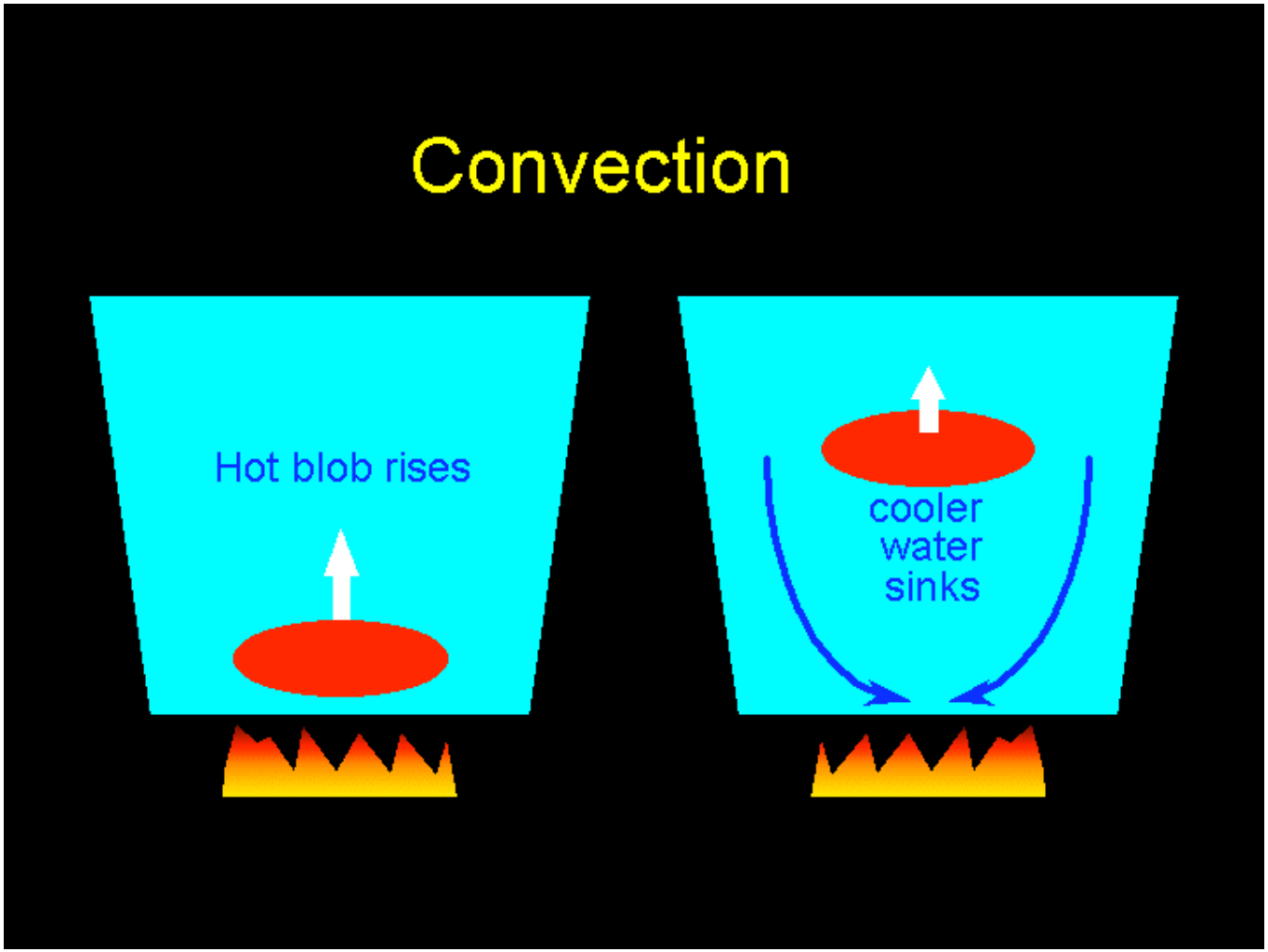
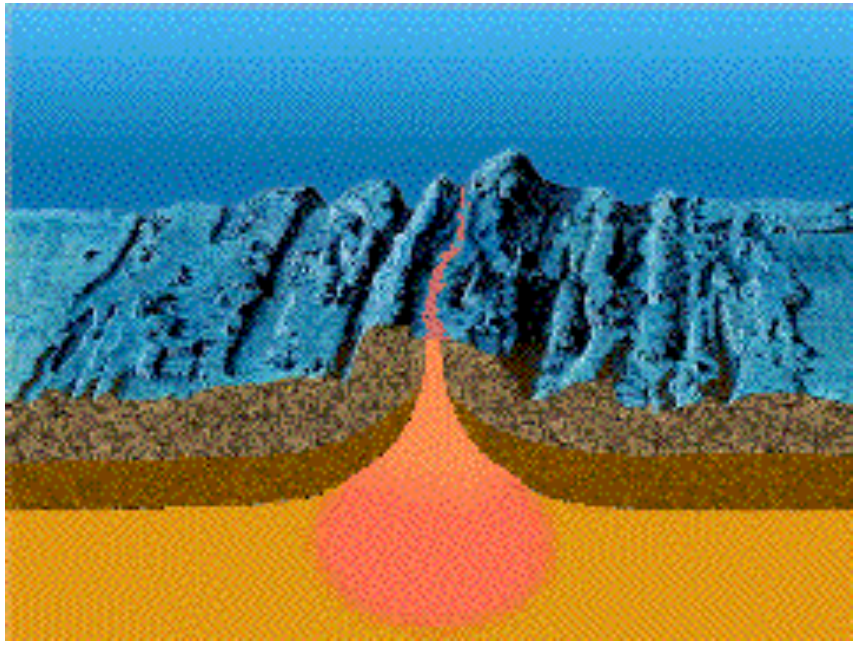


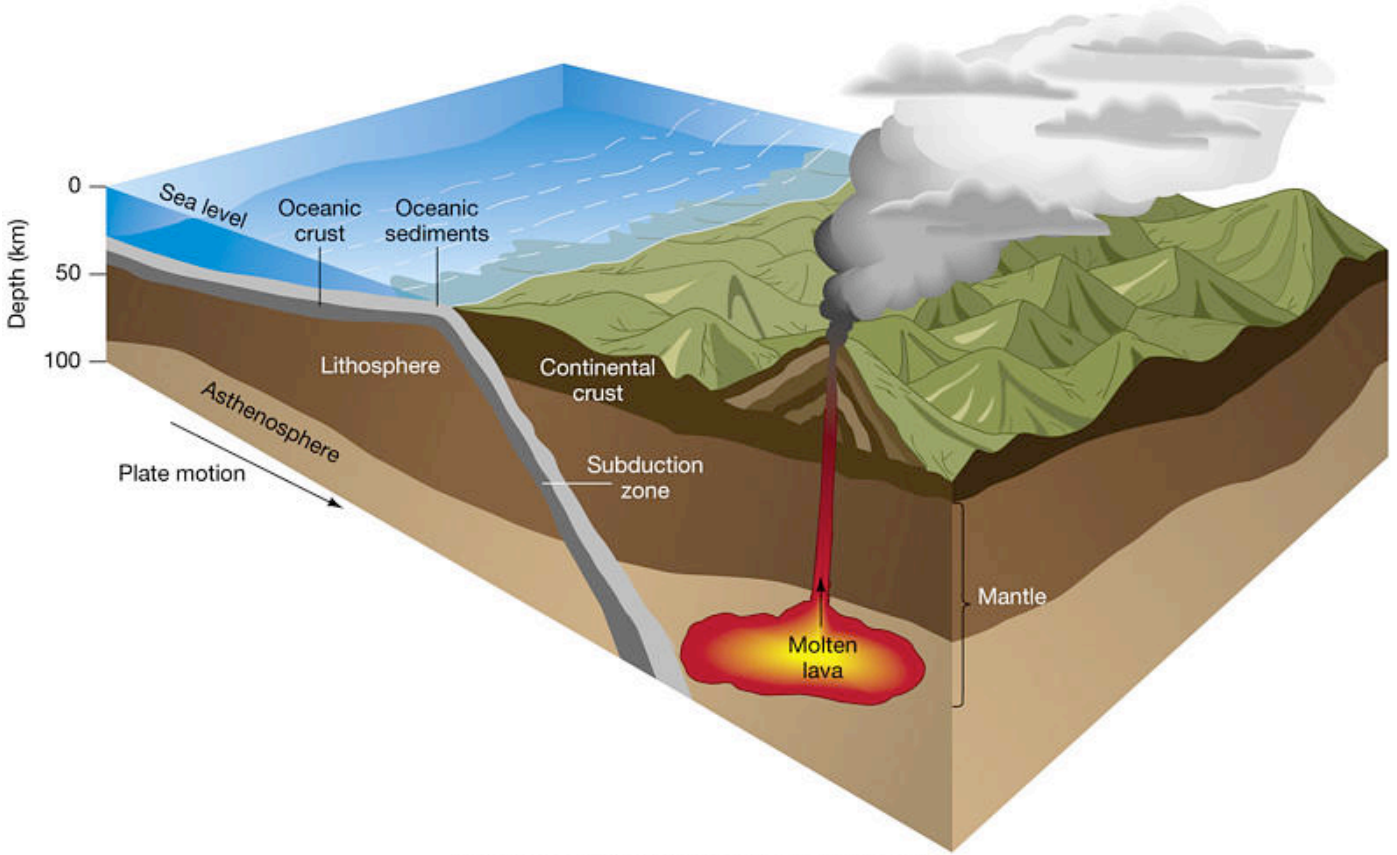
Plate tectonics is driven by heat flow from the Earth's interior. Obviously, the Earth's interior is hot…….



What supplies the Earth's internal heat? …radioactive decay (the breakdown of unstable isotopes) and heat produced from mineral transformations.

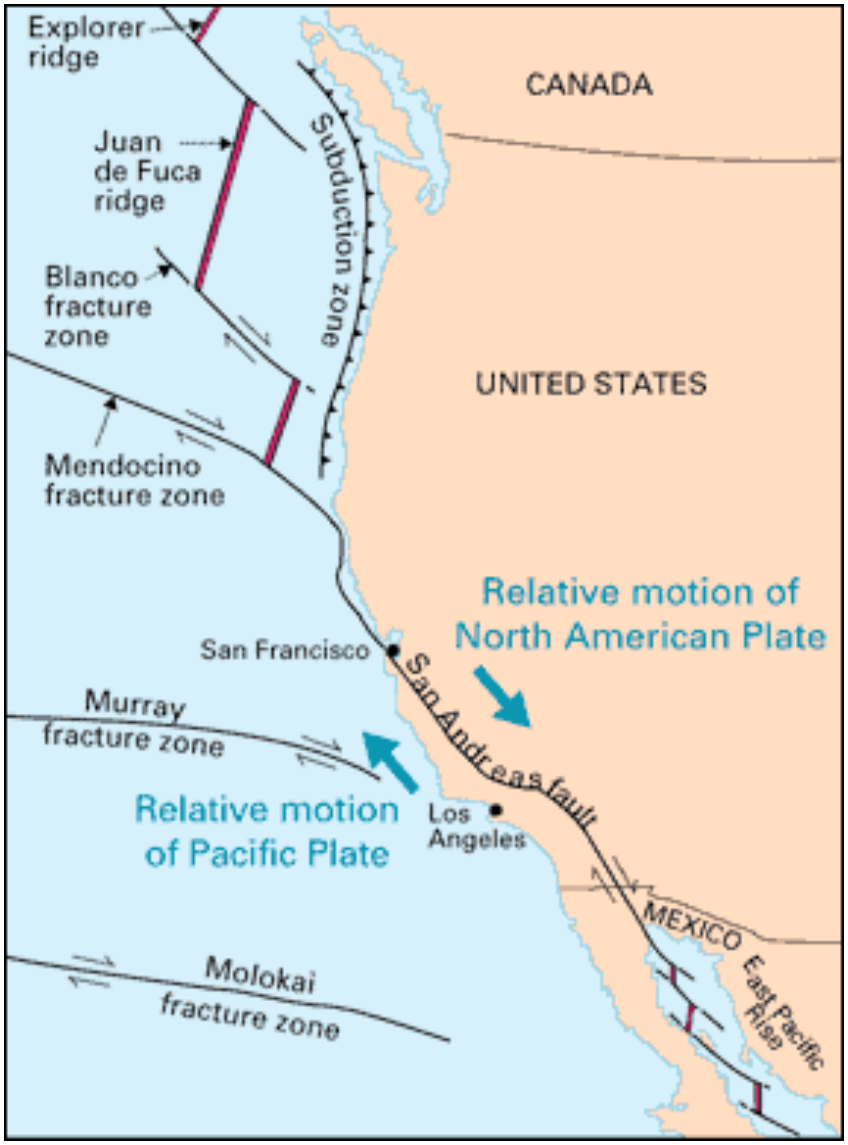


Extensional Plate Boundaries: melted rock, or magma, erupts on the earth's surface where the plates are moving apart. A modern example of where this is happening: the Red Sea is opening up, pushing the African and Arabian plates apart. Extensional plate boundaries occur where heat rises from the earth's interior, rocks melt and magma erupts.

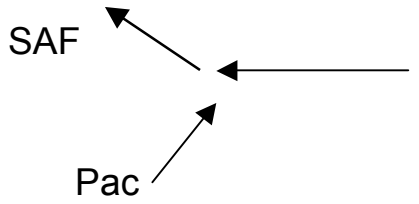


A cross section of the earth at a collisional plate boundary where the motion of the plates is toward one another. One plate is pushed beneath another, back into the mantle. Melting of rock occurs,forming magma, which erupts in volcanoes. Great temperatures and pressures form metamorphic rocks. The rocks are deformed (bend =fold and break =fault). Mountains form!

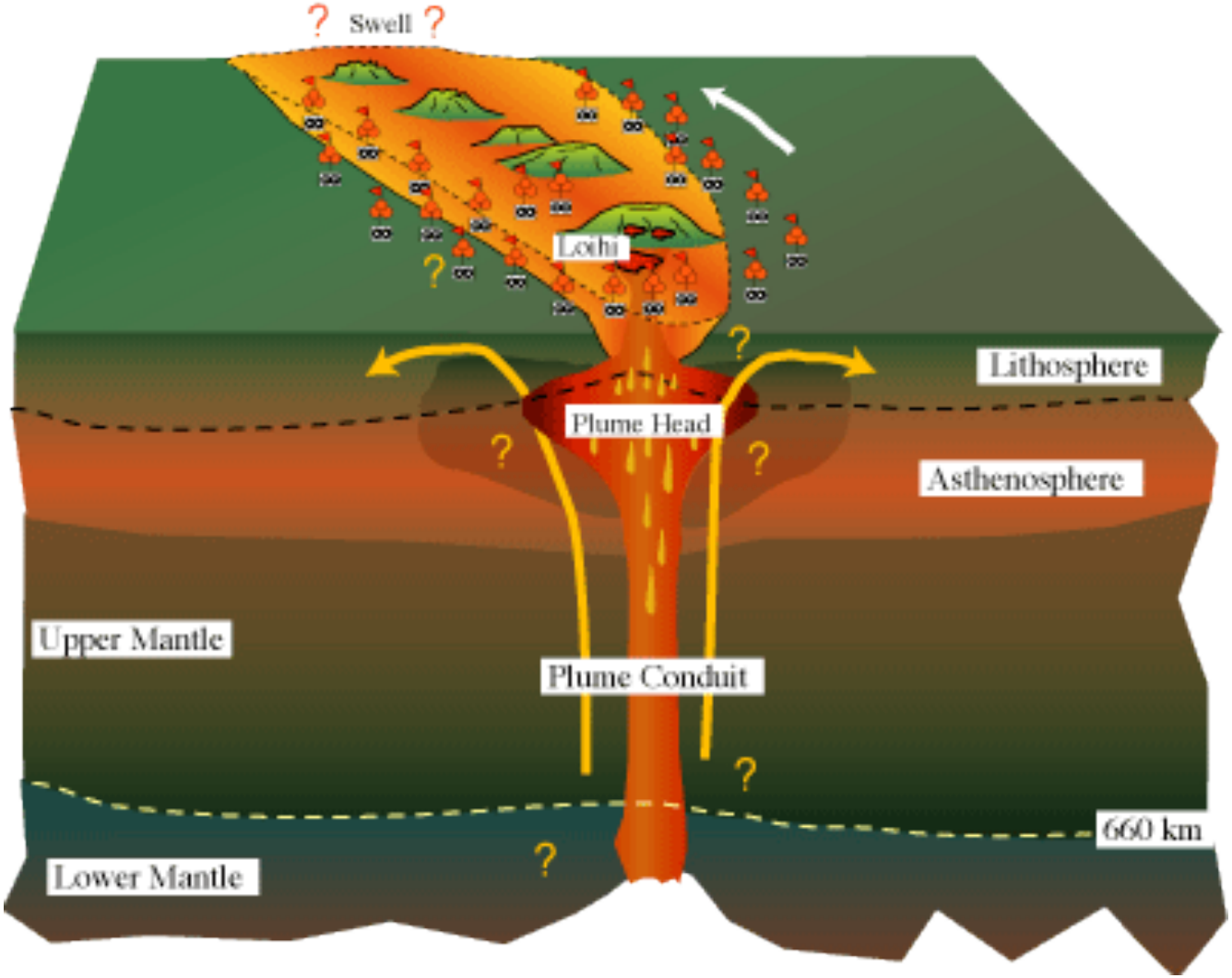
Strike Slip or Transform Boundaries



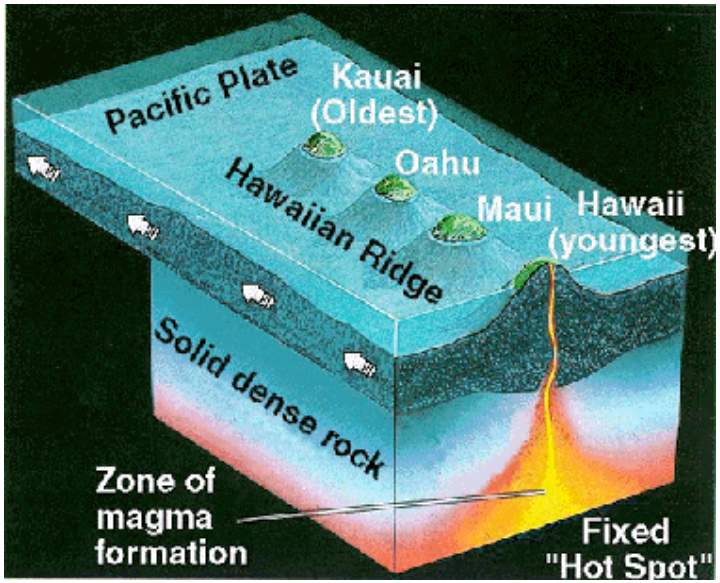
When plates collide at an angle to one another, the angular motion is taken up by sideways slipping, forming a strike-slip or transform plate boundary. An excellent example of this is southern CA, where the San Andreas Fault is moving part of the Pacific Plate northward along the North American Plate, in response to the N. Am and Pacific plates colliding at an angle

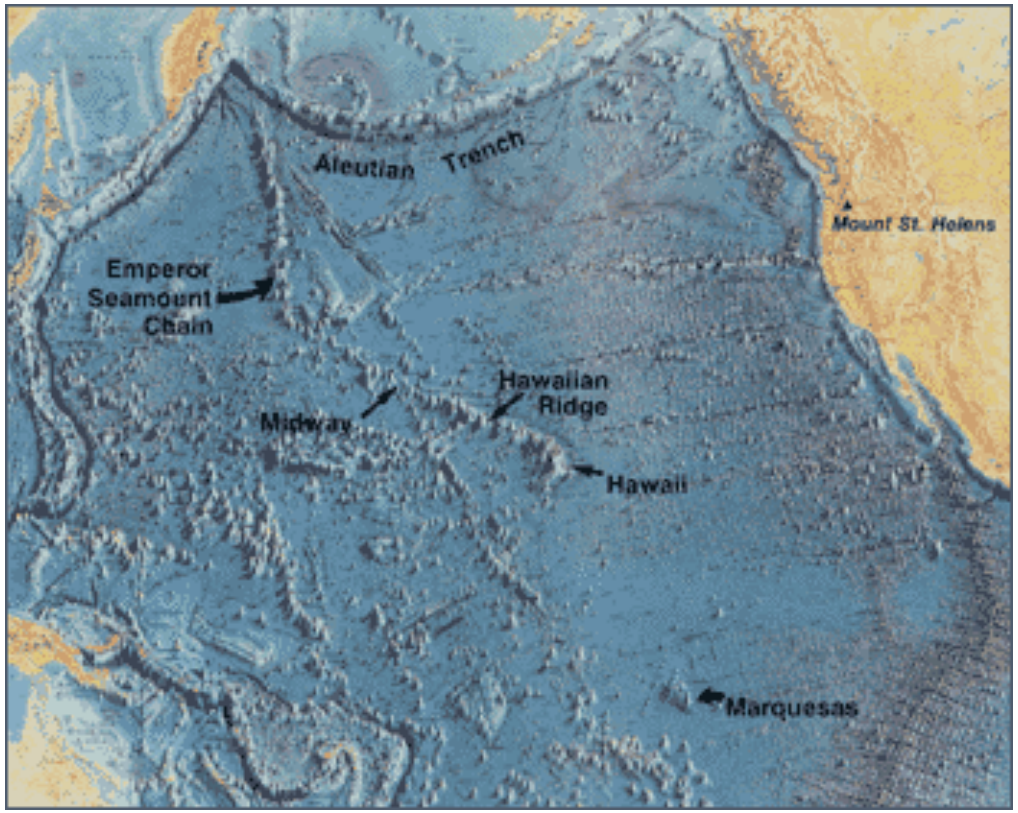


vectors!



Collisional and extensional plate boundaries aren't the only places where we get volcanoes on earth. Isolated "plumes" of heat from the mantle (not a complete convection cell) rise to the surface and create "hot spots" where volcanoes form. The Hawaiian Islands are an example of a hot spot



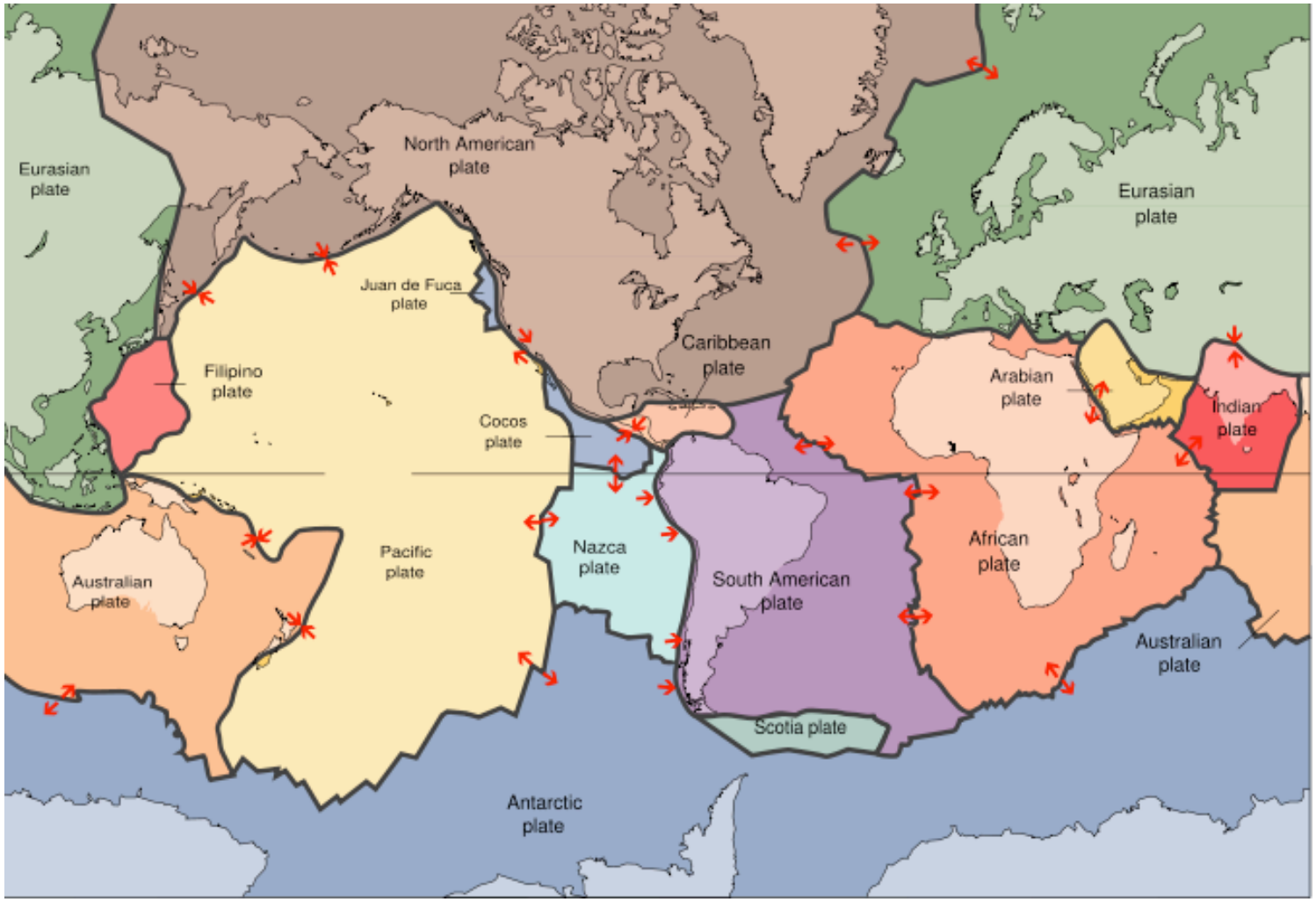


How the Hawaiian Islands illustrate plate movement: they form a chain of volcanic islands that stretches across the Pacific Ocean, marking the movement of the plate over a stationary plume. The figure on the left shows the plume of heat within the mantle. The Pacific plate is moving over the plume, creating a volcano. As the plate continues its motion, the older volcano is carried away and a new one forms. The map on the right shows the Hawaiian Island chain of volcanic islands. Kauai, the oldest Hawaiian island, is 10 million years old

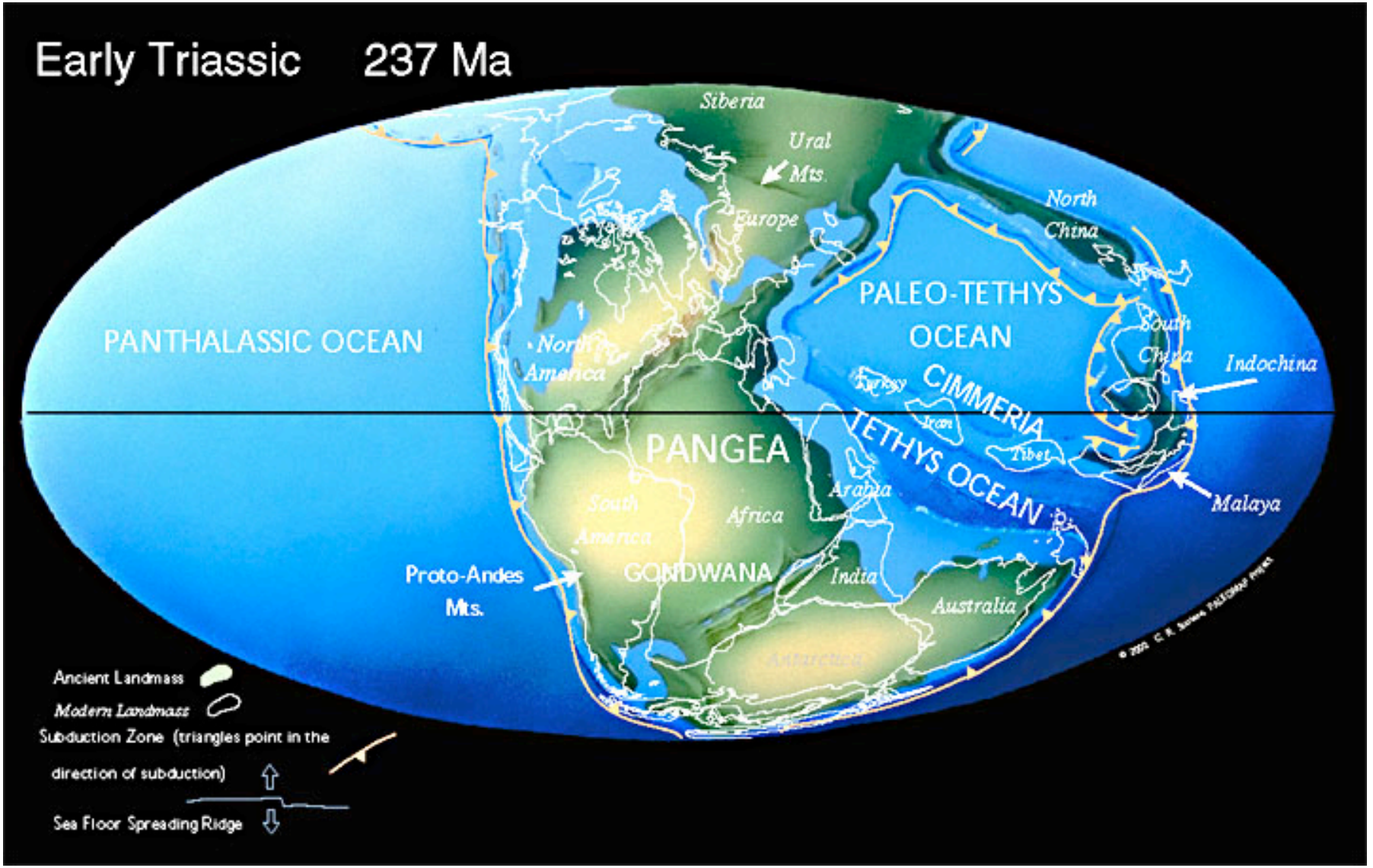
We can use the age of Kauai (10 Ma), and its distance (250 km) from the currently active island, Hawaii (0 Ma) to calculate the rate at which the Pacific plate is moving.

In geology, rates are commonly expressed in units of cm/year. Calculate the rate of motion of the Pacific plate over the past 10 Ma.

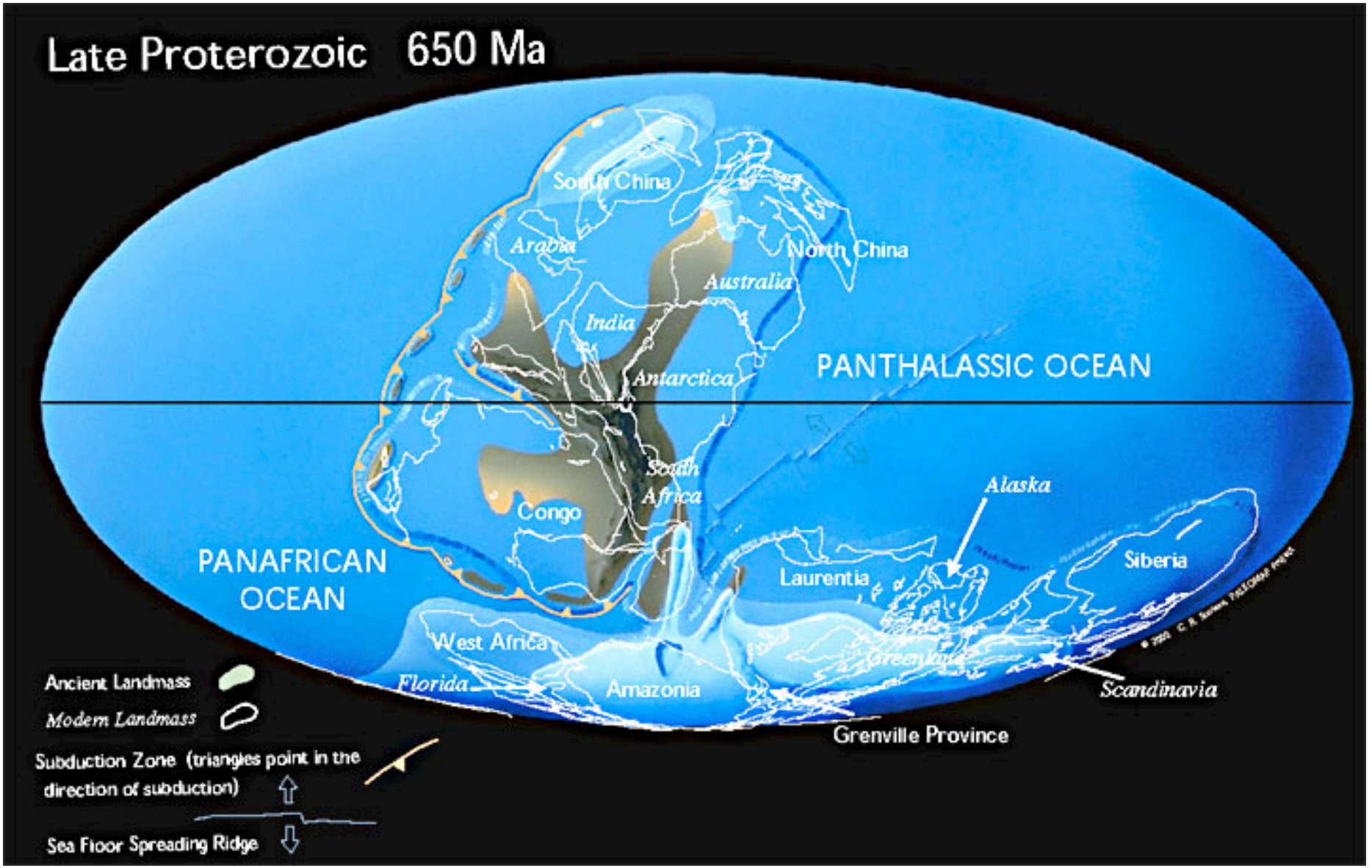
* **Ma = millions of years**

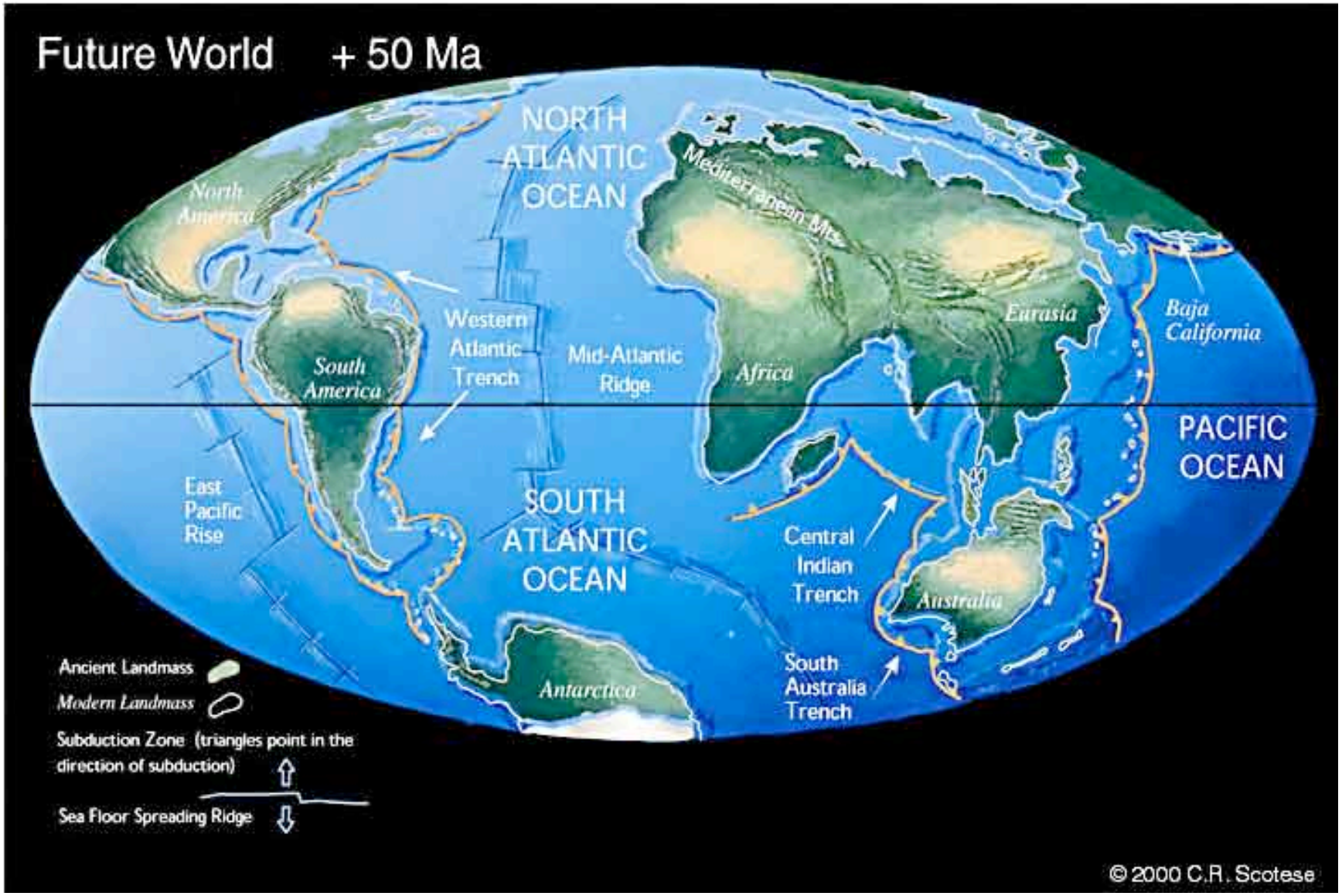


These are the present day plates….these have not been the plates throughout earth history…the Earth has been divided into these plates for only ~150 million years



"Pangea"…a "supercontinent"


Late Proterozoic 650 Ma
South China
Arabia
North China
Australia
India
Antarctica
PANTHALASSIC OCEAN
South Africa
Congo
Alaska
PANAFRICAN OCEAN
Laurentia
Siberia
West Africa
Florida
Amazonia
Scandinavia
Grenville Province
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Future World + 50 Ma
NORTH ATLANTIC OCEAN
North America
Mediterranean Mts.
Eurasia
Baja California
Western Atlantic Trench
Mid-Atlantic Ridge
South America
Africa
PACIFIC OCEAN
East Pacific Rise
SOUTH ATLANTIC OCEAN
Central Indian Trench
Australia
South Australia Trench
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge
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