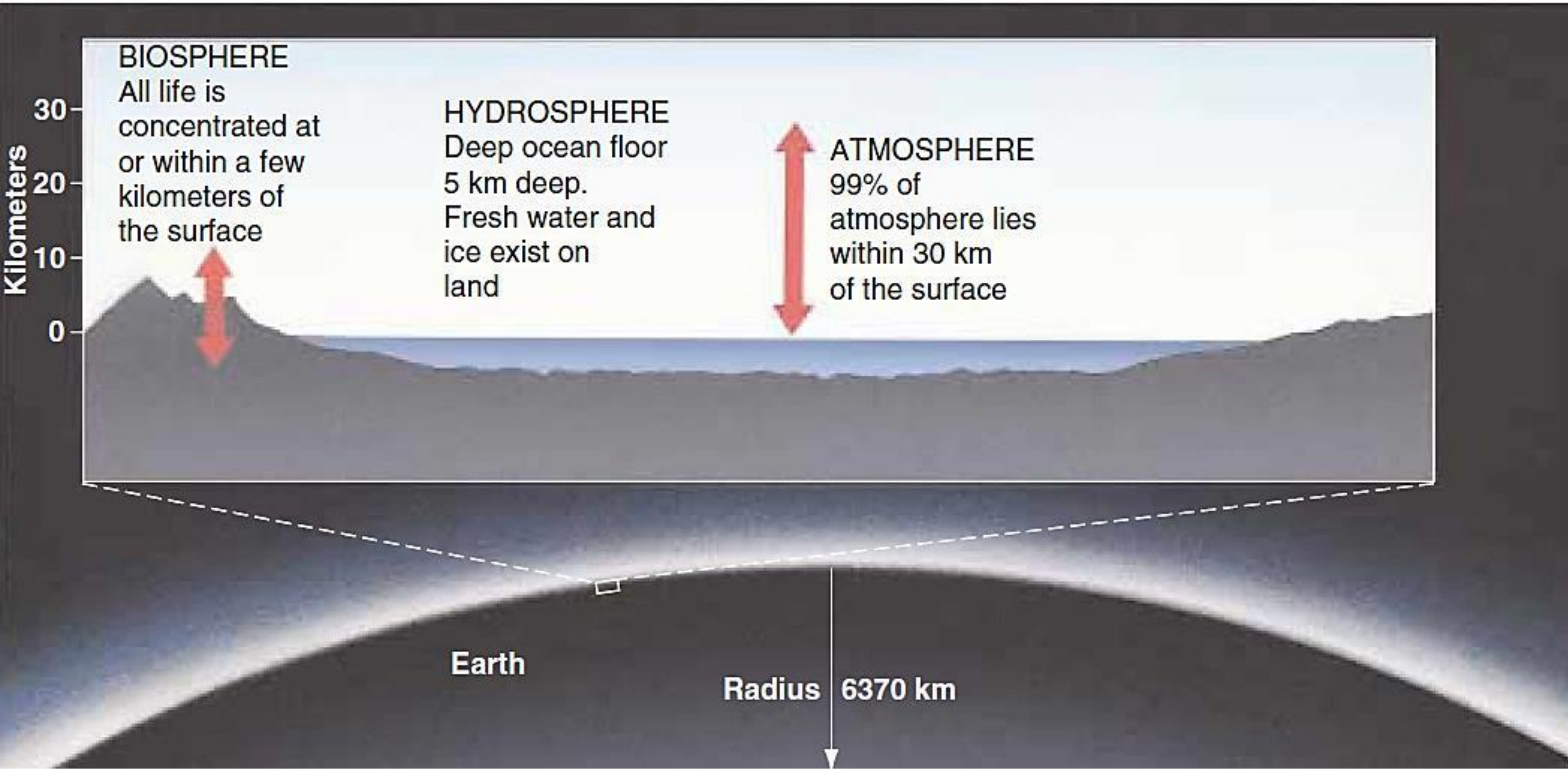
GEOLOGY FOR MINING ENGINEERS

Largely documented from the notes of Dr. Kadir Dirik

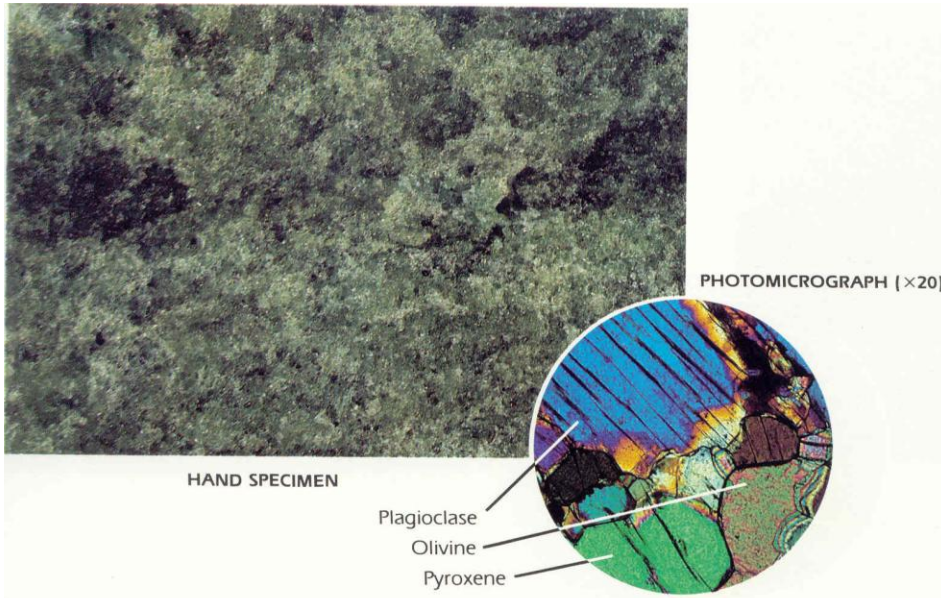
THE SCIENCE OF GEOLOGY

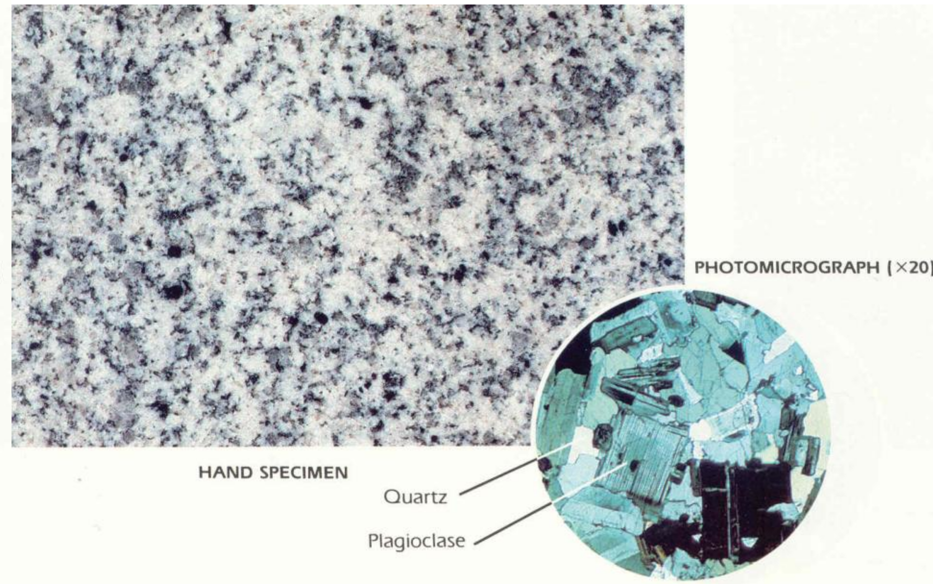
GEOLOGY is the study of the Earth, including **the materials** that it is made of, the **physical and chemical changes** that occur on its surface and in its interior, and the **history** of the planet and its **life** forms.

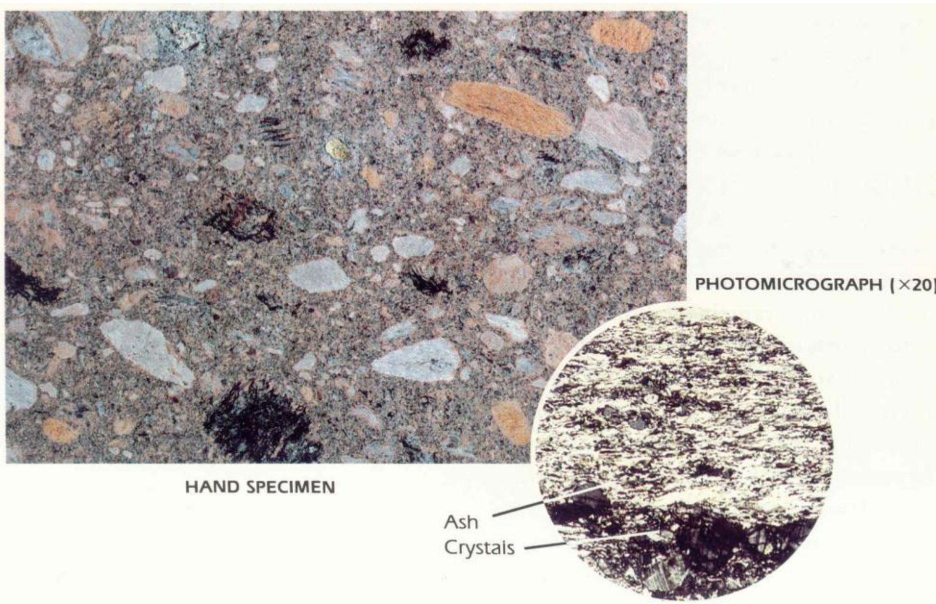


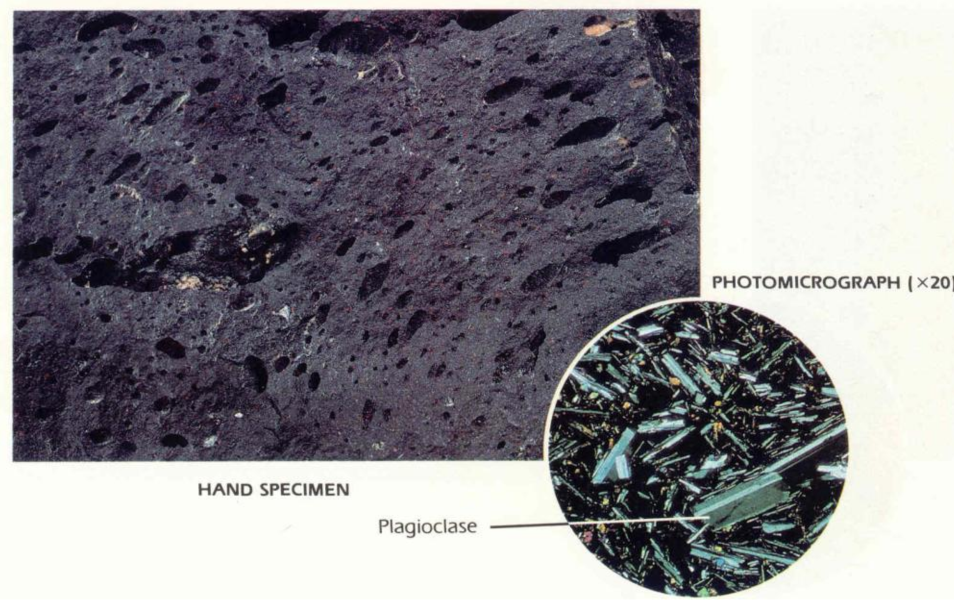
Most of the Earth is solid rock, surrounded by the hydrosphere, the biosphere, and the atmosphere.

Most of the Earth is composed of **rocks**. Rocks, in turn, are composed of **minerals**









Most of the Earth is solid rock, surrounded by the hydrosphere, the biosphere, and the atmosphere. Although more than 3500 different minerals exist, fewer than a **dozen** are common. We study the origins, properties and compositions of both rocks and minerals.

There are **two processes** acting on the earth, namely internal and external processes.

INTERNAL PROCESSES

Processes that originate deep in the Earth's interior are called **internal processes**. These are the ***driving forces*** that raise mountains, cause earthquakes and produce volcanic eruptions.

SURFACE PROCESSES

Surface processes are all of those processes that sculpt the Earth's surface. Most surface processes are driven by water, although wind, ice, and gravity are also significant.

UNIFORMITARIANISM AND CATASTROPHISM

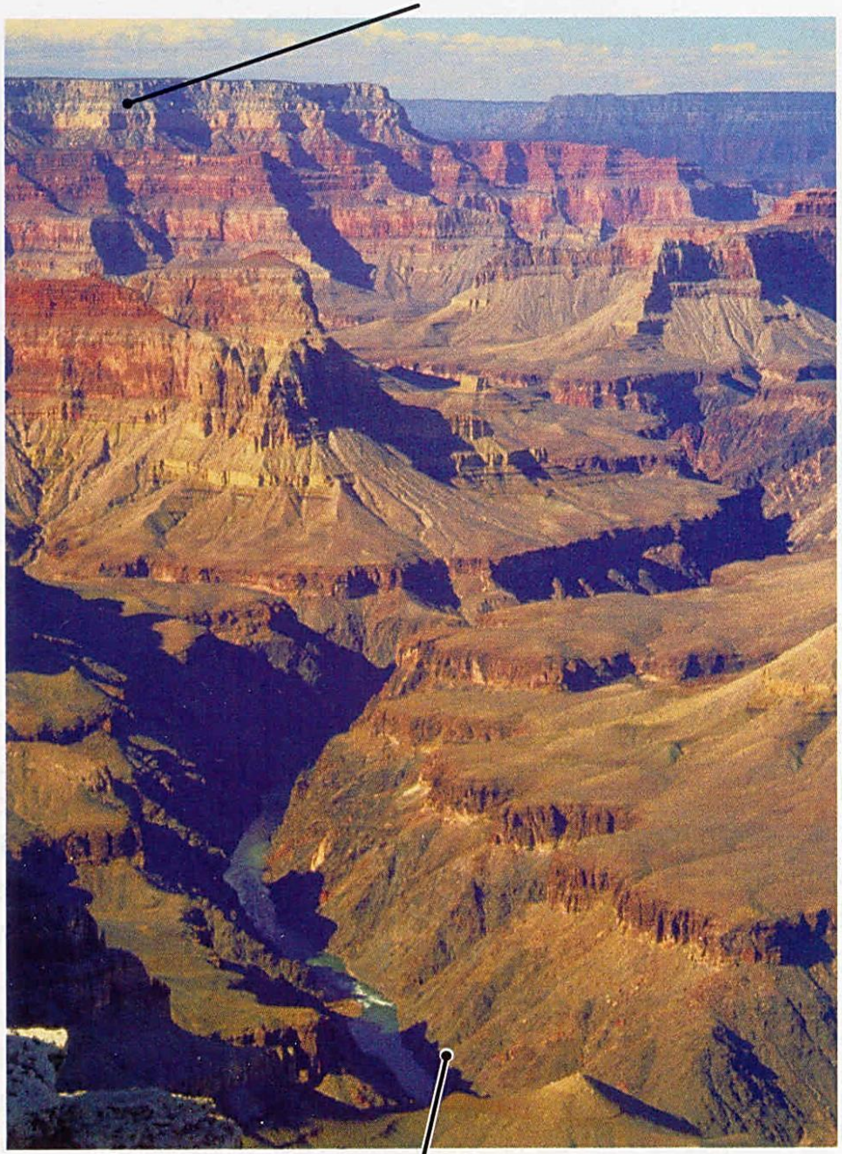
James Hutton was a gentleman farmer who lived in Scotland in the late 1700s. Although trained as a physician, he never practiced medicine and, instead, turned to geology. Hutton observed that a certain type of rock, called sandstone, is composed of sand grains cemented together. He also noted that rocks slowly decompose into sand, and that streams carry sand into the lowlands. He inferred that sandstone is composed of sand grains that originated by the erosion of ancient cliffs and mountains.

Hutton's conclusions led him to formulate a principle now known as **uniformitarianism**. The principle states that **geologic change occurs over long periods of time, by a sequence of almost imperceptible events.** Hutton surmised that **geologic processes operating today also operated in the past**. Thus, scientists can explain events that occurred in the past by observing changes occurring today. Sometimes this idea is summarized in the statement **"The present is the key to the past."**

(a)

Sue Monroe

2 Over millions of years, layers of sediments built up over that rock. The most recent layer—the top—is about 250 million years old.

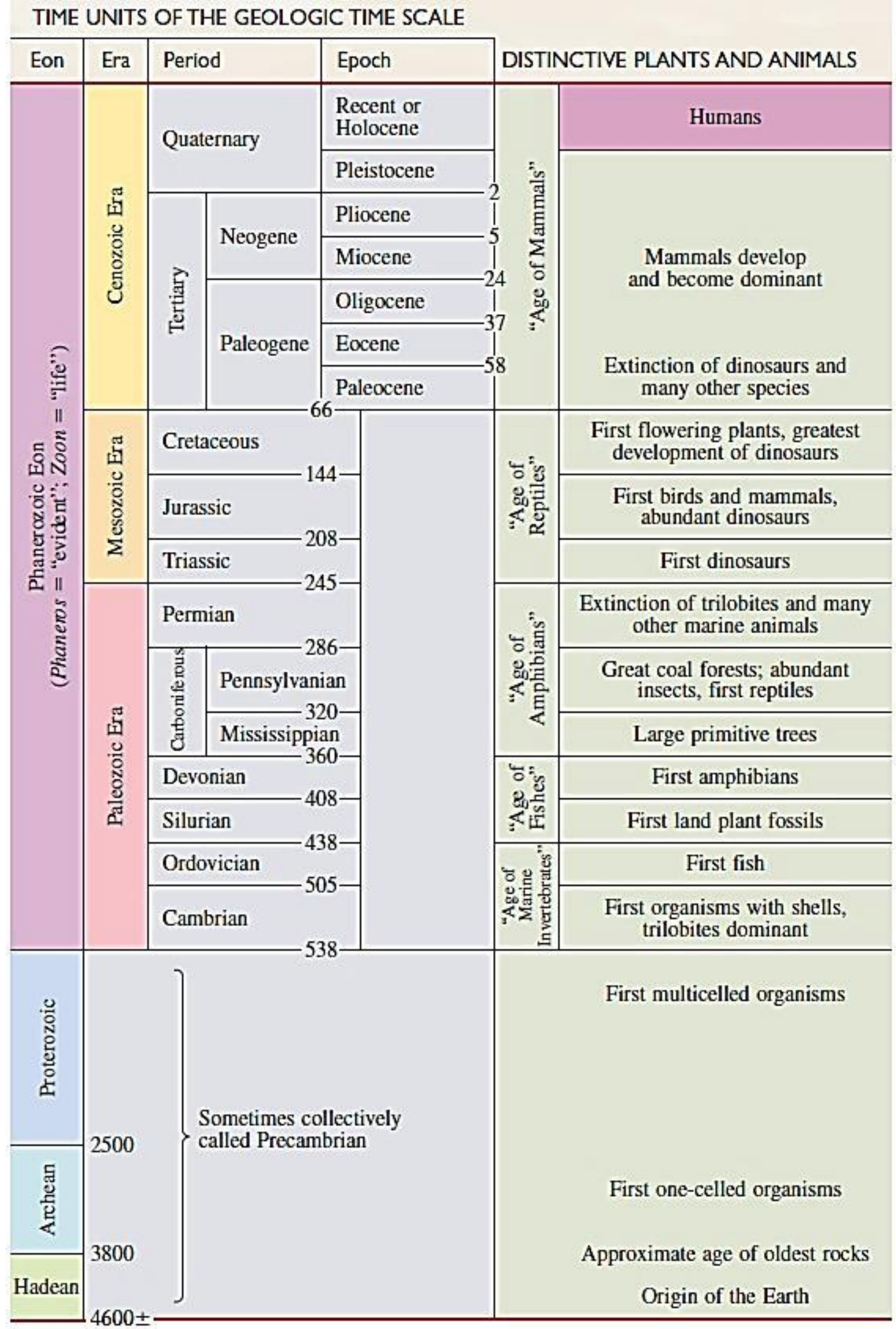


1 The rocks at the bottom of the Grand Canyon are 1.7–2.0 billion years old.

About 50,000 years ago, the explosive impact of a meteorite (perhaps weighing 300,000 tons) created this 1.2-km-wide crater in just a few seconds.

THE GEOLOGIC TIME SCALE

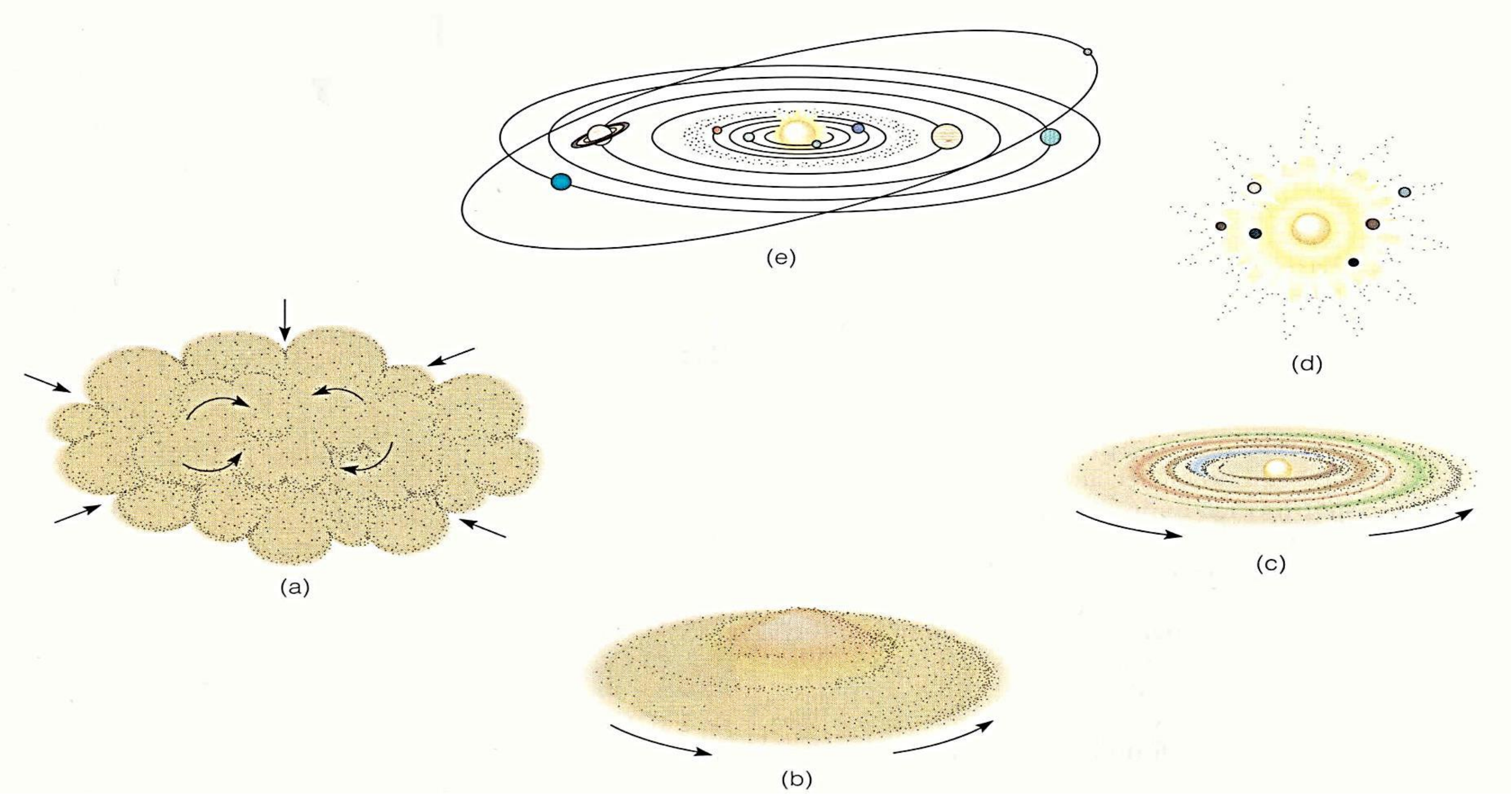
Geologists have divided Earth history into units displayed in the **geologic time scale**. The units are called eons, eras, periods, and epochs and are identified primarily by the types of life that existed at the various times.



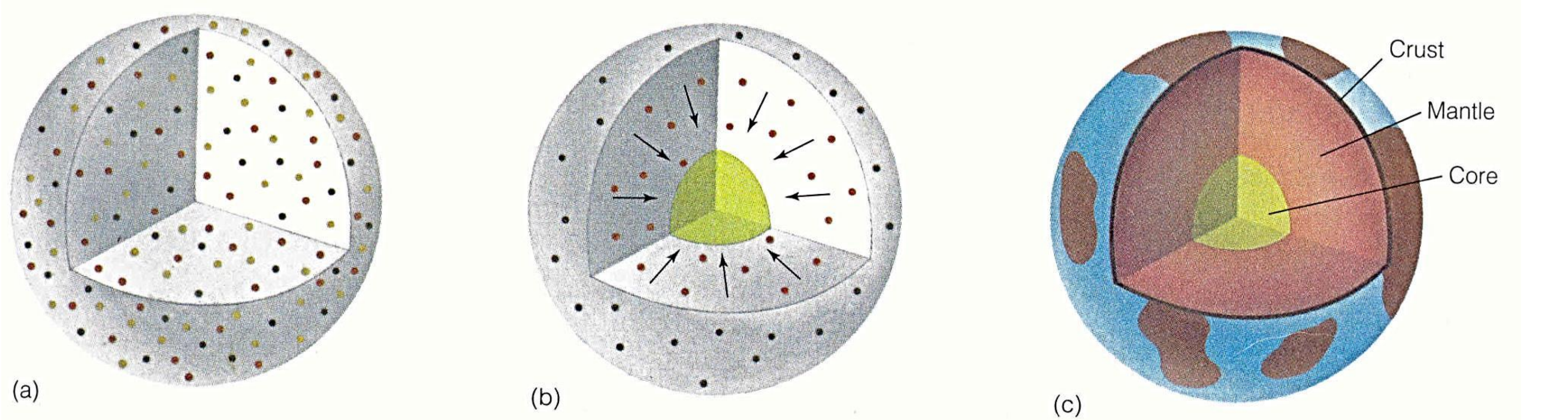
TIME UNITS OF THE GEOLOGIC TIME SCALE

Eon	Era	Period		Epoch			DISTINCTIVE PLANTS AND ANIMALS
Phanerozoic Eon (*Phaneros* = "evident"; *Zoon* = "life")	Cenozoic Era	Quaternary		Recent or Holocene		"Age of Mammals"	Humans
				Pleistocene	2		Mammals develop and become dominant
		Tertiary	Neogene	Pliocene	5		
				Miocene	24		
			Paleogene	Oligocene	37		
				Eocene	58		
				Paleocene	66		Extinction of dinosaurs and many other species
	Mesozoic Era	Cretaceous			144	"Age of Reptiles"	First flowering plants, greatest development of dinosaurs
		Jurassic			208		First birds and mammals, abundant dinosaurs
		Triassic			245		First dinosaurs
	Paleozoic Era	Permian			286	"Age of Amphibians"	Extinction of trilobites and many other marine animals
		Carboniferous	Pennsylvanian		320		Great coal forests; abundant insects, first reptiles
			Mississippian		360		Large primitive trees
		Devonian			408	"Age of Fishes"	First amphibians
		Silurian			438		First land plant fossils
		Ordovician			505	"Age of Marine Invertebrates"	First fish
		Cambrian			538		First organisms with shells, trilobites dominant
Proterozoic	2500	Sometimes collectively called Precambrian					First multicelled organisms
Archean	3800						First one-celled organisms
							Approximate age of oldest rocks
Hadean	4600±						Origin of the Earth

The Origin of the Solar System and the Differentiation of the Early Earth



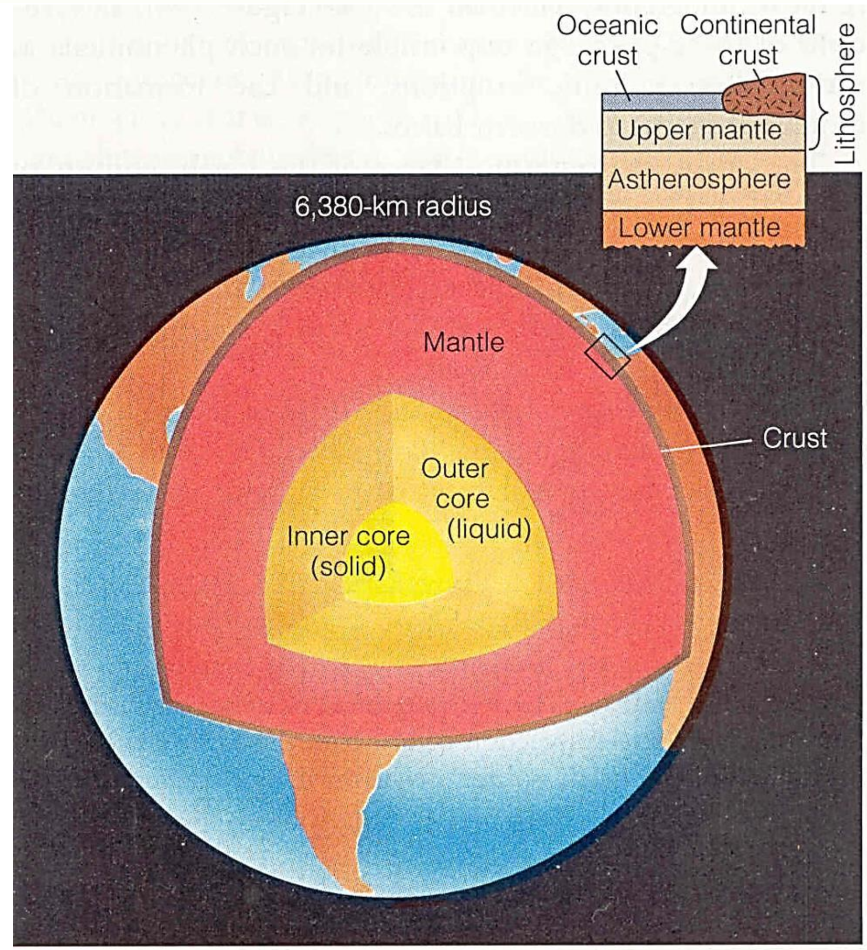
The currently accepted theory for the origin of our solar system involves: (a) **a huge nebula** condensing under its own ***gravitational attraction***, then (b) contracting, rotating, and (c) flattening into a disk, with the Sun forming in the center and eddies gathering up material to form planets. As the sun contracted and began to visibly shine, (d) intense solar radiation blew away unaccreted gas and dust until finally, (e) the Sun began burning hydrogen and the planets completed their formation.

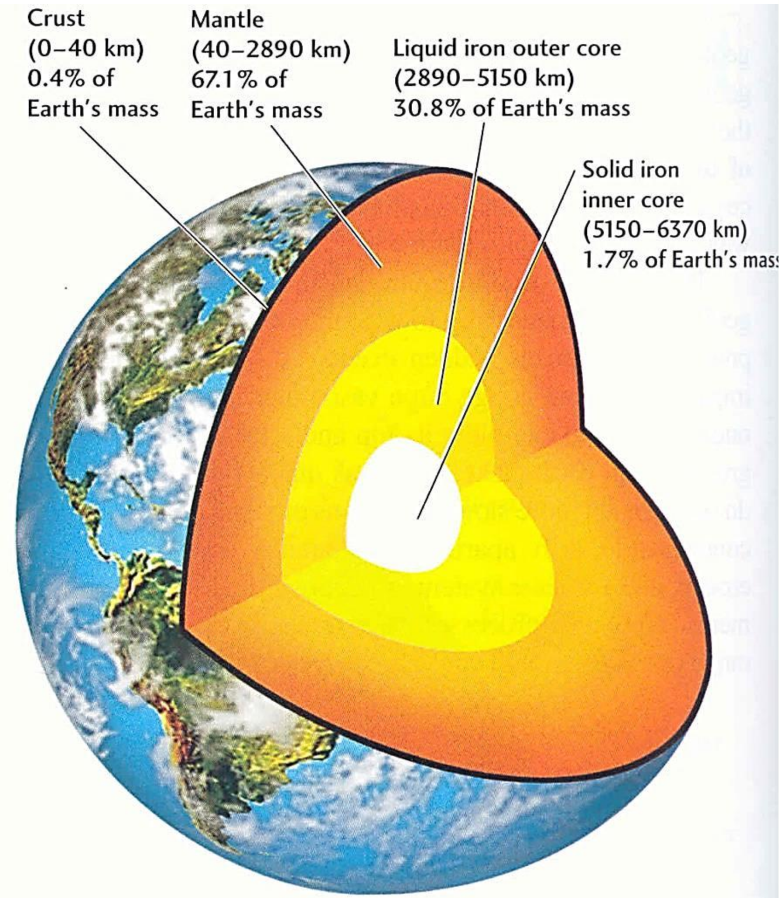


(a) The early Earth was probably of uniform composition and density throughout,

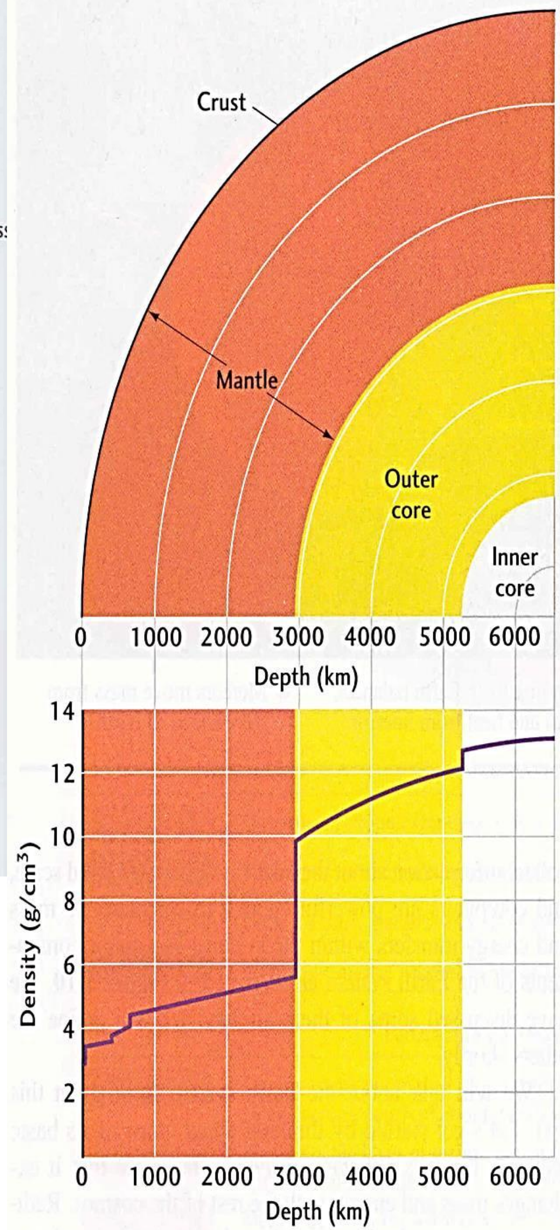
(b) Heating of the early Earth reached the melting point of iron and nickel, which, being denser than silicate minerals, settled to the Earh's center. At the same time, the lighter silicates flowed upward to form the mantle and the crust.

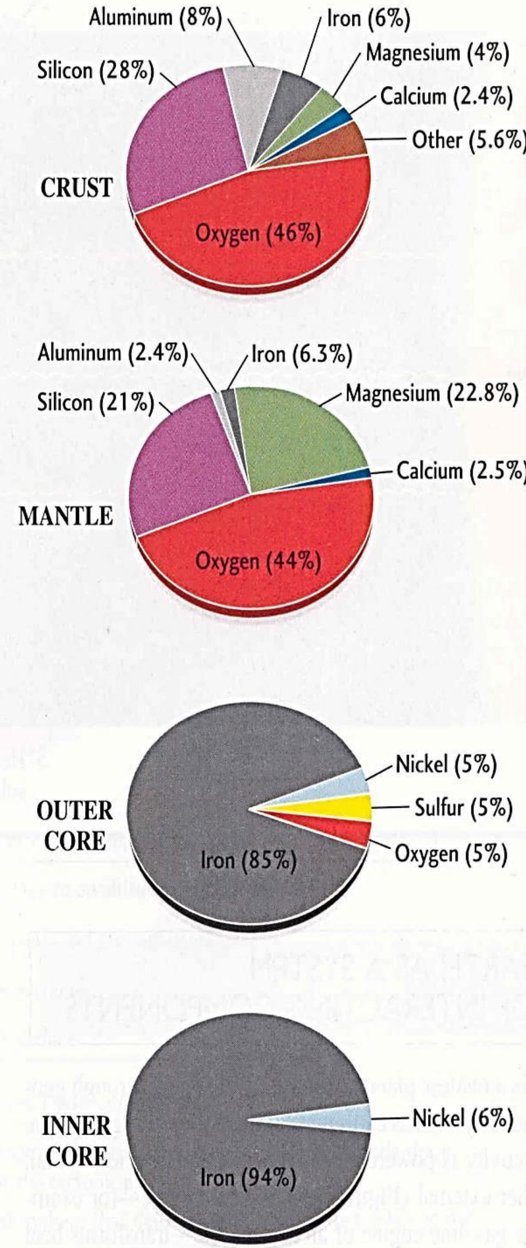
(c) In this way, a differentiated Earth formed, consisting of a dense iron-nickel core, an iron-rich silicate mantle, and a silicate crust with continents and ocean basin



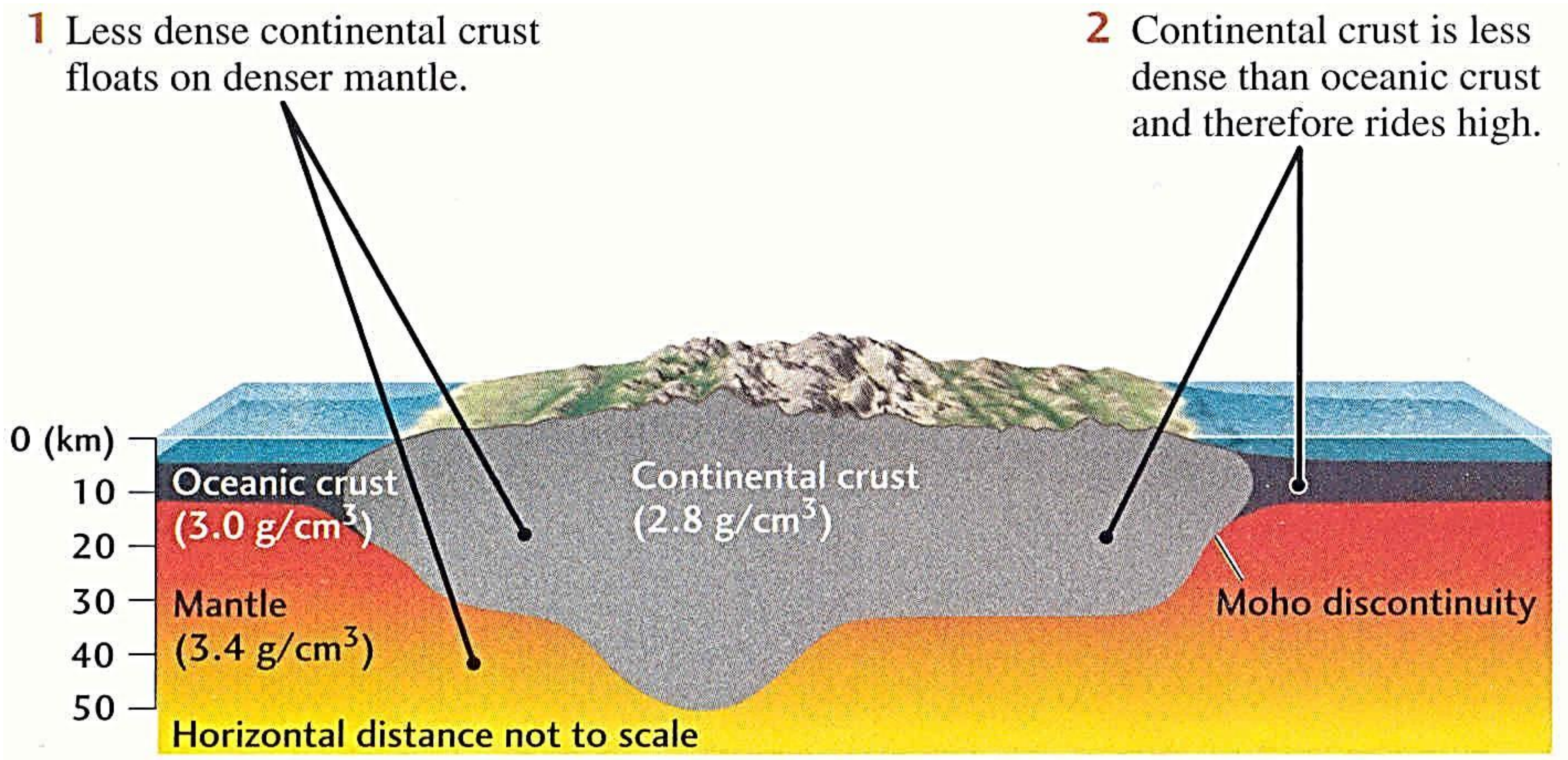


A schematic view of the interior of the Earth

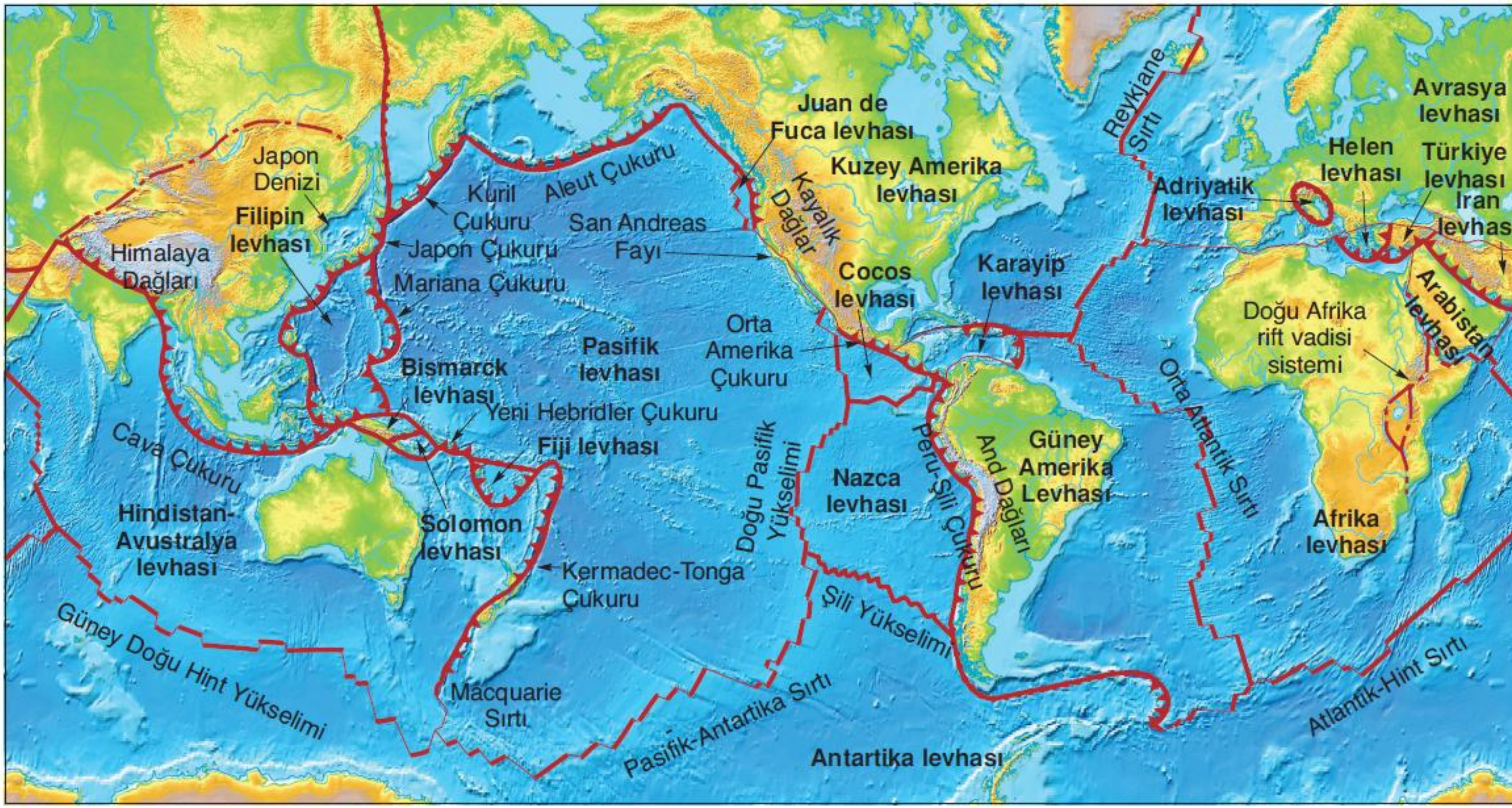




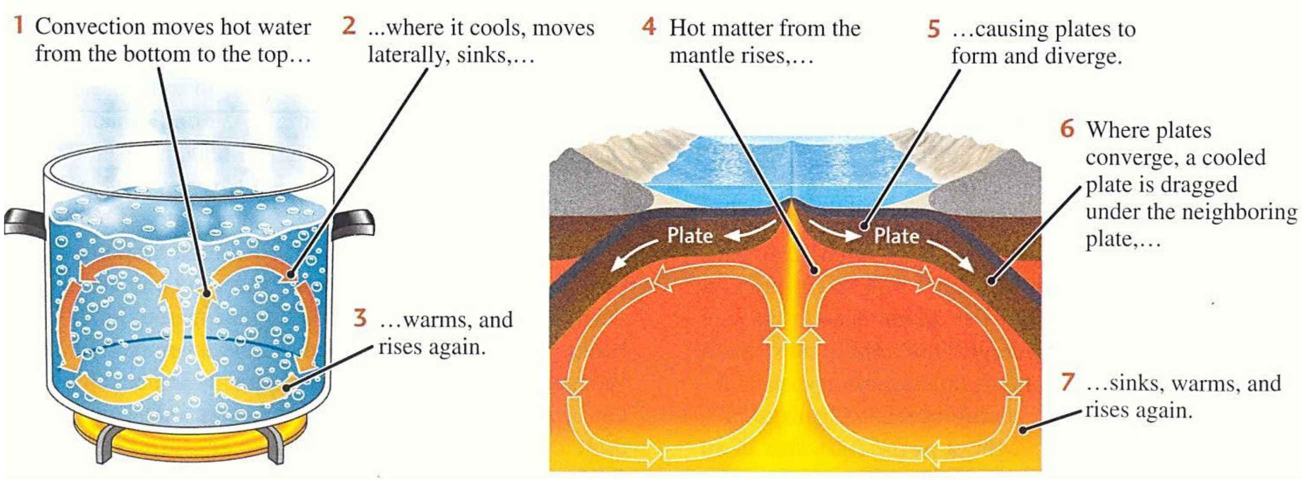
Jumps in density between Earth's major layers caused by changes in their chemical composition



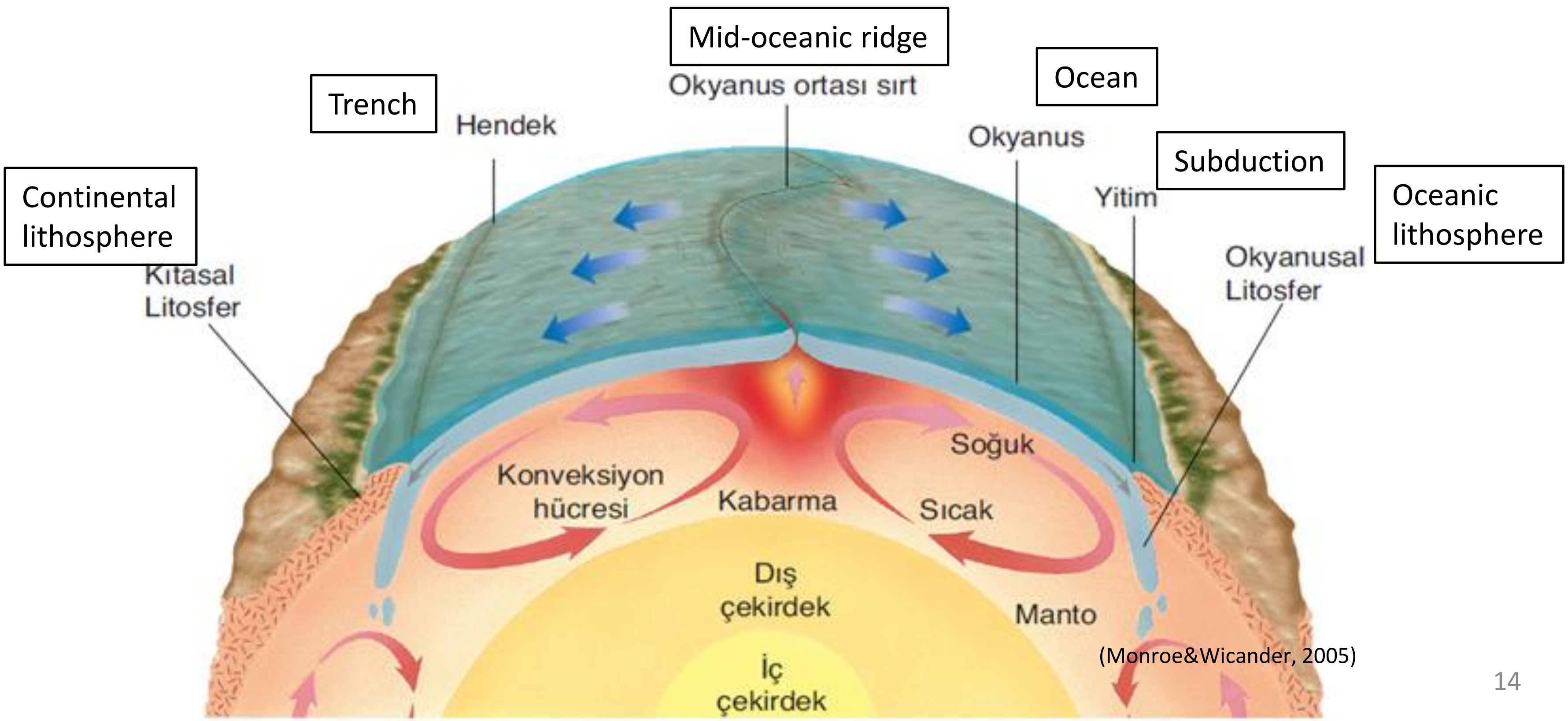
Continents float high because they are made of rocks with lower densities than rocks of the mantle or oceanic crust



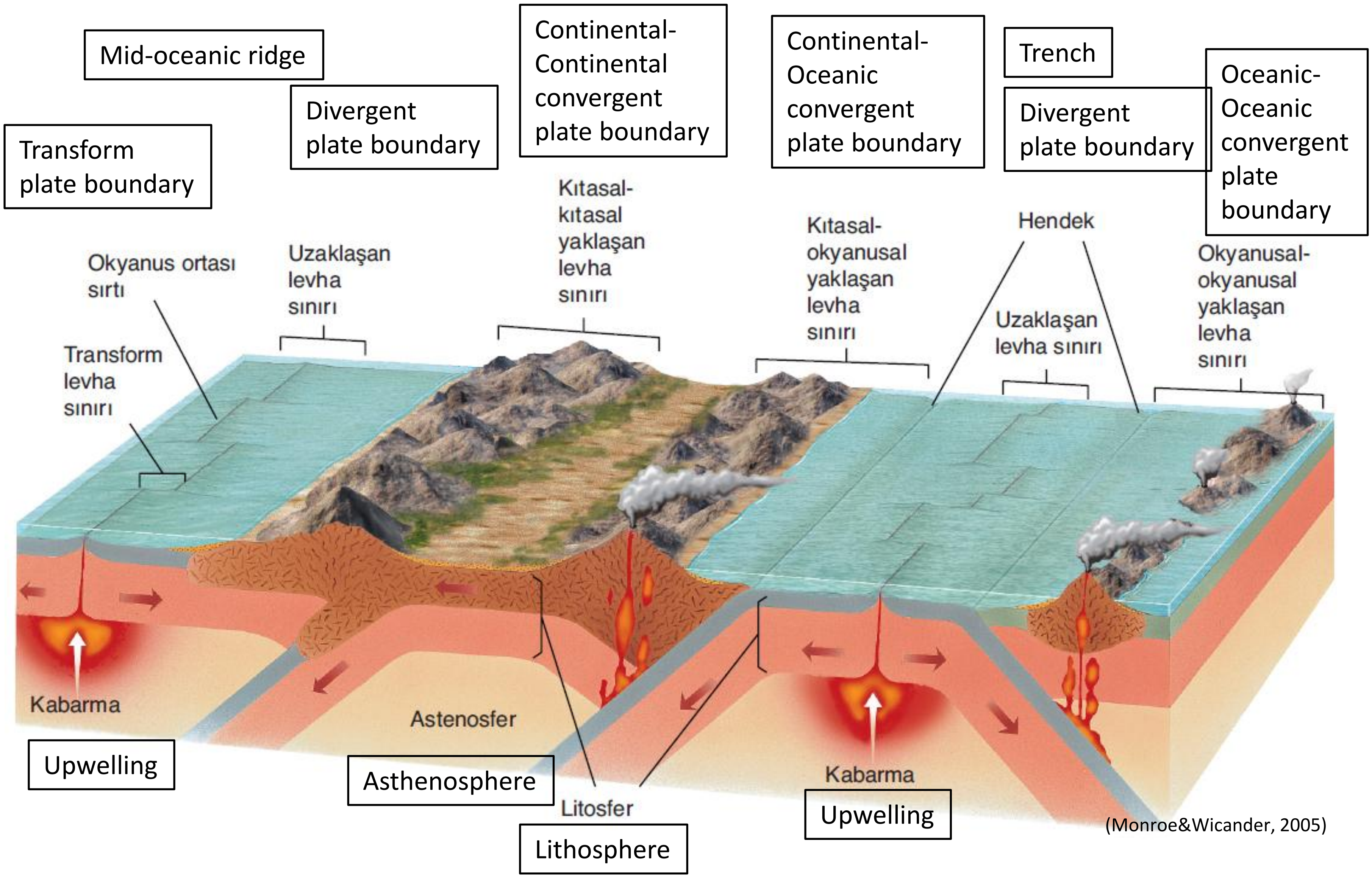
Sırt ekseni uzaklaşan sınır	Transform	Yitim kuşağı yaklaşan sınır	Kıta içlerindeki genişleme kuşakları	Belirsiz levha sınırı
Axial ridge Divergent boundary	Transform	Subduction zone Convergent boundary	Extensional zone in the continents	Uncertain plate boundary



Convection carries heat upward by the motion of matter



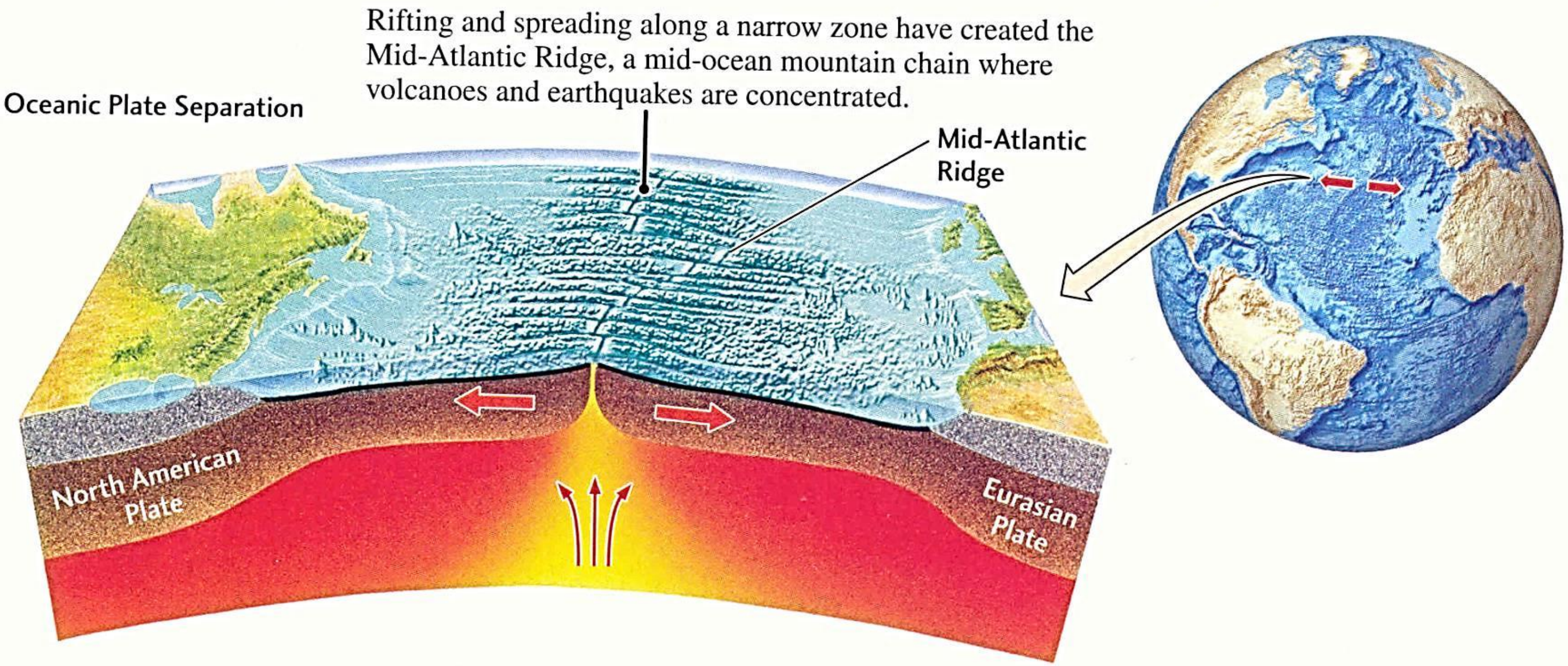
(Monroe&Wicander, 2005)



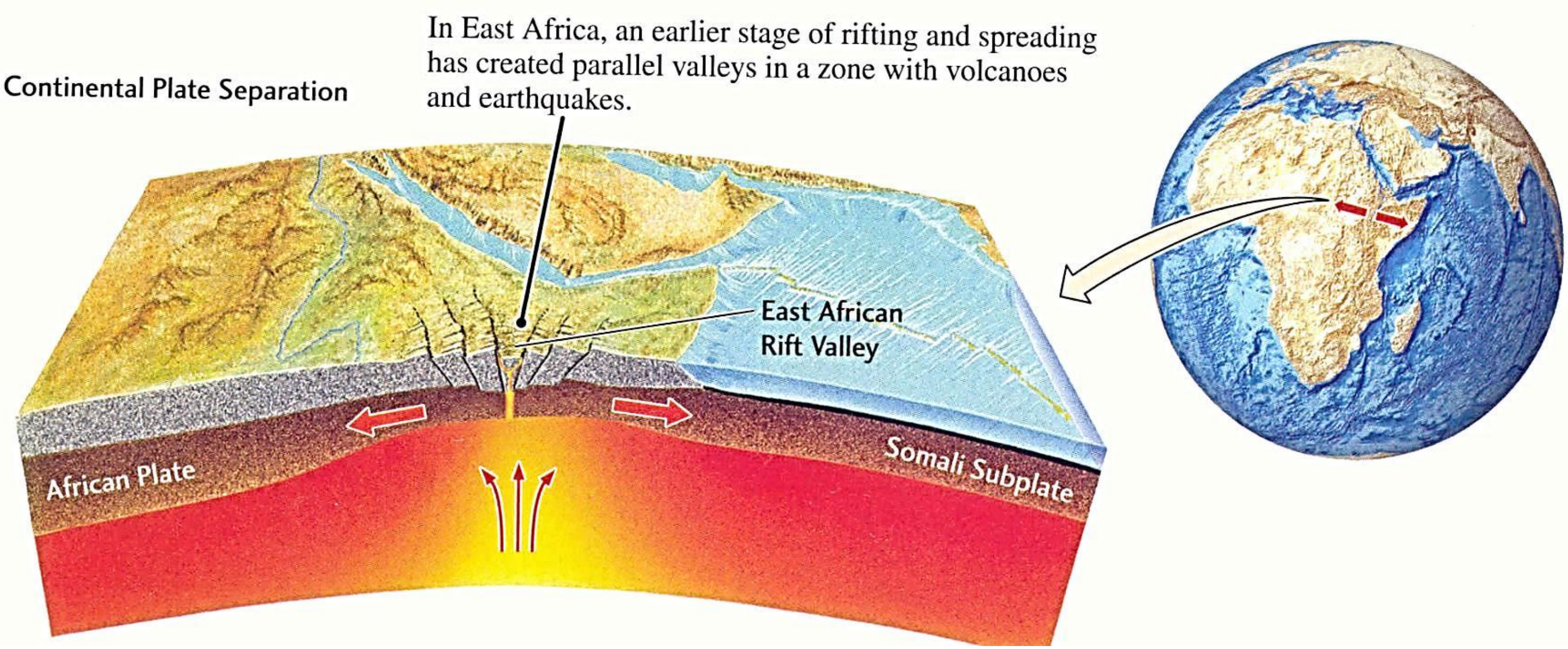
An idealized cross section illustrating the relationship between lithosphere and underlying asthenosphere and the three principal types of boundaries convergent (yaklaşan), divergent (uzaklaşan) and transform (transform).

DIVERGENT BOUNDARIES

(a) Oceanic Plate Separation

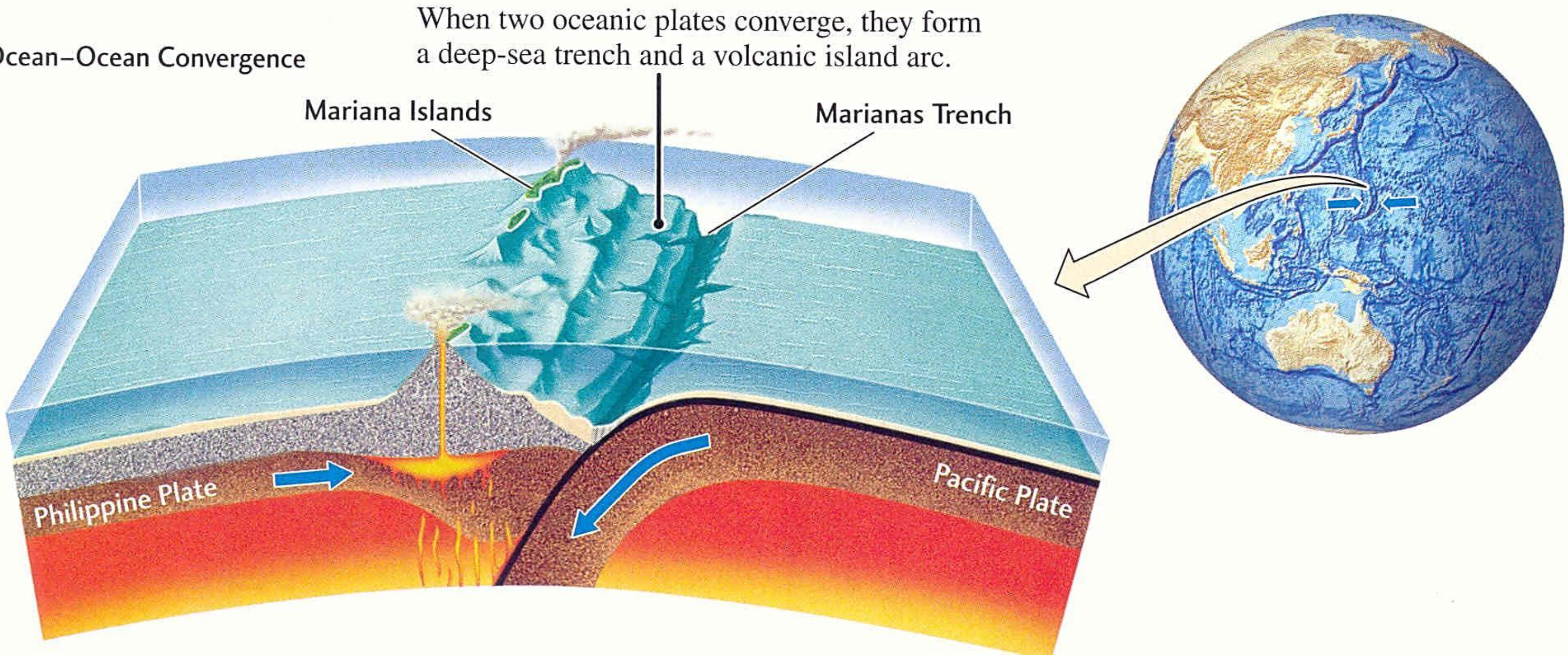


(b) Continental Plate Separation



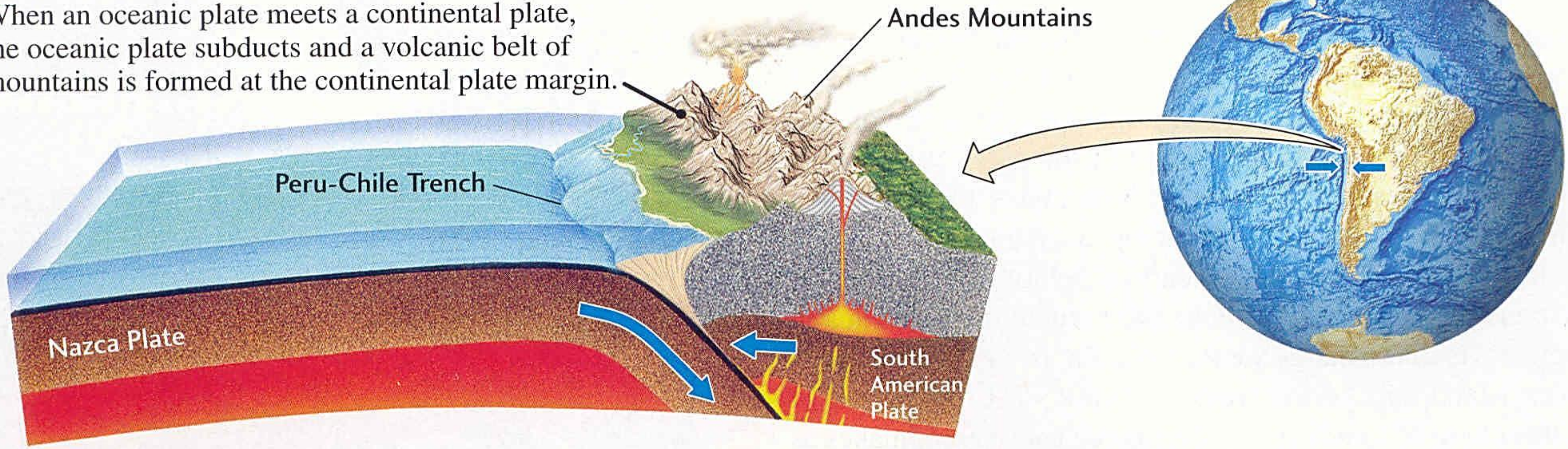
CONVERGENT BOUNDARIES

(c) Ocean–Ocean Convergence



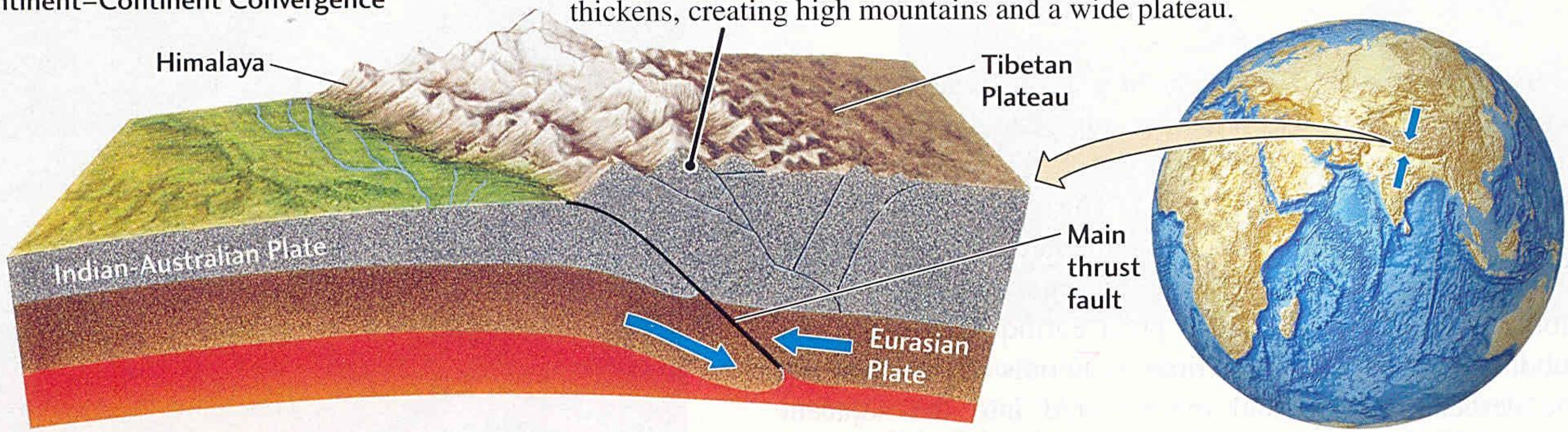
(d) Ocean–Continent Convergence

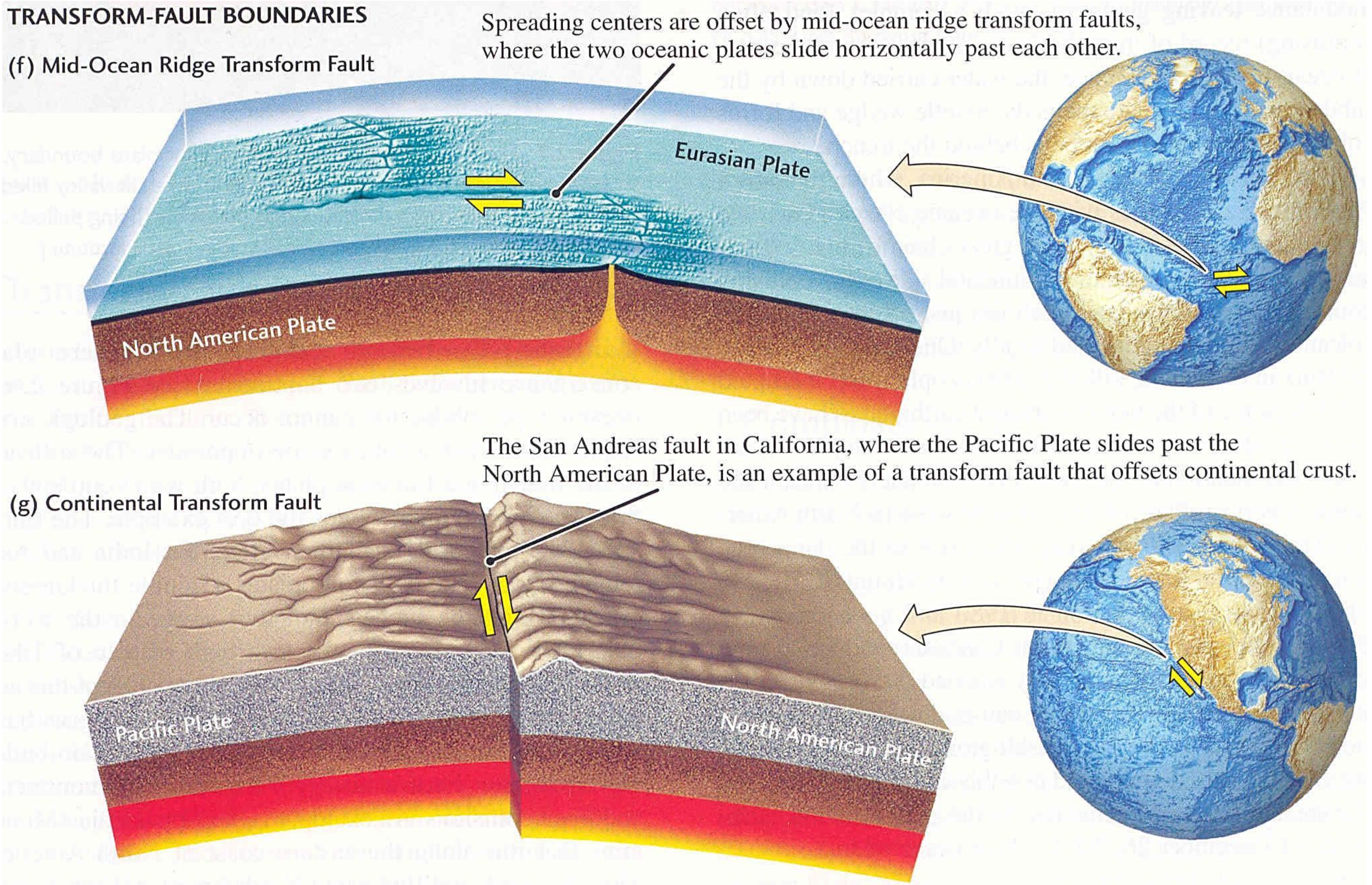
When an oceanic plate meets a continental plate, the oceanic plate subducts and a volcanic belt of mountains is formed at the continental plate margin.



(e) Continent–Continent Convergence

When two continental plates collide, the crust crumples and thickens, creating high mountains and a wide plateau.




TRANSFORM-FAULT BOUNDARIES
(f) Mid-Ocean Ridge Transform Fault
Spreading centers are offset by mid-ocean ridge transform faults, where the two oceanic plates slide horizontally past each other.
Eurasian Plate
North American Plate
The San Andreas fault in California, where the Pacific Plate slides past the North American Plate, is an example of a transform fault that offsets continental crust.
(g) Continental Transform Fault
Pacific Plate
North American Plate