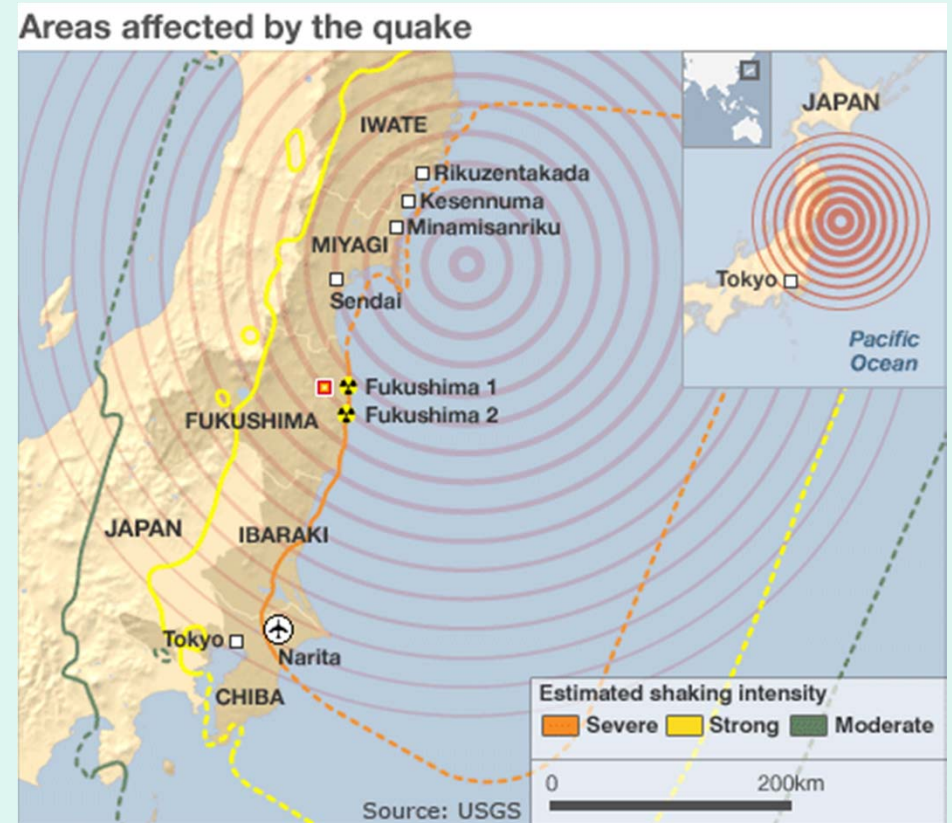
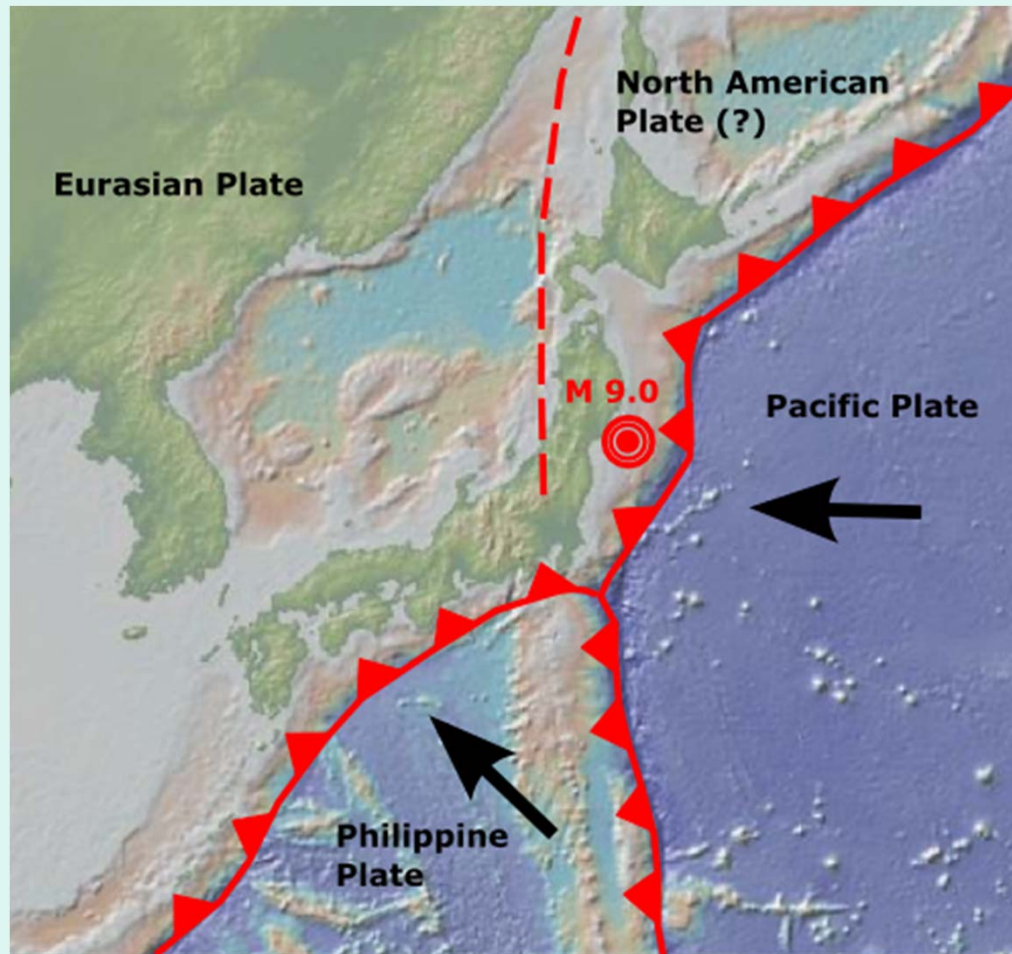


Japan Earth Quake

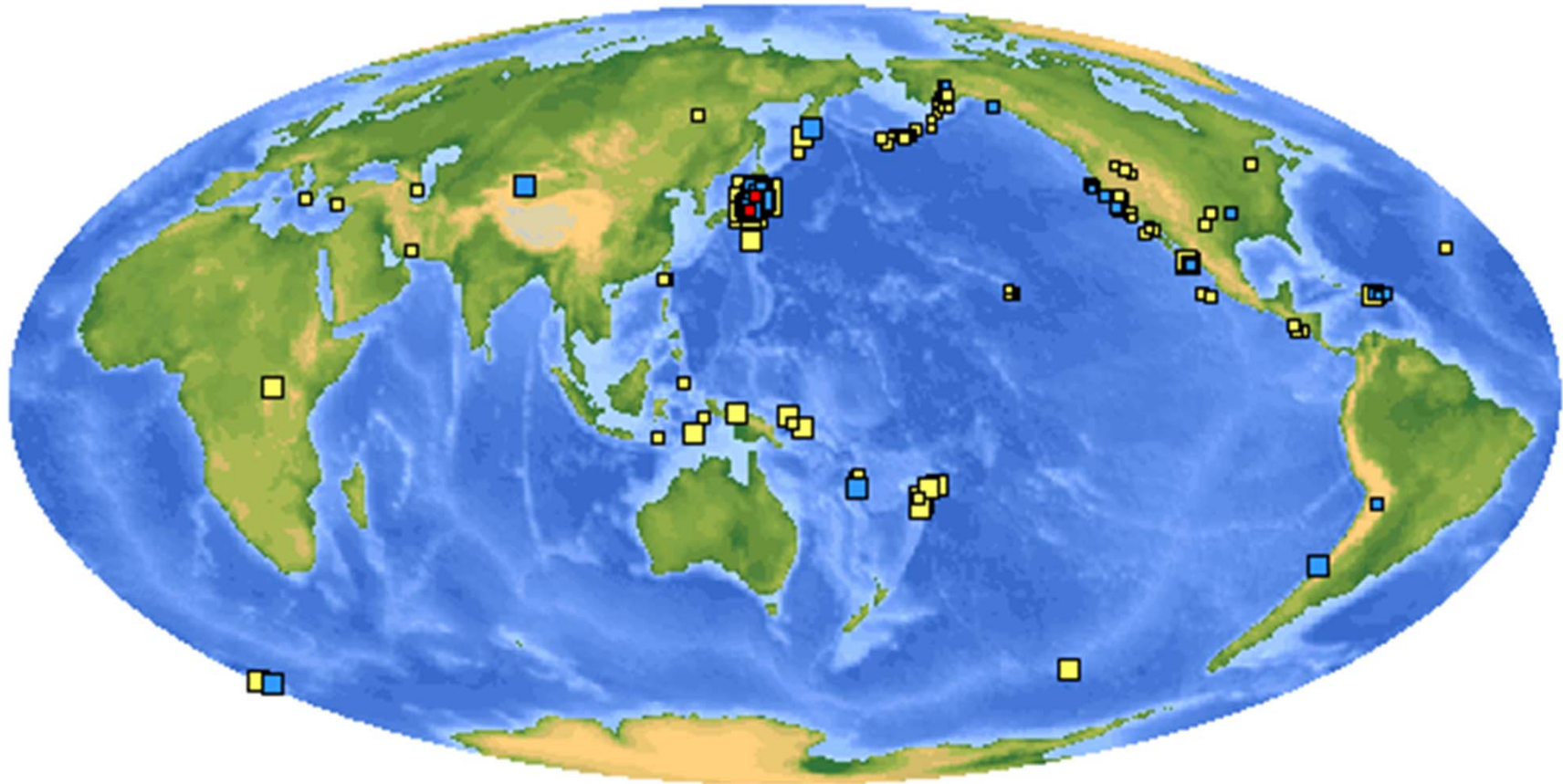
- 9.0 magnitude quake (the 4th largest since 1990)
- Caused when the Pacific tectonic plate subducted under the North American plate
- Eastern Japan shifted about 13 feet
- shifted the earth's axis by 6.5 inches, shortened day by about 1.6 microseconds
- Sank Japan downward by about two feet.



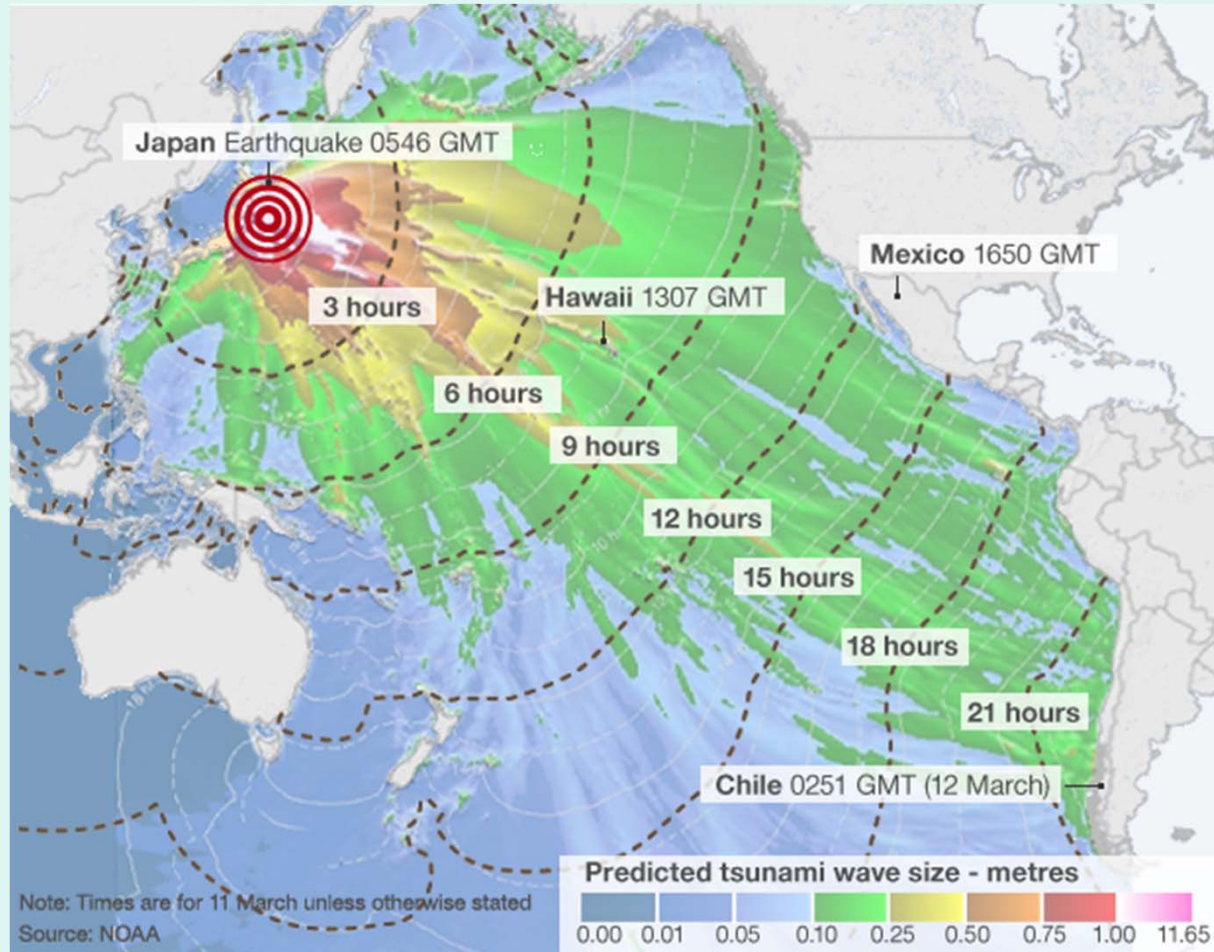


Japan Earth Quake

Thu Mar 17 21:50:10 UTC 2011 709 earthquakes on this map



Japan Earth Quake











Chapter 7
Fires Within: Igneous
Activity

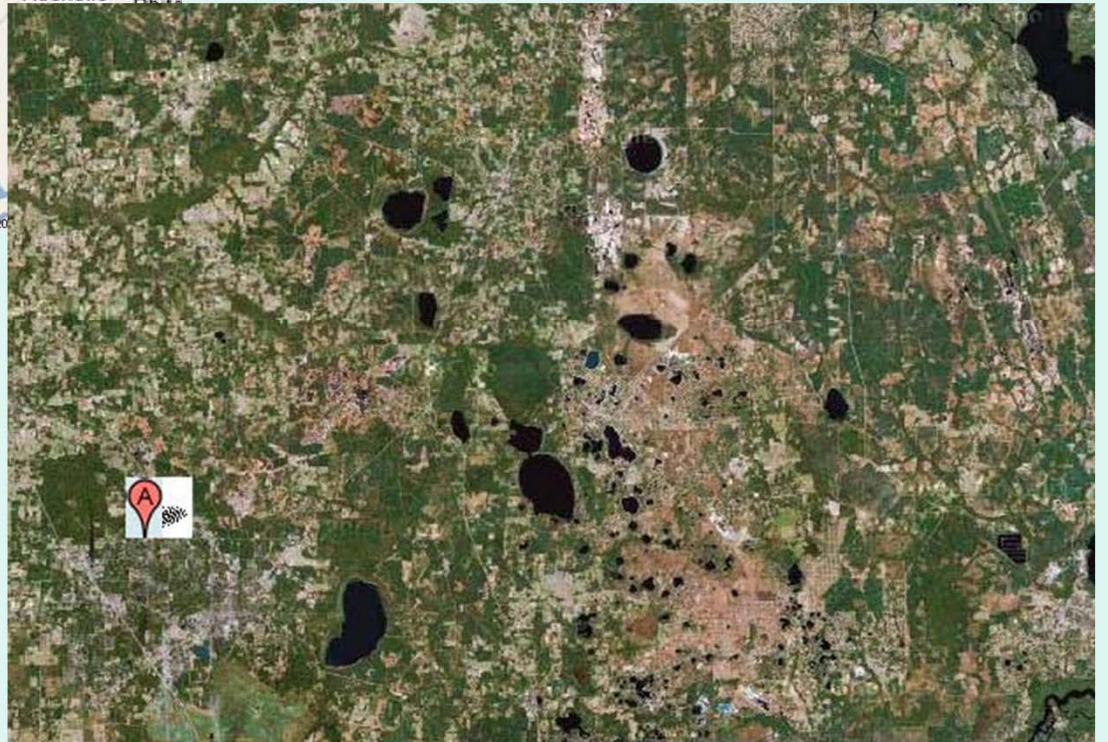
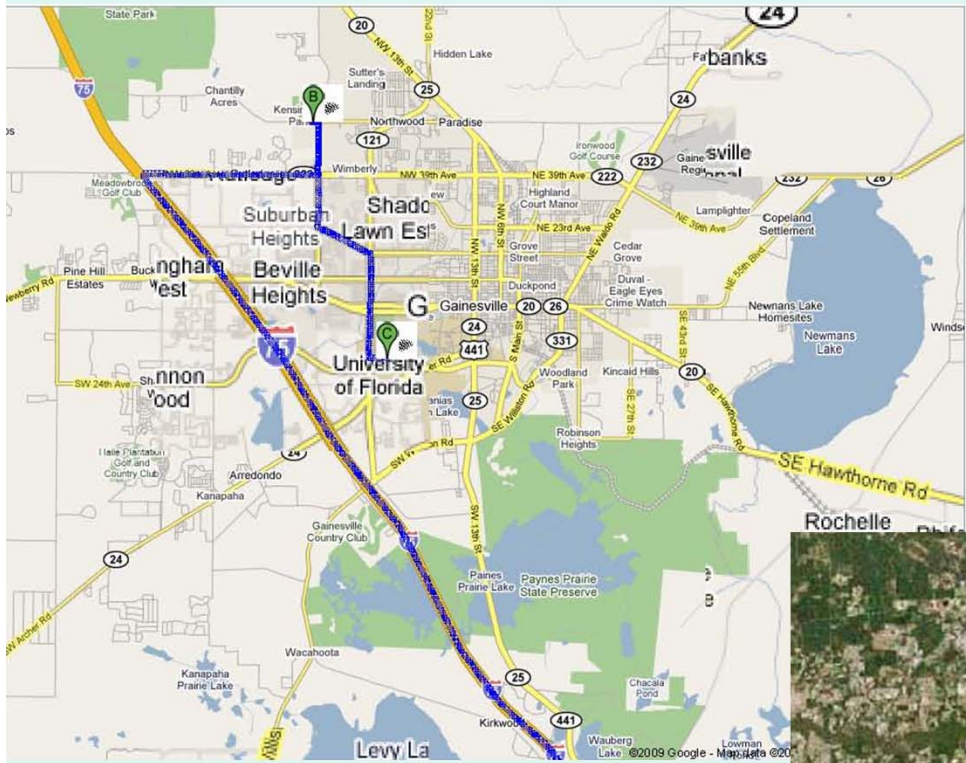
EARTH SCIENCE
GLY 1001
QUIZ Chapter 8

Name _____

Ed Meyers

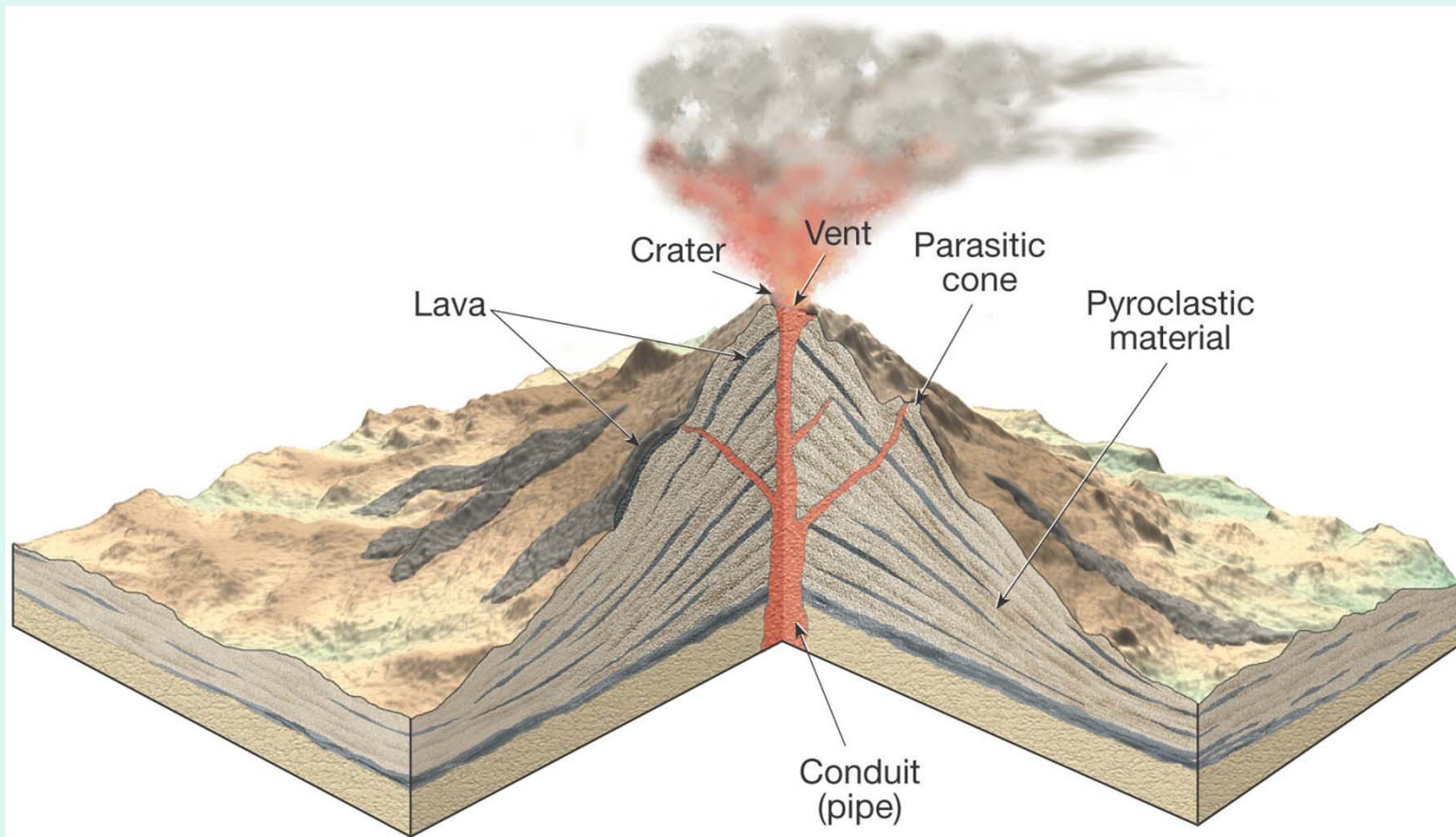
Match the following words with their definition and/or description:

1. K Angular Unconformity
2. A Disconformity
3. E Relative Dating
4. F Absolute Dating
5. H Index Fossil
6. B Correlation
7. J Nonconformity
8. G Half life
9. I Fossil Succession
10. C Original horizontality



Volcanic Features

Crater and Vent



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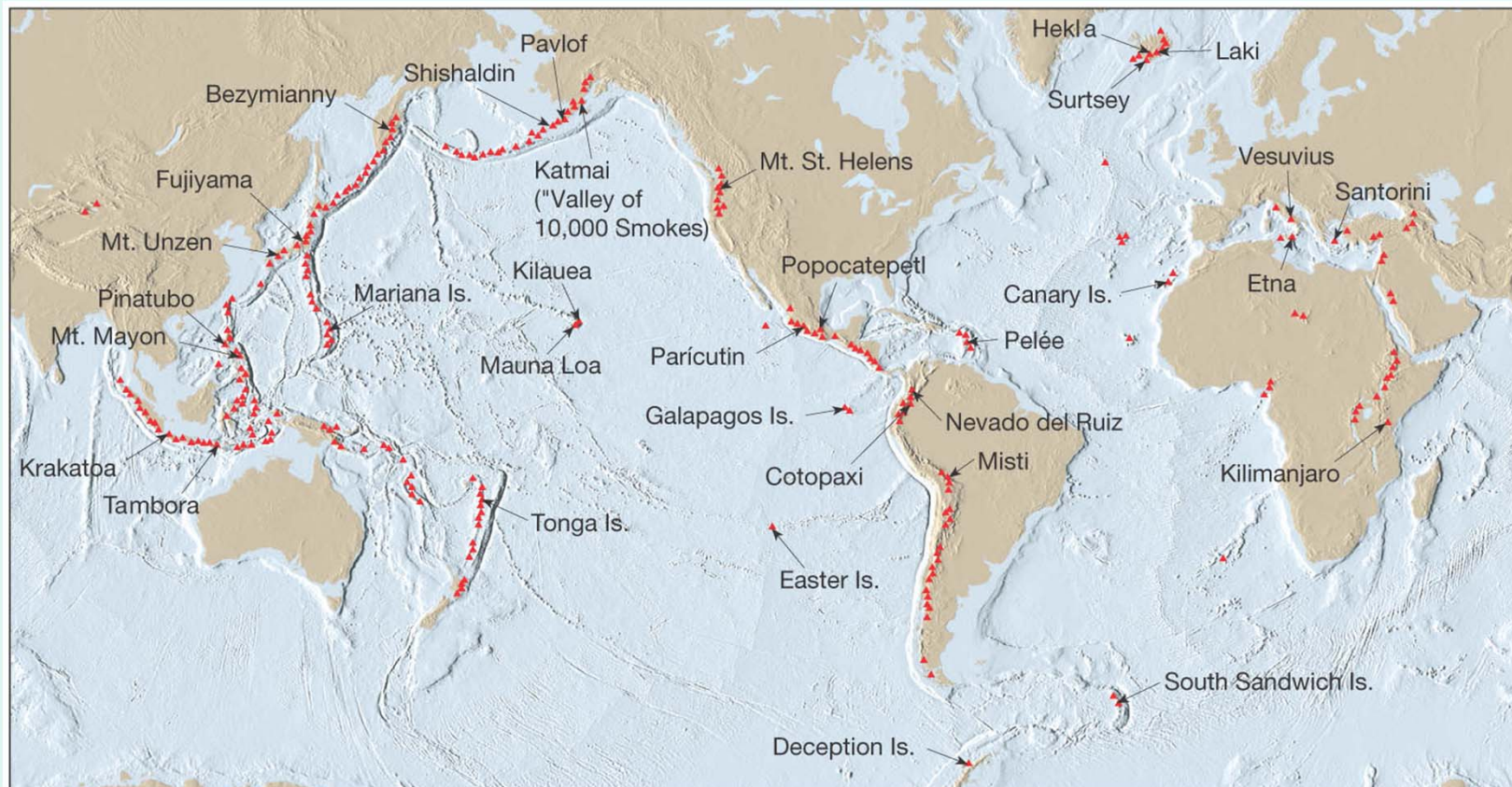


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Plate Tectonics and Volcanoes

The type of magma and volcano depend on
1) Tectonic Settings



Types of Volcanoes

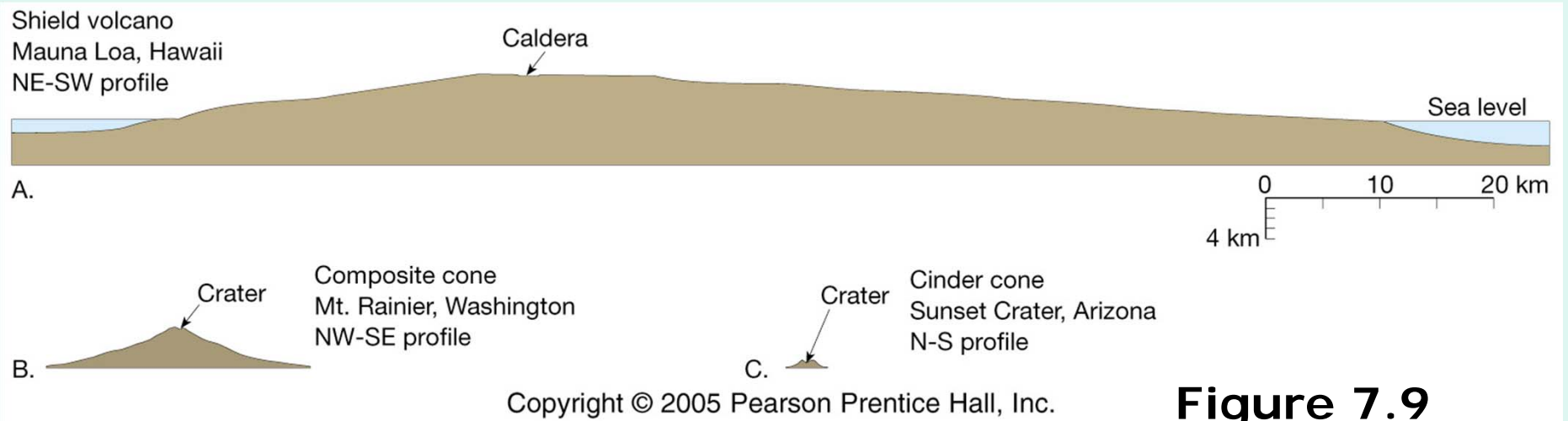
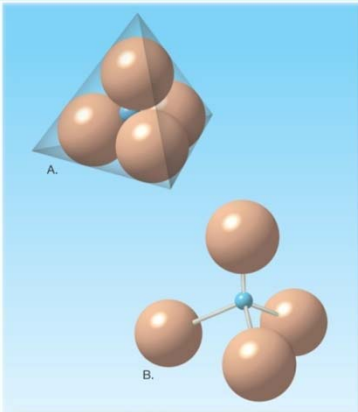


Figure 7.9

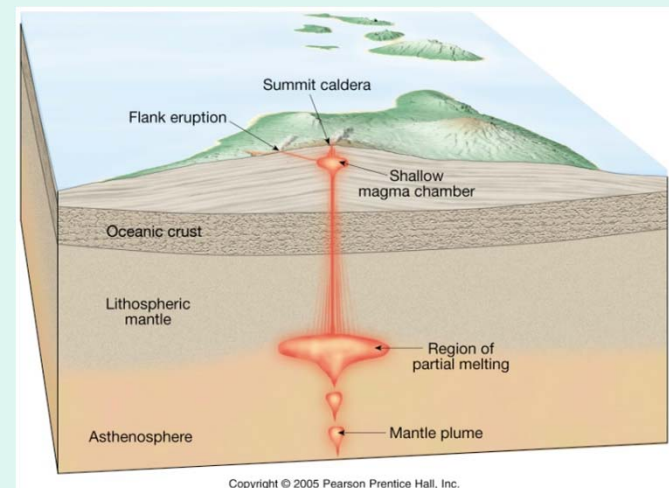
The Nature of Volcanic Eruptions

- **Viscosity** is a measure of a material's resistance to flow
- **Factors affecting viscosity**
 - **Temperature**—Hotter magmas are less viscous
 - **Composition**—Silica (SiO_2) content
 - Higher silica content = higher viscosity
 - Lower silica content = lower viscosity

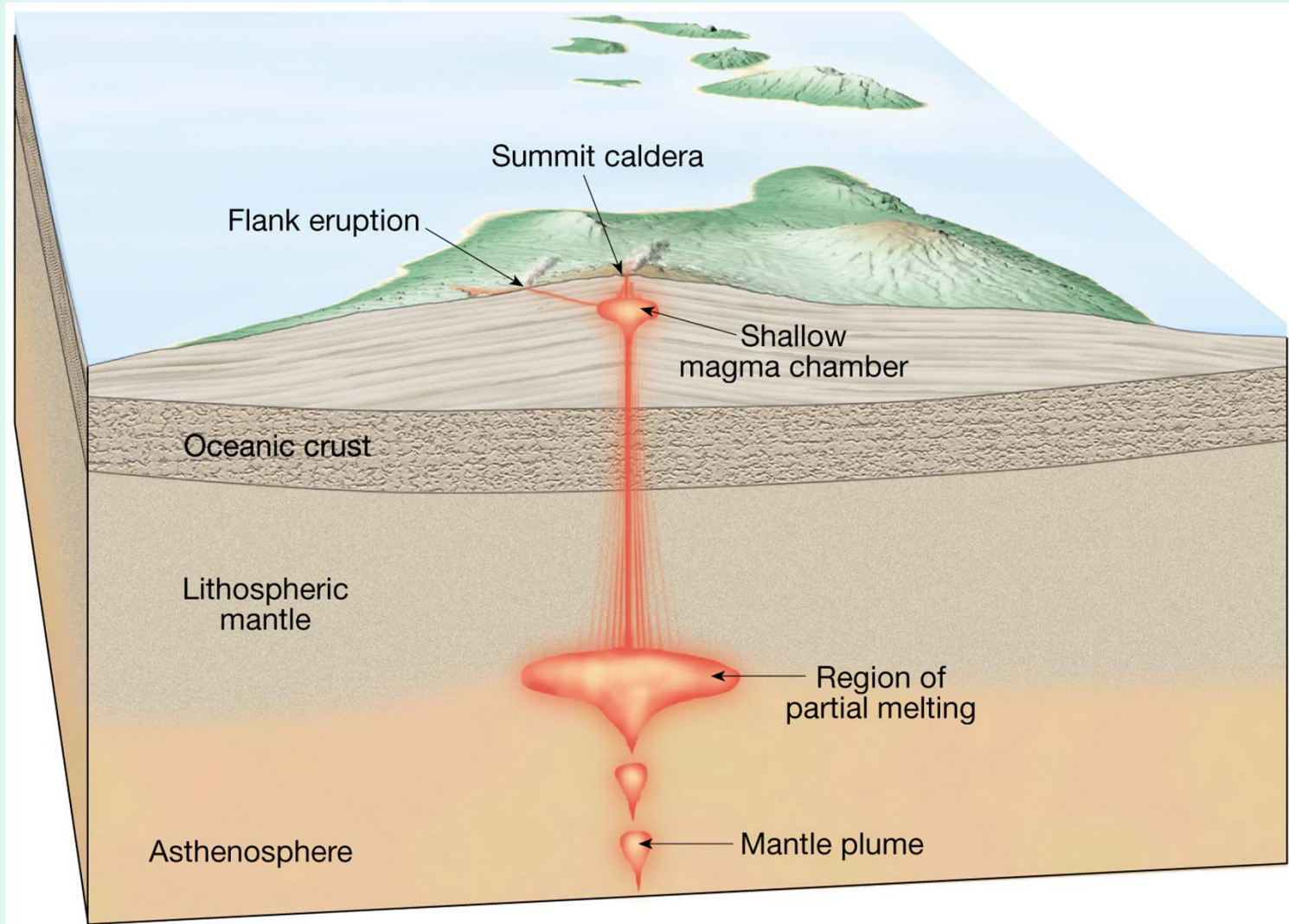


Volcanic Structures

- **Types of volcanoes**
 - ***Shield volcano***
 - **Broad, slightly domed shaped**
 - **Generally cover large areas**
 - **Produced by mild eruptions of large volumes of basaltic lava**
 - **Example = Mauna Loa on Hawaii**



Anatomy of a Shield Volcano

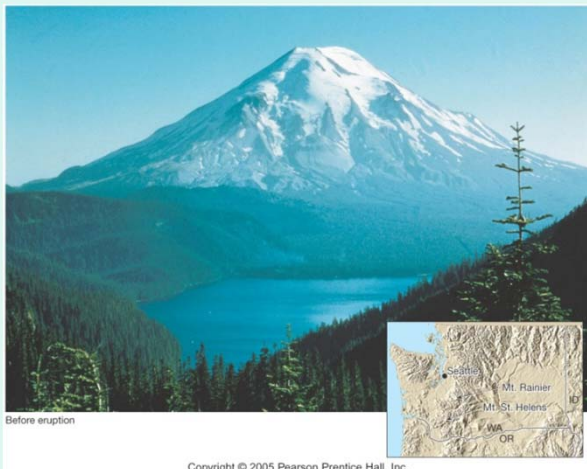


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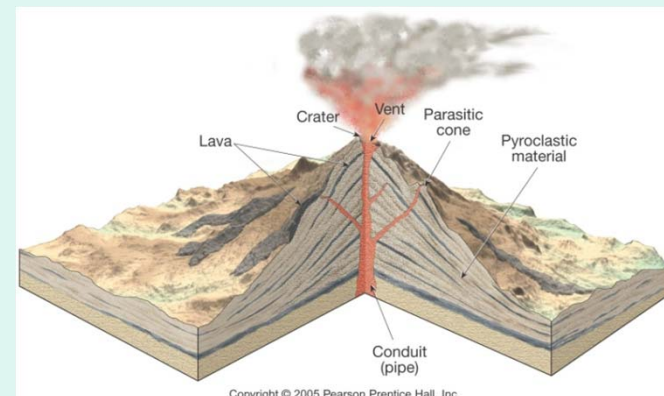
Figure 7.8

Volcanic Structures

- ***Composite cone (stratovolcano)***
 - Most are located adjacent to the Pacific Ocean (e.g., Fujiyama, Mt. St. Helens)
 - Large, classic-shaped volcano (1000s of ft. high and several miles wide at base)
 - Composed of interbedded lava flows and pyroclastic debris
 - Most violent type of activity (e.g., Mt. Vesuvius)



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Anatomy of a Strata Volcano

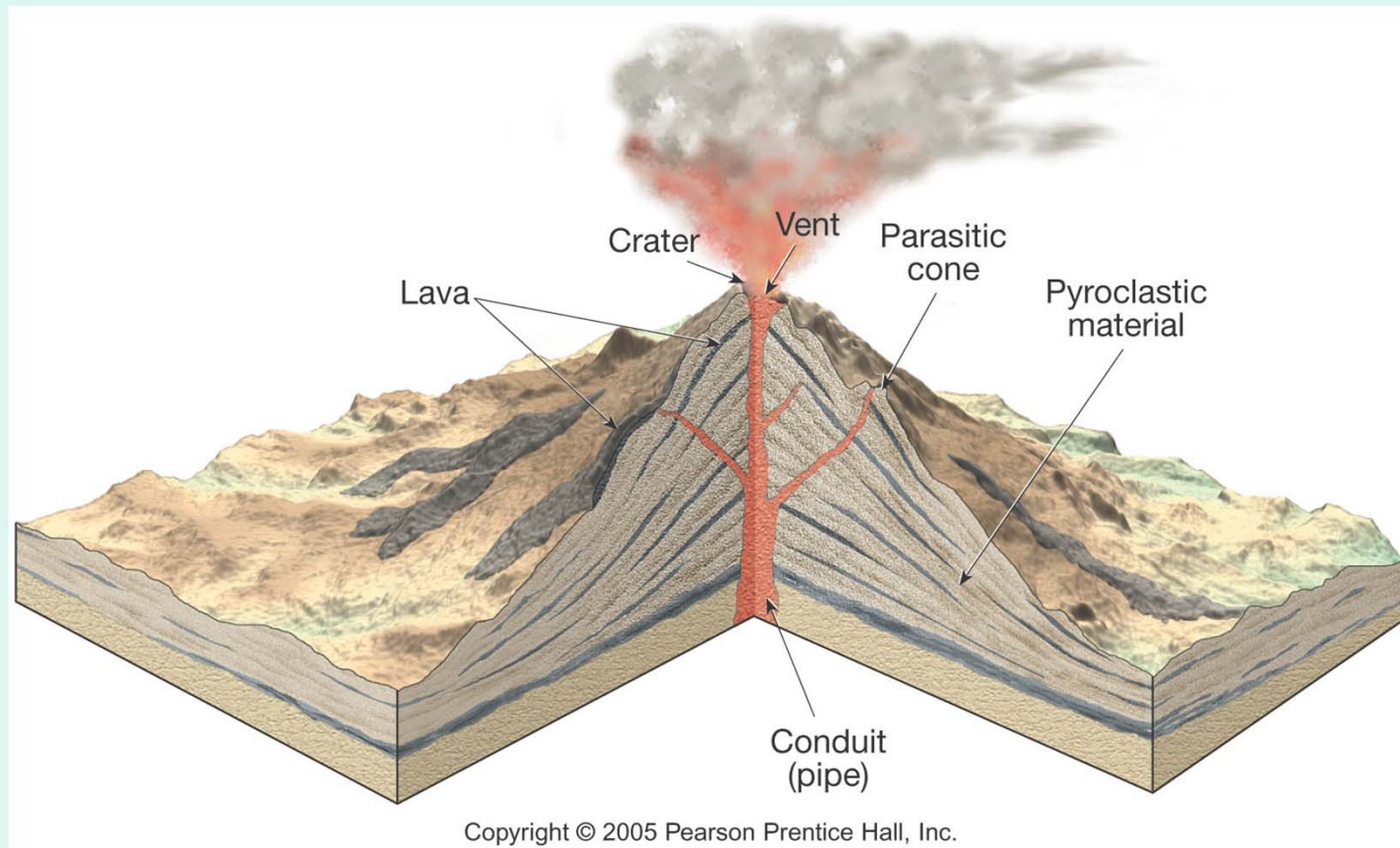


Figure 7.8

Mt. St. Helens—Prior to the 1980 Eruption



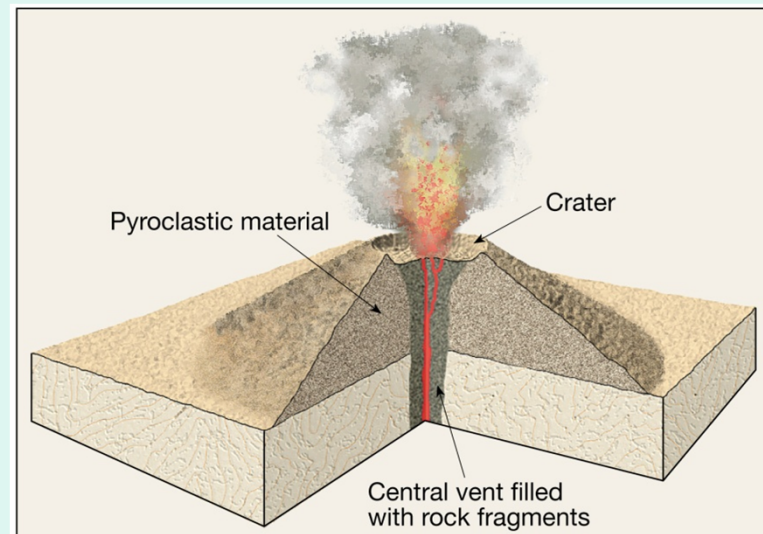
Mt. St. Helens After the 1980 Eruption



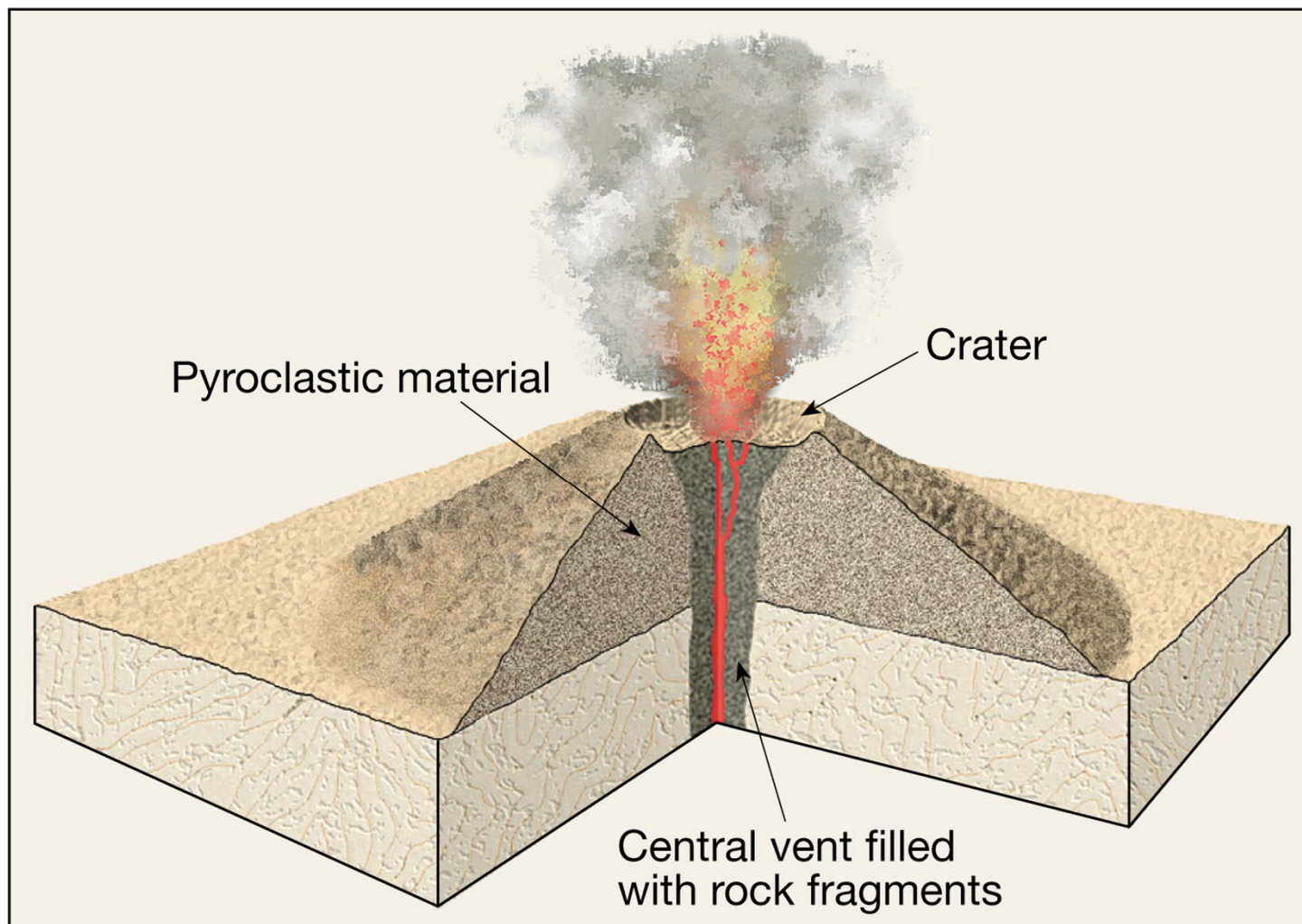
Volcanic Structures

- ***Cinder cone***

- Built from ejected lava (mainly cinder-sized) fragments
- Steep slope angle
- Small size
- Frequently occur in groups



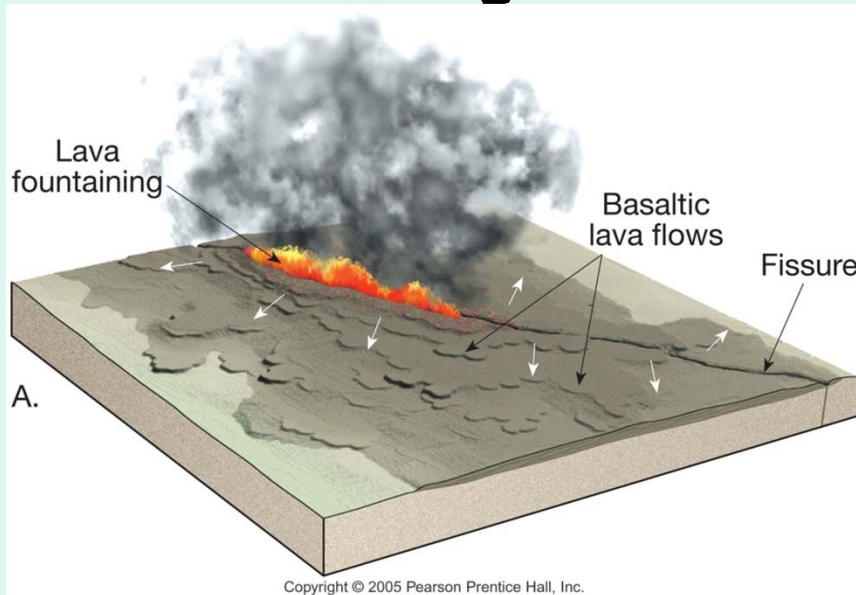
Cinder Cone Volcano



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Volcanic Structures

- **Flood Basalt**
 - Low viscosity flows
 - High Volume of Magma
 - No volcanic structure
 - Large Volume of Magma



Yellowstone

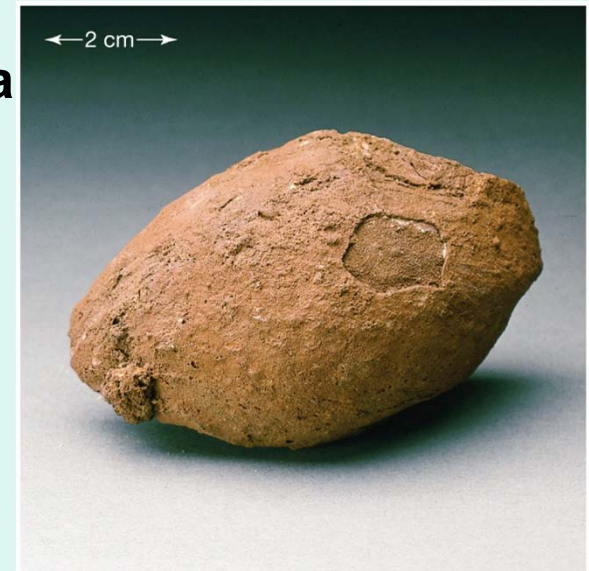


Materials Extruded from a Volcano

- **Lava flows**
 - **Basaltic lavas exhibit fluid behavior**
 - **Types of basaltic flows**
 - *Pahoehoe* lava (resembles a twisted or ropey texture)
 - *Aa* lava (rough, jagged blocky texture)
- **Dissolved gases**
 - **1%–6% by weight**
 - **Mainly H₂O and CO₂**

Materials Extruded from a Volcano

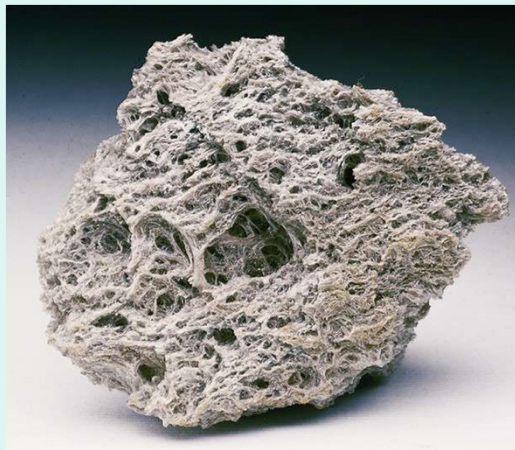
- **Pyroclastic materials—“Fire fragments”**
 - **Types of pyroclastic debris**
 - ***Cinders***—Pea-sized material
 - ***Lapilli***—Walnut-sized material
 - **Particles larger than lapilli**
 - » ***Blocks***—Hardened or cooled lava
 - » ***Bombs***—Ejected as hot lava



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Materials Extruded from a Volcano

- **Pyroclastic materials—“Fire fragments”**
 - **Types of pyroclastic debris**
 - **Ash and dust—Fine, glassy fragments**
 - ***Pumice*—Porous rock from “frothy” lava**



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A Nueé Ardente on Mt. St. Helens



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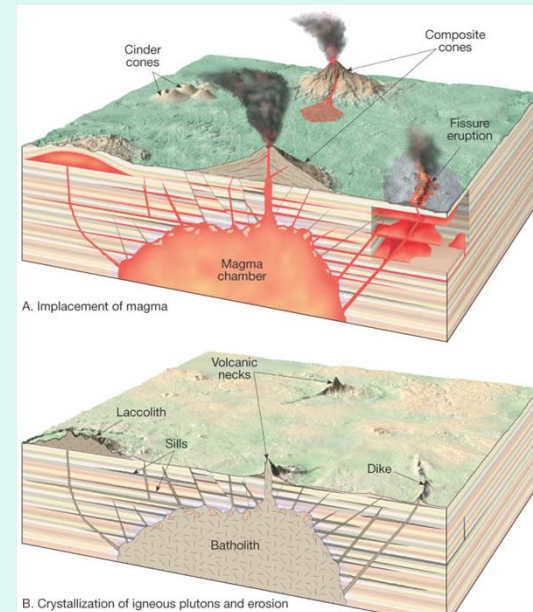
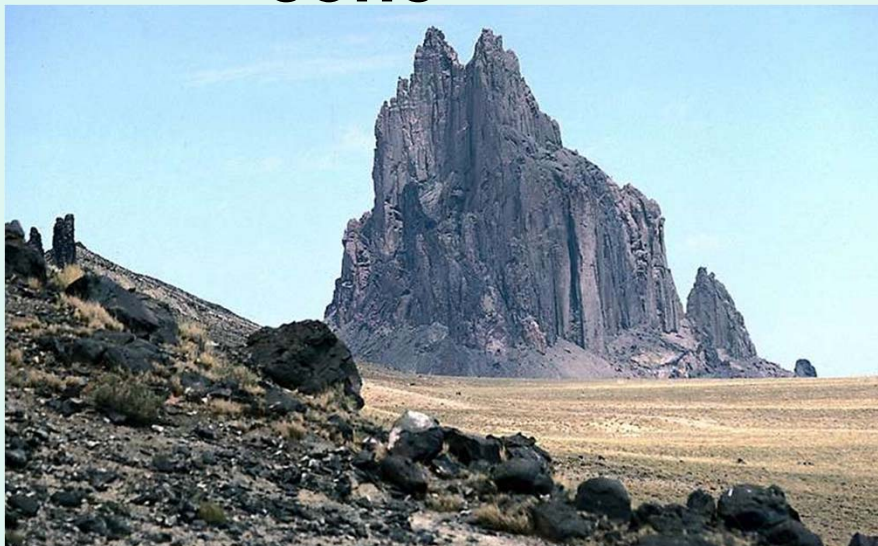
Volcanic Structures

- ***Lahar***—Volcanic mudflow
 - Mixture of volcanic debris and water
 - Move down stream valleys and volcanic slopes, often with destructive results

Other Volcanic Landforms

Volcanic pipes and necks

- **Pipes**—Short conduits that connect a magma chamber to the surface
- **Volcanic necks** (e.g., Ship Rock, New Mexico)—Resistant vents left standing after erosion has removed the volcanic cone



Mud cracks



Other Volcanic Landforms

Volcanic pipes and necks



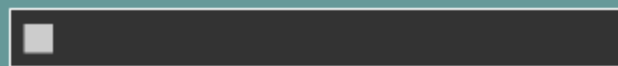
Intrusive Igneous Activity

Most magma is emplaced at depth in the Earth

- **Once cooled and solidified, is called a *pluton***

Nature of plutons

- **Shape—Tabular (sheetlike) vs. massive**
- **Orientation with respect to the host (surrounding) rock**
 - ***Concordant vs. discordant***



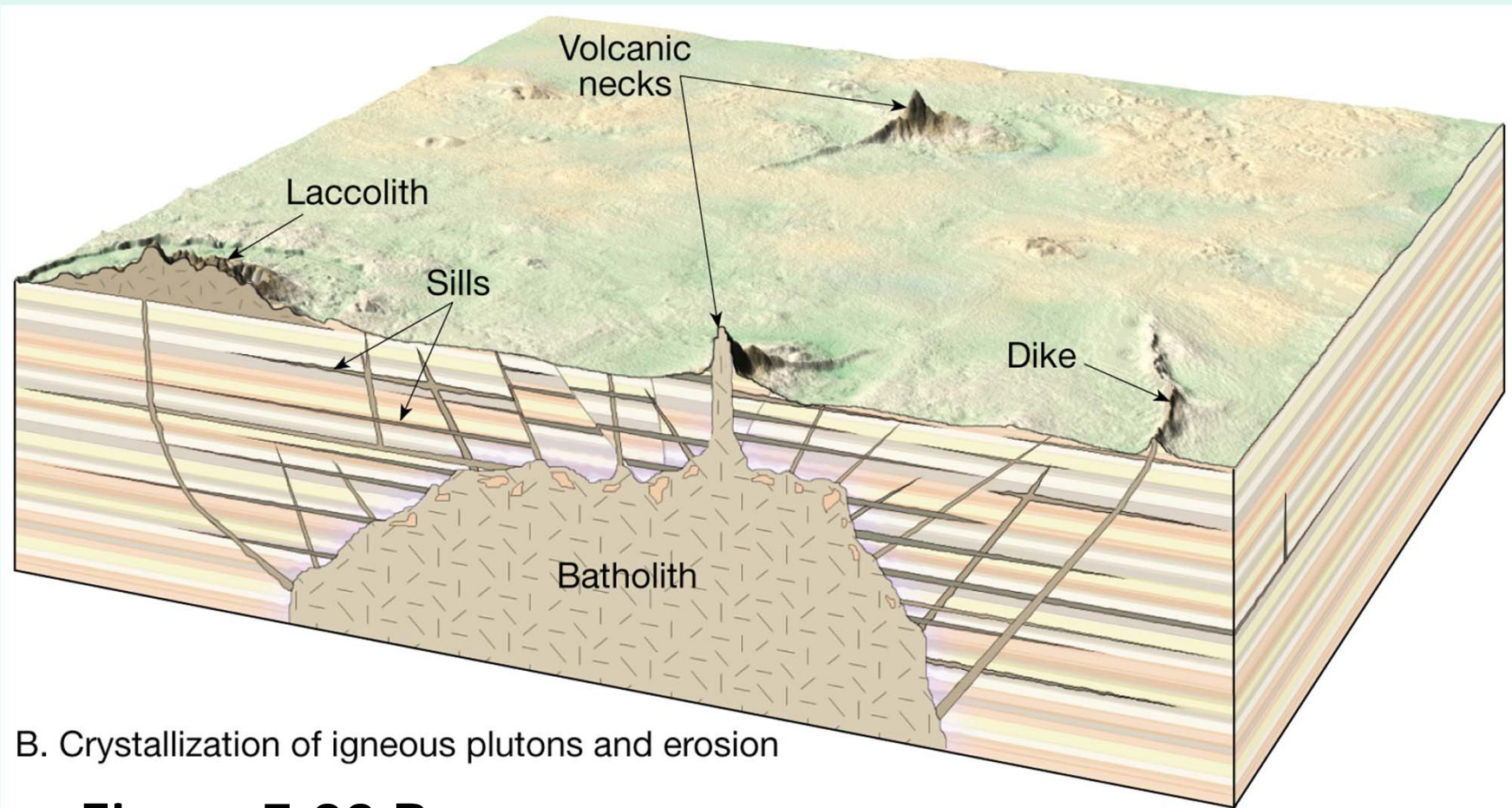
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Intrusive Igneous Activity

- **Types of intrusive igneous features**
 - ***Dike***—A tabular, discordant pluton
 - ***Sill***—A tabular, concordant pluton (e.g., Palisades Sill in New York)
 - ***Laccolith***
 - Similar to a sill
 - Lens or mushroom-shaped mass
 - Arches overlying strata upward

Igneous Structures



B. Crystallization of igneous plutons and erosion

Figure 7.22 B

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A Sill in the Salt River Canyon, Arizona



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Figure 7.23

Intrusive Igneous Activity

- **Intrusive igneous features continued**
 - ***Batholith***
 - Largest intrusive body
 - Surface exposure $> 100+$ km² (smaller bodies are termed *stocks*)
 - Frequently form the cores of mountains



Chapter 8
Geologic Time

Geologic Time

Eon	Era	Period	Epoch	Development of Plants and Animals	Relative Time Span of Eras		
Phanerozoic	Cenozoic	Quaternary	Holocene	0.01	Humans develop	Cenozoic	
			Pleistocene	1.8		Mesozoic	
		Tertiary	Pliocene	5.3	"Age of Mammals"	Paleozoic	
			Miocene	23.8			
			Oligocene	33.7			
			Eocene	54.8			
			Paleocene	65.0			Extinction of dinosaurs and many other species
			Mesozoic	Cretaceous			
	144	First birds					
	Jurassic			Dinosaurs dominant			
	206						
	Paleozoic	Carboniferous	Permian	"Age of Amphibians"	Extinction of trilobites and many other marine animals	Precambrian	
			Pennsylvanian				First reptiles
		323	Large coal swamps				
		Mississippian		Amphibians abundant			
		354					
		Devonian	"Age of Fishes"	First insect fossils			
		417			Fishes dominant		
		Silurian	First land plants				
443							
Ordovician	"Age of Invertebrates"	First fishes					
490			Trilobites dominant				
Cambrian				First organisms with shells			
540							
Proterozoic	Collectively called Precambrian, comprises about 88% of the geologic time scale	First multicelled organisms					
Archean			First one-celled organisms				
3800				Origin of Earth			
4500							

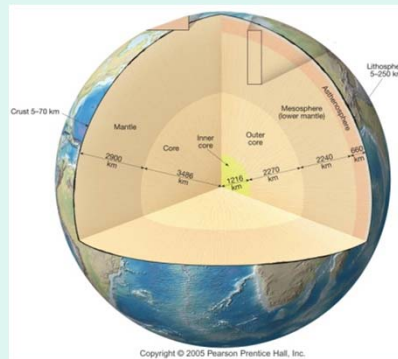
Historical Estimates of Geologic Time

Augustine of Hippo (354-430 AD) established the AD and BC time scale

James Ussher, mid-1600s, concluded Earth was only a few thousand years old – landscapes created by disasters that no longer occur presently

Historical Estimates of Geologic Time

George Louis de Buffon (1707 -1788) estimated the earth to be 96,000 years old based on cooling rates of iron



Abraham Werner (1749-1817) All rocks were precipitated in an orderly sequence from a world wide ocean

Primitive Rocks

Transition Rocks

Secondary Rocks

Alluvial Rocks

Oldest Rocks

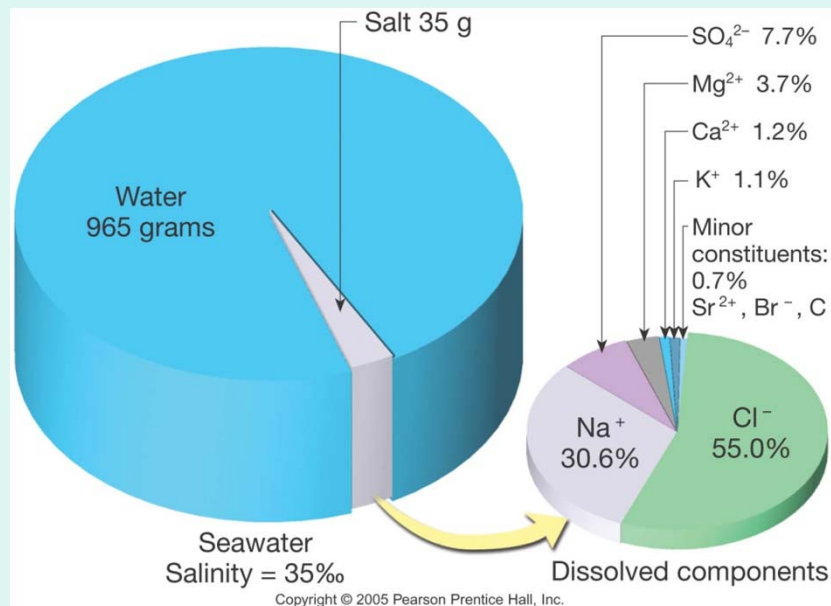
Early fossils and sed rocks

Later fossils and sed rocks

Unconsolidated Sediment

Historical Estimates of Geologic Time

**John Joly (1899) earth 90 million years old
based on ocean salinity**



Historical Notes

Catastrophism

- **Landscape developed by catastrophes**
- **James Ussher, mid-1600s, concluded Earth was only a few thousand years old**

Modern geology

- **Uniformitarianism**
 - **Fundamental principle of geology**
 - **"The present is the key to the past"**

Historical Notes

- **Modern geology**
 - **James Hutton**
 - *Theory of the Earth*
 - Published in the late 1700s

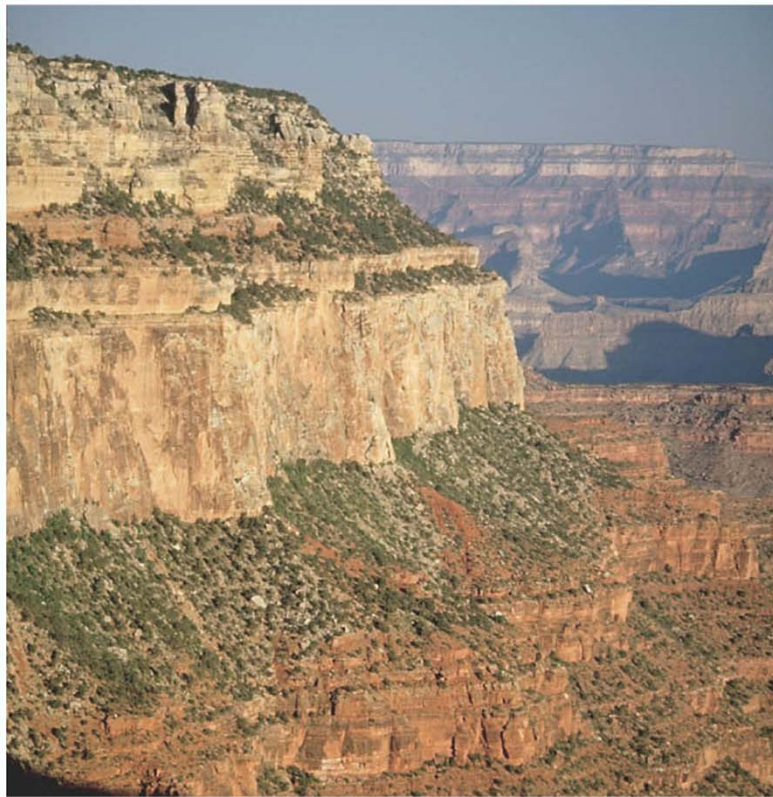
Charles Lyell – also advanced the theory of
Uniformitarianism

Relative Dating

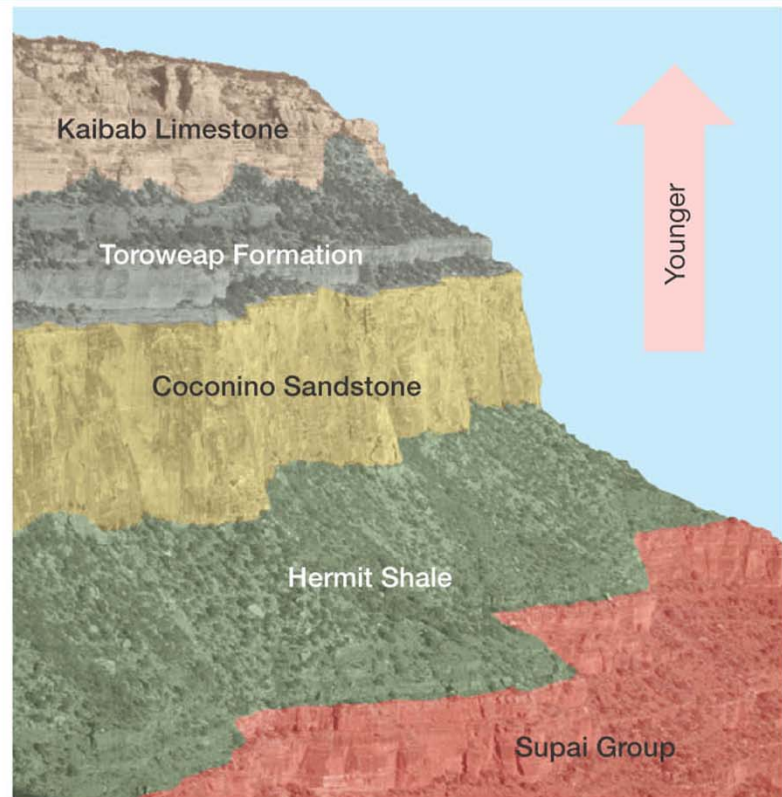
- **Law of superposition**
 - **Developed by Nicolaus Steno in 1669**
 - **In an undeformed sequence of sedimentary rocks (or layered igneous rocks), the oldest rocks are on the bottom**



Superposition Is Well Illustrated by the Strata in the Grand Canyon



A



B

Relative Dating

- **Principle of original horizontality**
 - **Layers of sediment are generally deposited in a horizontal position**
 - **Rock layers that are flat have not been disturbed**



Relative Dating

- **Principle of cross-cutting relationships**
 - **Younger features cut across older features**



Cross-Cutting Relationships

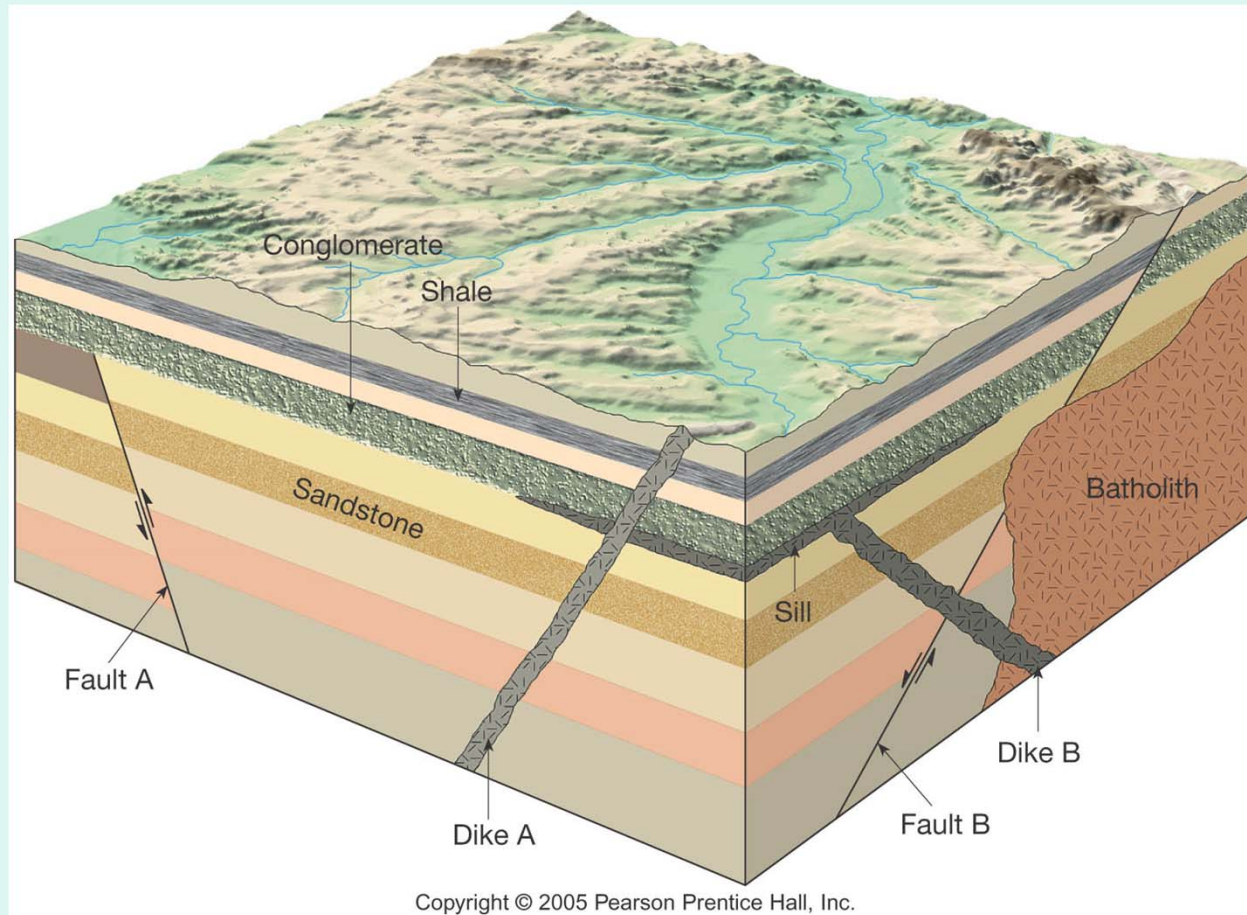
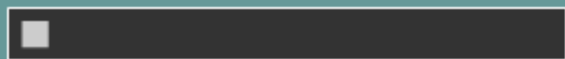


Figure 8.4



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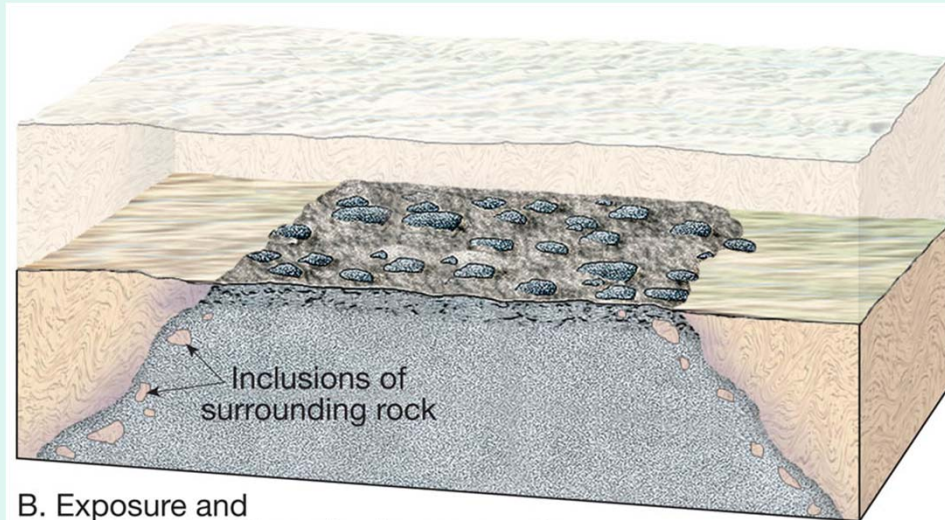
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Relative Dating

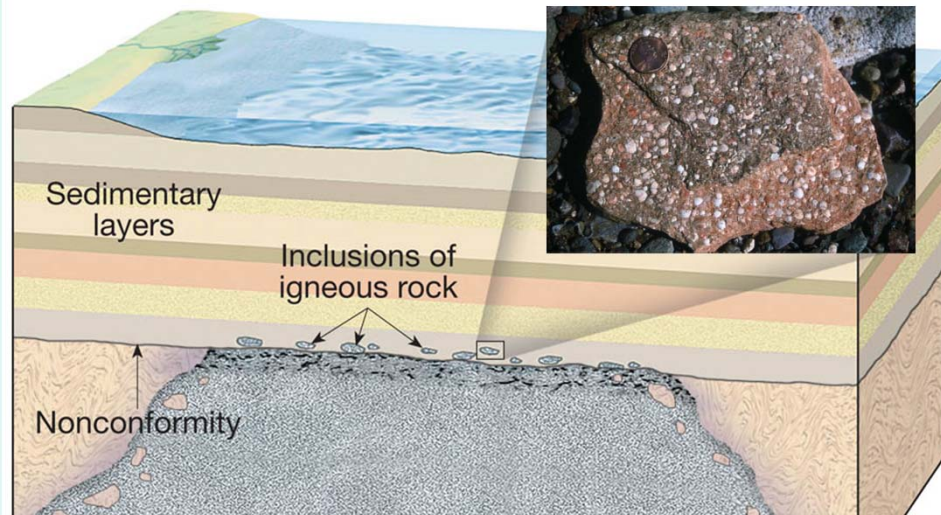
- **Inclusions**
 - **An inclusion is a piece of rock that is enclosed within another rock**
 - **Rock containing the inclusion is younger**



Relative Dating - Inclusions



B. Exposure and weathering of intrusive igneous rock



Relative Dating

Unconformity

- **An unconformity is a break in the rock record produced by erosion and/or nondeposition of rock units**

Relative Dating

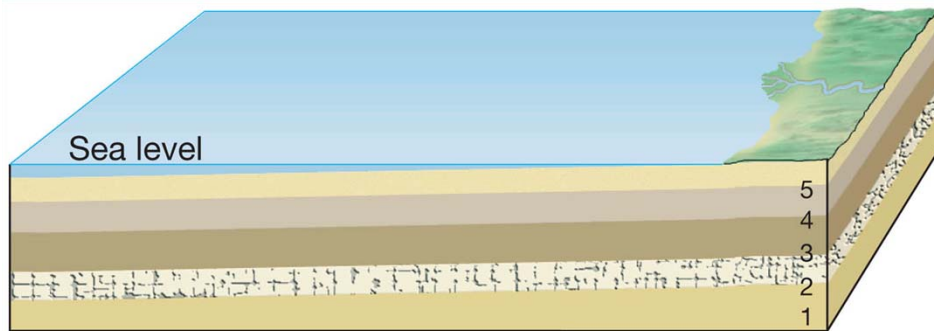
- **Unconformity**
 - **Types of unconformities**
 - ***Angular unconformity***—Tilted rocks are overlain by flat-lying rocks
 - ***Disconformity***—Strata on either side of the unconformity are parallel
 - ***Nonconformity***—Metamorphic or igneous rocks in contact with sedimentary strata



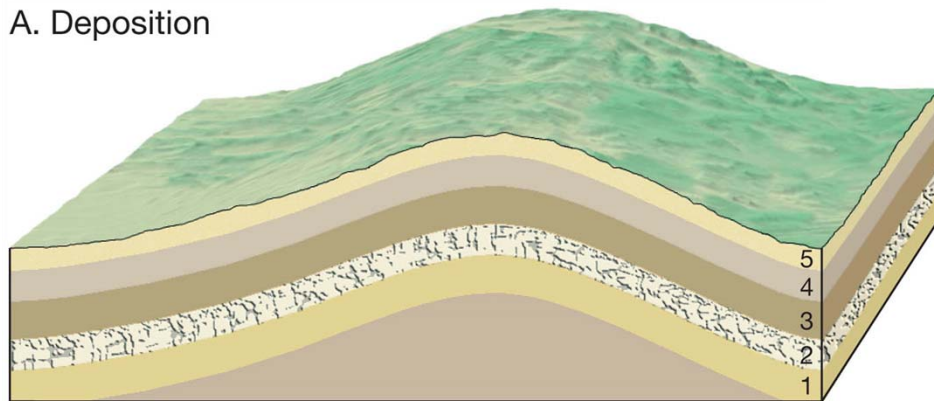
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Relative Dating - Angular Unconformity

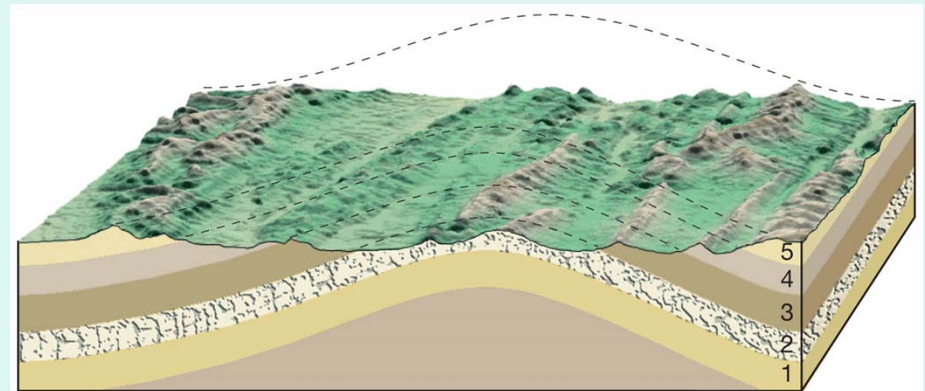


A. Deposition

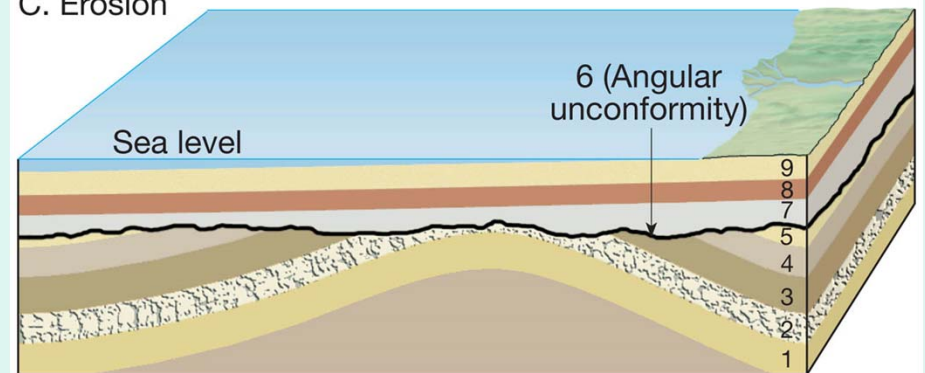


B. Folding and uplifting

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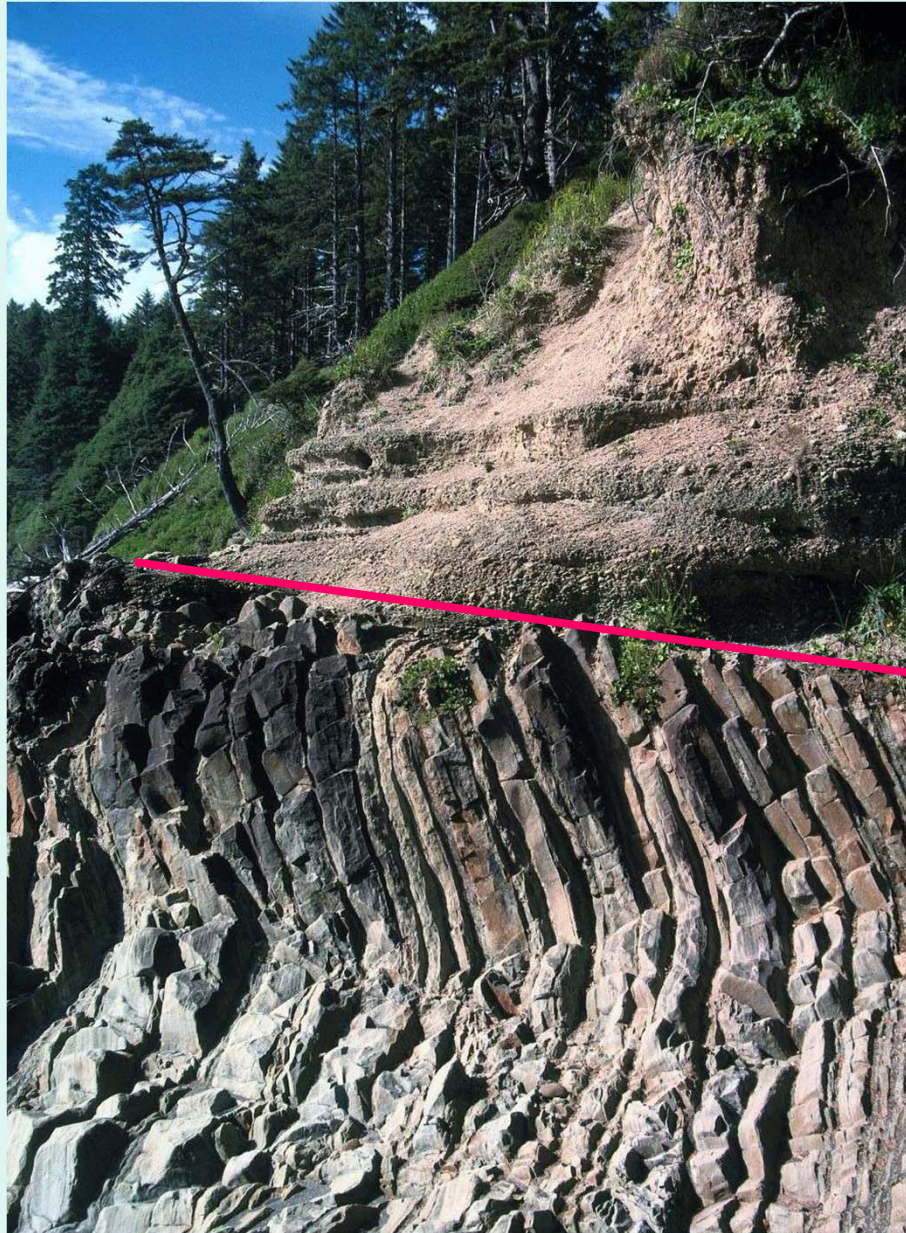
C. Erosion



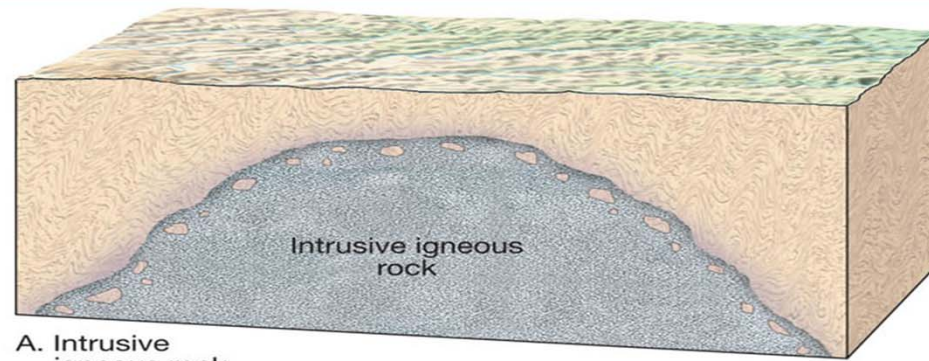
D. Subsidence and renewed deposition

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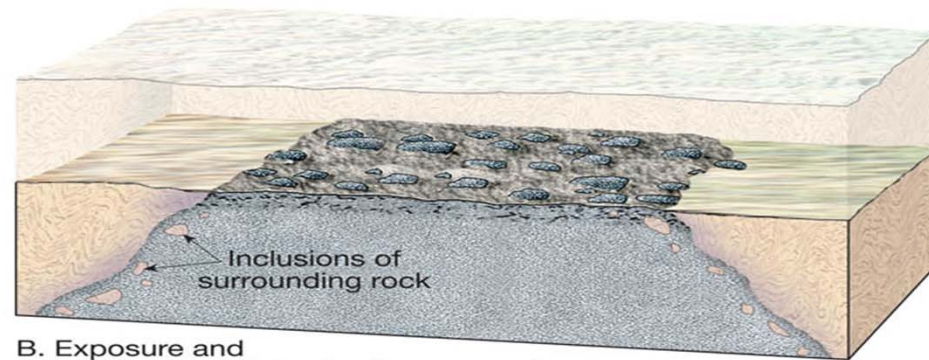
Relative Dating - Angular Unconformity



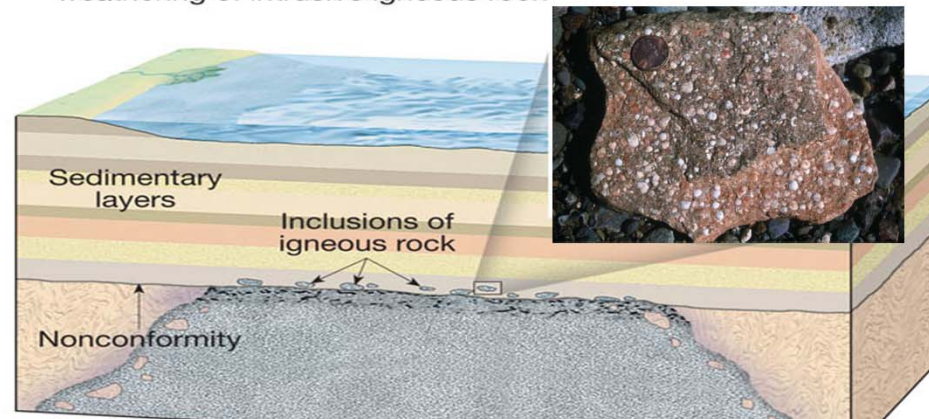
Relative Dating – Nonconformity



A. Intrusive igneous rock



B. Exposure and weathering of intrusive igneous rock

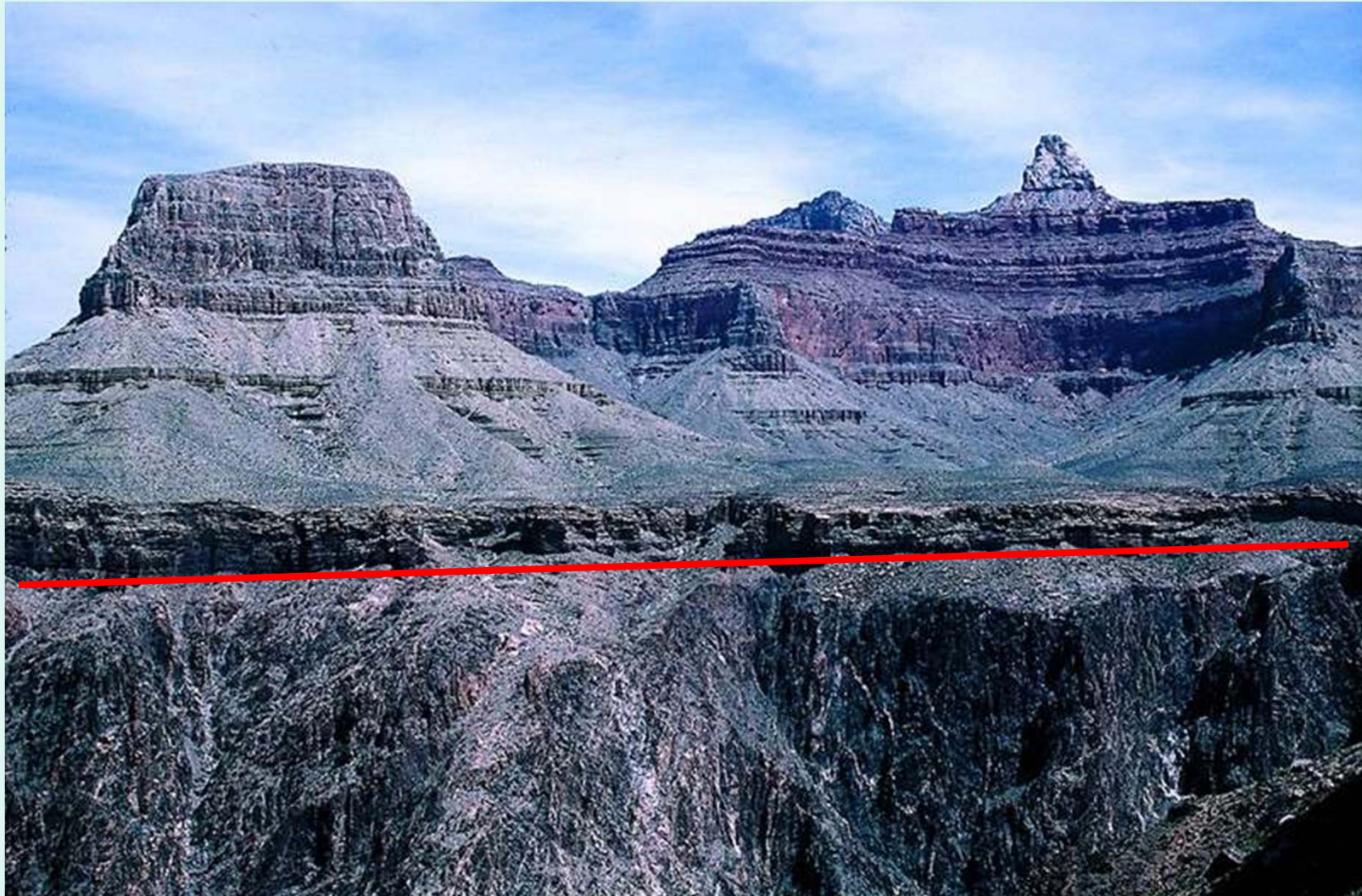


Sedimentary layers

Inclusions of igneous rock

Nonconformity

Relative Dating - Nonconformity

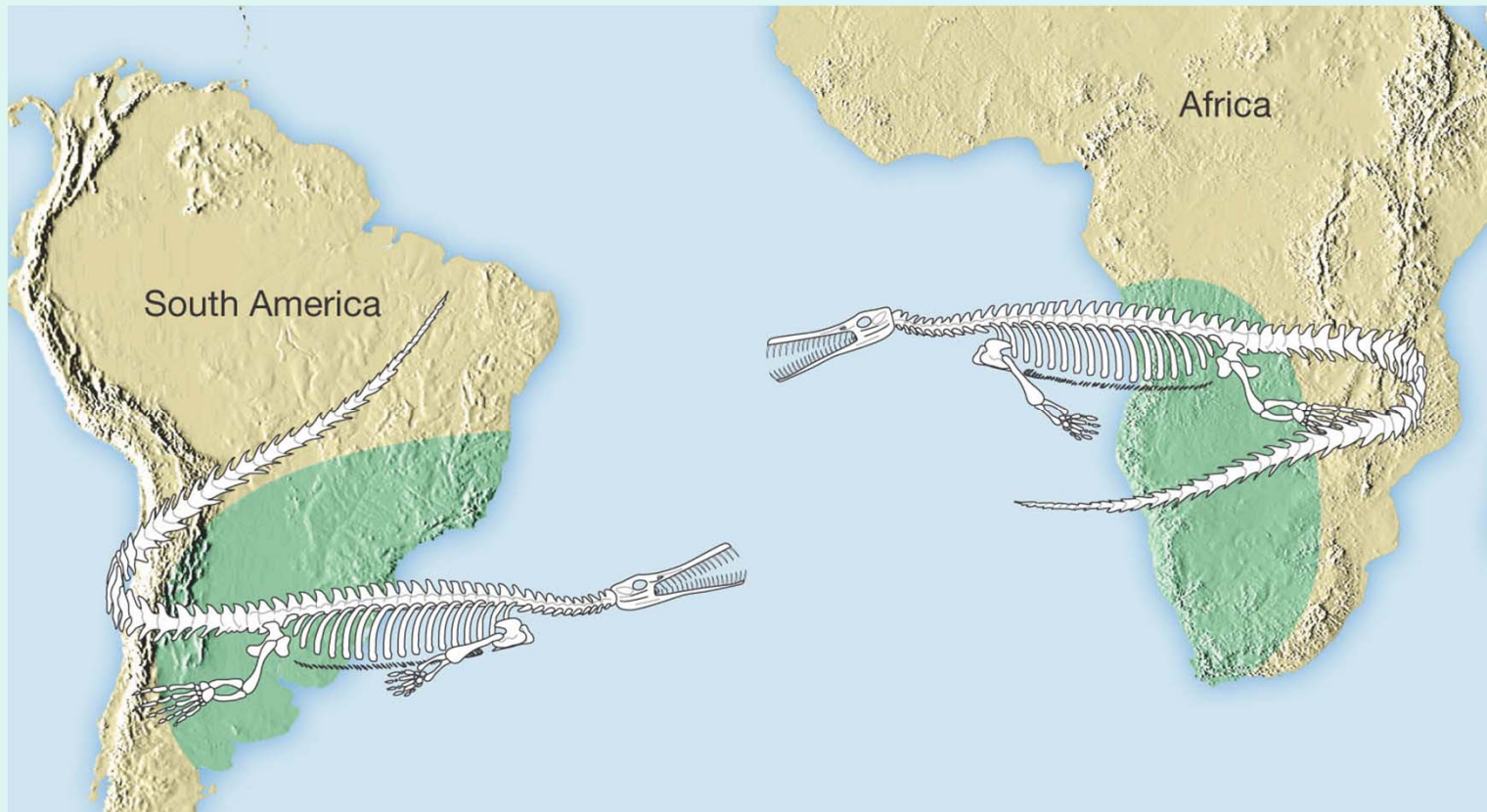


Relative Dating – Disconformities



Fossils and Correlation

Matching of rocks of similar ages in different regions is known as *correlation*



Fossils and Correlation

Correlation often relies upon fossils

William Smith (late 1700s) noted that sedimentary strata in widely separated area could be identified and correlated by their distinctive fossil content

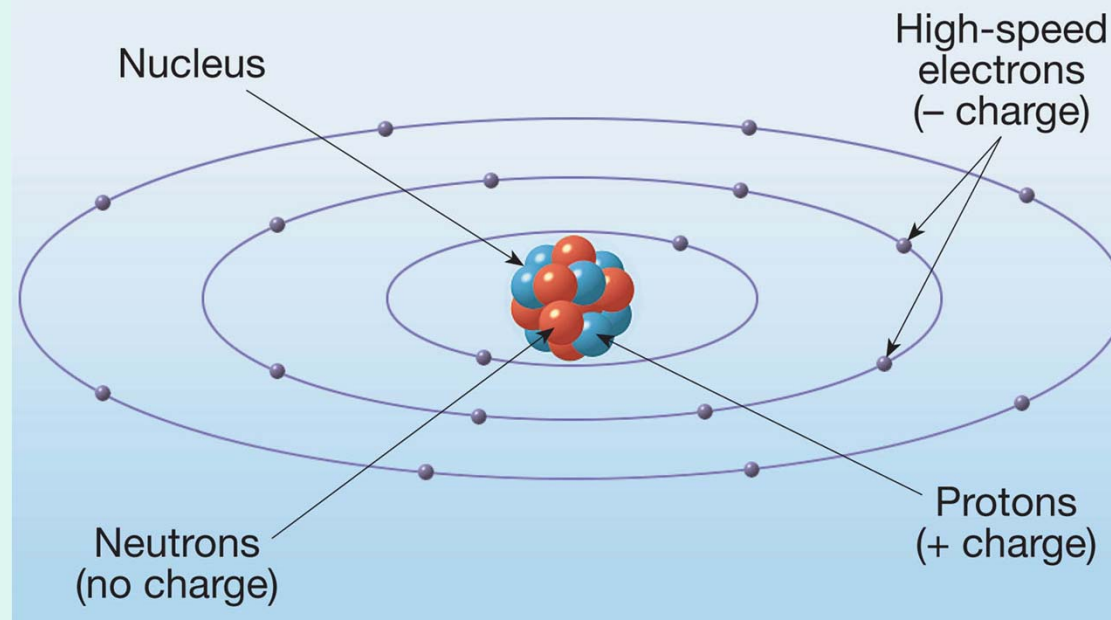


Fossils and Correlation

- ***Principle of fossil succession***—Fossil organisms succeed one another in a definite and determinable order, and therefore any time period can be recognized by its fossil content
- ***Index fossil***—Geographically widespread fossil that is limited to a short span of geologic time

Dating with Radioactivity

- **Reviewing basic atomic structure**
 - ***Nucleus***
 - ***Protons*** = + charged particles with mass
 - ***Neutrons*** = neutral particles with mass
 - ***Electrons*** = - charged particles that orbit the nucleus



Dating with Radioactivity

- Reviewing basic atomic structure
 - **Atomic number**
 - Element's identifying number
 - Equal to the number of protons
 - **Mass number**
 - Sum of the number of protons and neutrons

Tendency to lose outermost electrons to uncover full outer shell

Tendency to fill outer shell by sharing electrons

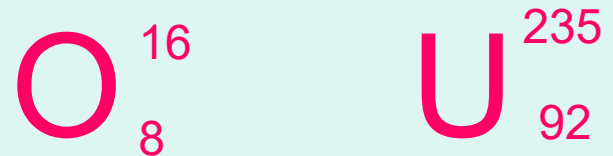
Tendency to gain electrons to make full outer shell

Noble gases (inert)

Metals
Transition metals
Nonmetals
Noble gases
Lanthanide series
Actinide series

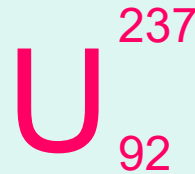
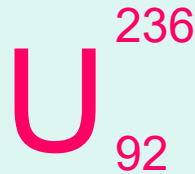
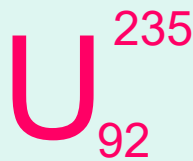
1 H 1.008 Hydrogen																	2 He 4.003 Helium		
3 Li 6.939 Lithium	4 Be 9.012 Beryllium																	10 Ne 20.183 Neon	
11 Na 22.990 Sodium	12 Mg 24.31 Magnesium																	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
19 K 39.102 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.71 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.63 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton		
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.90 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.87 Silver	48 Cd 112.40 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.75 Antimony	52 Te 127.60 Tellurium	53 I 126.905 Iodine	54 Xe 131.30 Xenon		
55 Cs 132.91 Cesium	56 Ba 137.34 Barium	57 La 138.91 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.85 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.37 Thallium	82 Pb 207.19 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon		
87 Fr 223 Francium	88 Ra 226.025 Radium	89 La 138.91 Lanthanum	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237 Neptunium	94 Pu 242 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 260 Lawrencium			

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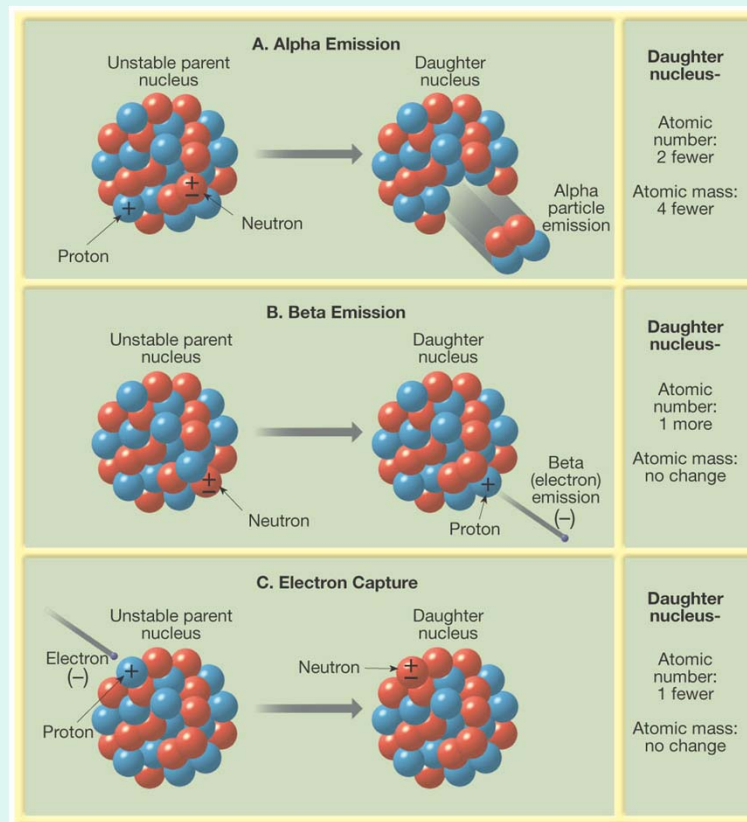
Dating with Radioactivity

- **Reviewing basic atomic structure**
 - *Isotope*
 - Variant of the same parent atom
 - Differs in the number of neutrons
 - Results in a different mass number than the parent atom

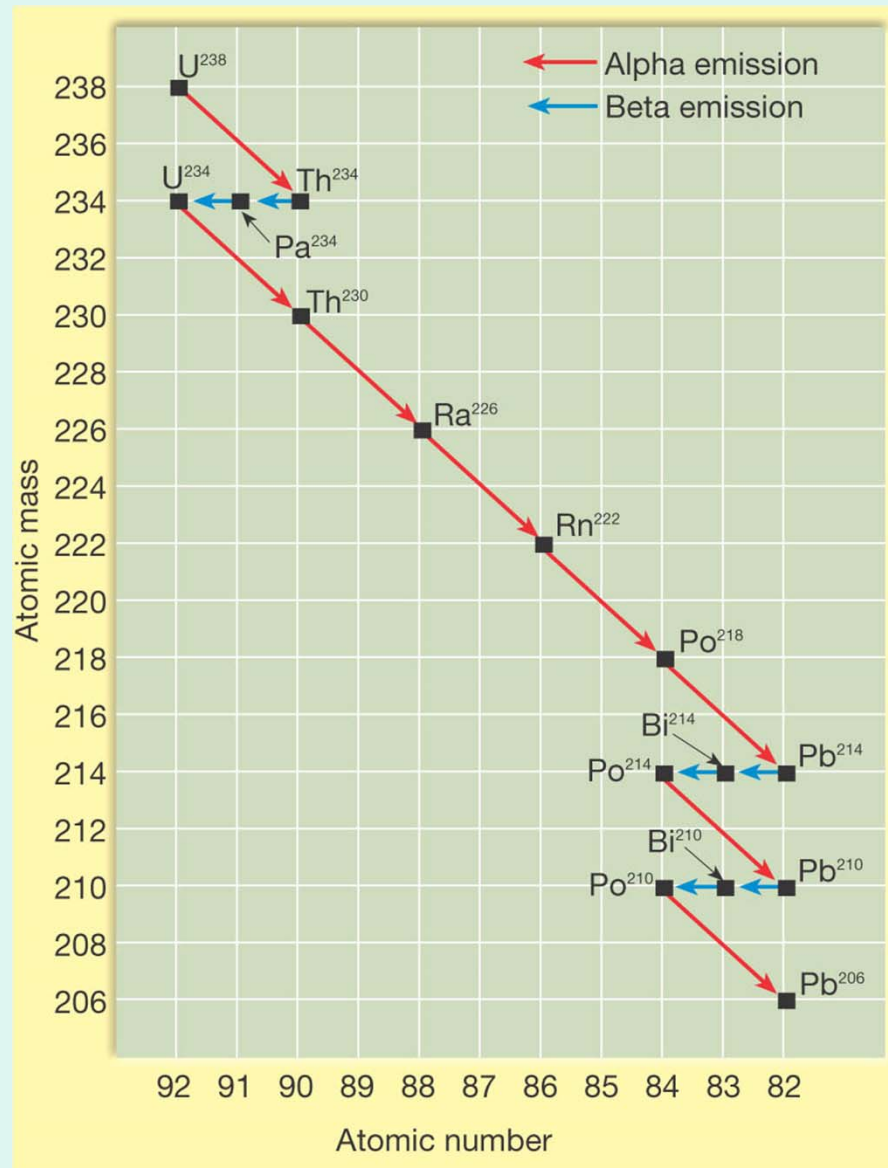


Dating with Radioactivity

- Radioactivity
 - Spontaneous changes (decay) in the structure of atomic nuclei



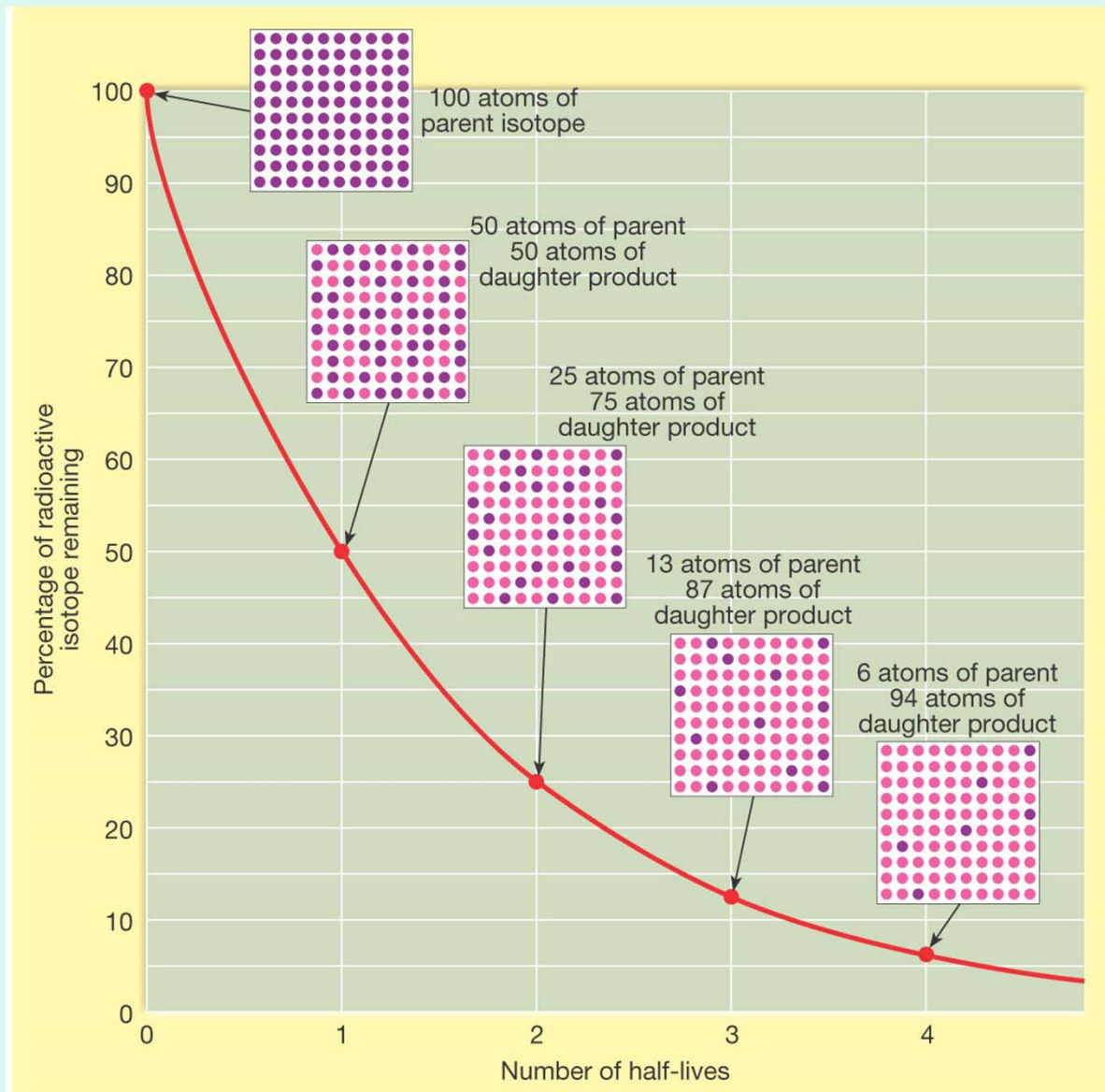
Dating with Radioactivity



Dating with Radioactivity

- ***Parent***—An unstable radioactive isotope
- ***Daughter product***—The isotopes resulting from the decay of a parent
- ***Half-life***—The time required for one-half of the radioactive nuclei in a sample to decay

Dating with Radioactivity



Dating with Radioactivity

Radiometric dating

- **Principle of radioactive dating**
 - The percentage of radioactive atoms that decay during one half-life is always the same (50 percent)
 - However, the actual number of atoms that decay continually decreases
 - Comparing the ratio of parent to daughter yields the age of the sample
 - Decay is not affected by external forces

Dating with Radioactivity

Table 8.1 Radioactive isotopes frequently used in radiometric dating

Radioactive Parent	Stable Daughter Product	Currently Accepted Half-life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

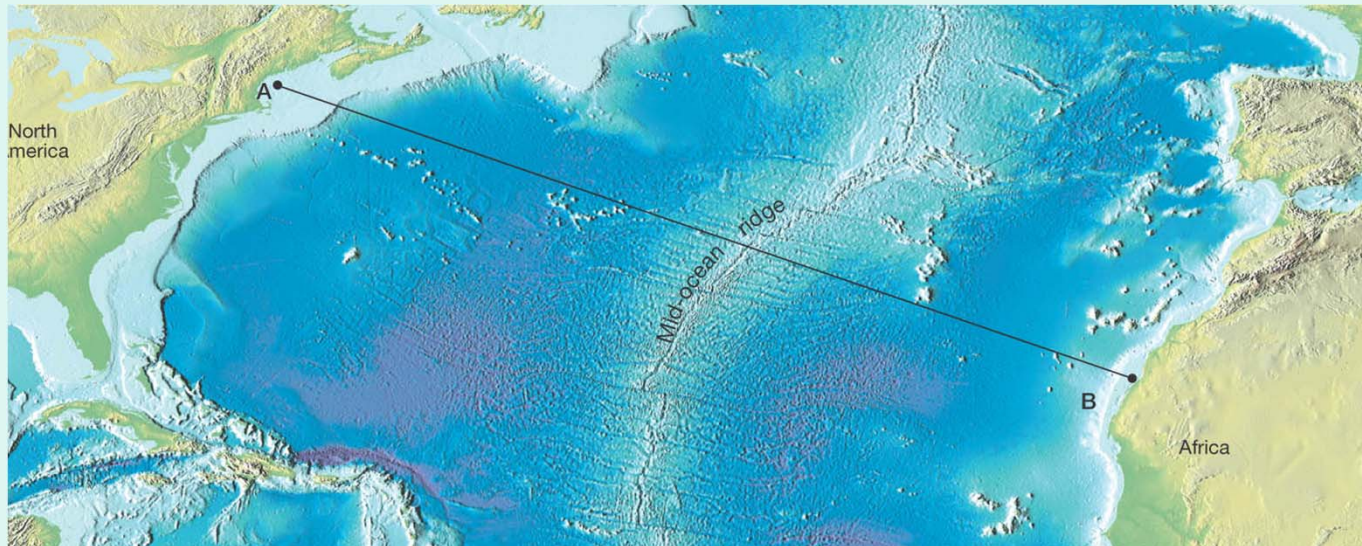
Dating with Radioactivity

- **Radiometric dating**
 - **Sources of error**
 - **A closed system is required**
 - **To avoid potential problems, only fresh, unweathered rock samples should be used**

Dating with Radioactivity

Importance of radiometric dating

- Rocks from several localities have been dated at more than 3 billion years
- Confirms the idea that geologic time is immense



The Geologic Time Scale

- **The geologic time scale—A “calendar” of Earth history**
 - **Subdivides geologic history into units**
 - **Originally created using relative dates**
- **Structure of the geologic time scale**
 - ***Eon*—The greatest expanse of time**

The Geologic Time Scale

Eon	Era	Period	Epoch	Development of Plants and Animals	Relative Time Span of Eras				
Phanerozoic	Cenozoic	Quaternary	Holocene	Humans develop	Cenozoic				
			Pleistocene		0.01	Mesozoic			
		Tertiary	Pliocene	1.8	"Age of Mammals"	Paleozoic			
			Miocene	5.3					
			Oligocene	23.8					
			Eocene	33.7					
			Paleocene	54.8					
	Mesozoic	Cretaceous	Triassic	65.0	"Age of Reptiles"	Precambrian			
							Jurassic	144	Extinction of dinosaurs and many other species
									First flowering plants
							Triassic	206	First birds
									Dinosaurs dominant
							Paleozoic	Carboniferous	Permian
	Pennsylvanian	290	Extinction of trilobites and many other marine animals						
	Mississippian	323	First reptiles						
	Paleozoic	Devonian	Silurian	417	"Age of Fishes"				
						Ordovician		443	Large coal swamps
									Amphibians abundant
						Cambrian		490	540
First fishes dominant									
Proterozoic	Archean	Hadean	2500	3800	First land plants				
					Proterozoic	2500	Archean	3800	First fishes
									Hadean
Collectively called Precambrian, comprises about 88% of the geologic time scale				First land plants					
				"Age of Fishes"	First land plants				
				"Age of Invertebrates"	First fishes				
				First organisms with shells					
				First multicelled organisms					
				First one-celled organisms					
				Origin of Earth					

The Geologic Time Scale

- **Structure of the geologic time scale**
 - **Names of the eons**
 - ***Phanerozoic*** (“visible life”)—The most recent eon, began about 540 million years ago
 - ***Proterozoic***
 - ***Archean***
 - ***Hadean***—The oldest eon

The Geologic Time Scale

- **Structure of the geologic time scale**
 - ***Era***—Subdivision of an eon
 - **Eras of the Phanerozoic eon**
 - ***Cenozoic*** (“recent life”)
 - ***Mesozoic*** (“middle life”)
 - ***Paleozoic*** (“ancient life”)
 - **Eras are subdivided into *periods***
 - **Periods are subdivided into *epochs***

The Geologic Time Scale

- **Precambrian time**
 - **Nearly 4 billion years prior to the Cambrian period**
 - **Not divided into smaller time units because the events of Precambrian history are not known in great enough detail**
 - **First abundant fossil evidence does not appear until the beginning of the Cambrian**

The Geologic Time Scale

- **Difficulties in dating the geologic time scale**
 - **Not all rocks can be dated by radiometric methods**
 - **Grains comprising detrital sedimentary rocks are not the same age as the rock in which they formed**
 - **The age of a particular mineral in a metamorphic rock may not necessarily represent the time when the rock formed**

The Geologic Time Scale

- **Difficulties in dating the geologic time scale**
 - **Datable materials (such as volcanic ash beds and igneous intrusions) are often used to bracket various episodes in Earth history and arrive at ages**

Bracketing Sedimentary Ages Using Igneous Rocks

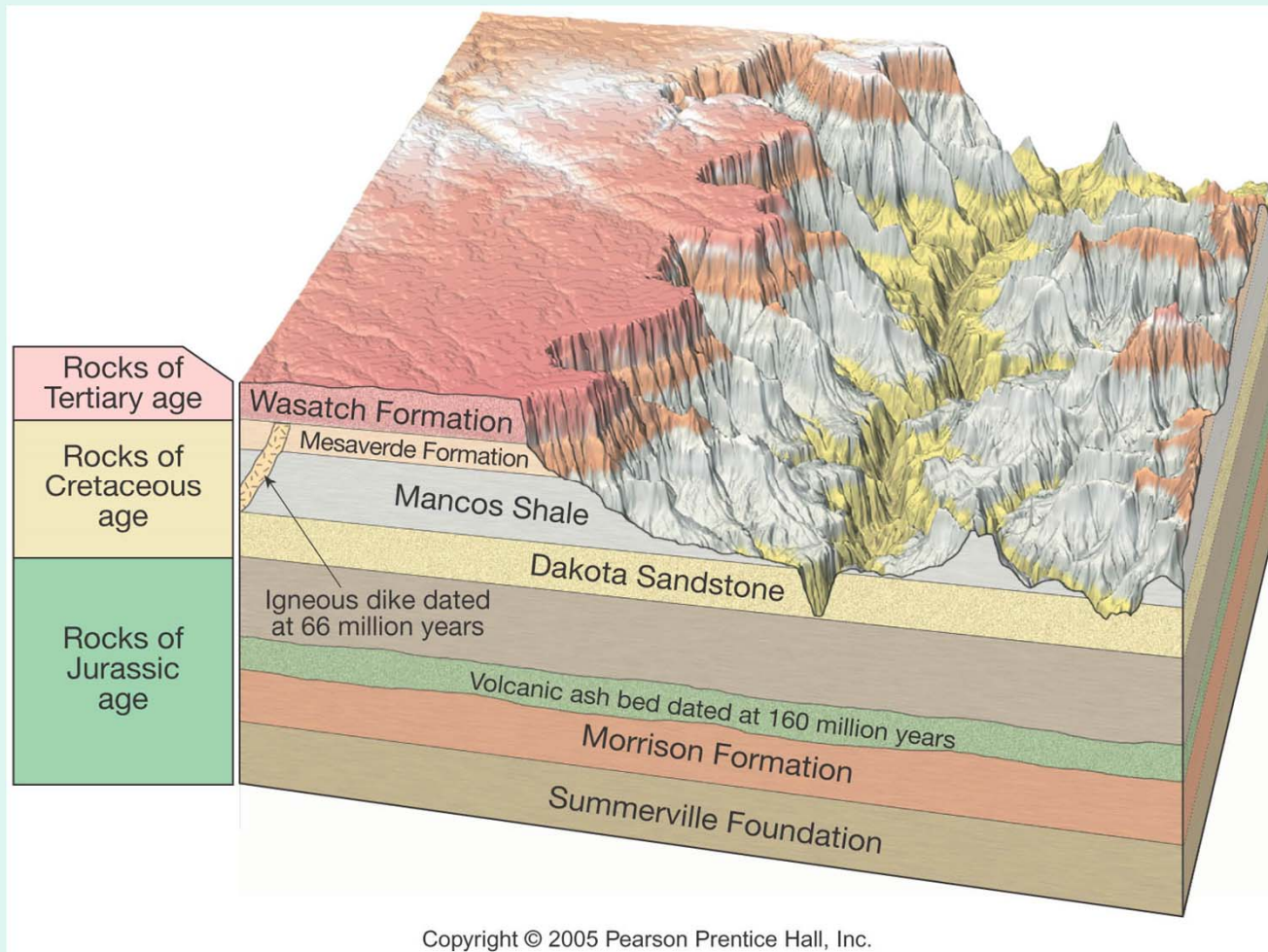


Figure 8.16

Fossils: Evidence of Past Life

- ***Fossil*** = traces or remains of prehistoric life now preserved in rock
- **Fossils** are generally found in sediment or sedimentary rock (rarely in metamorphic and never in igneous rock)
- ***Paleontology*** = study of fossils



Fossils: Evidence of Past Life

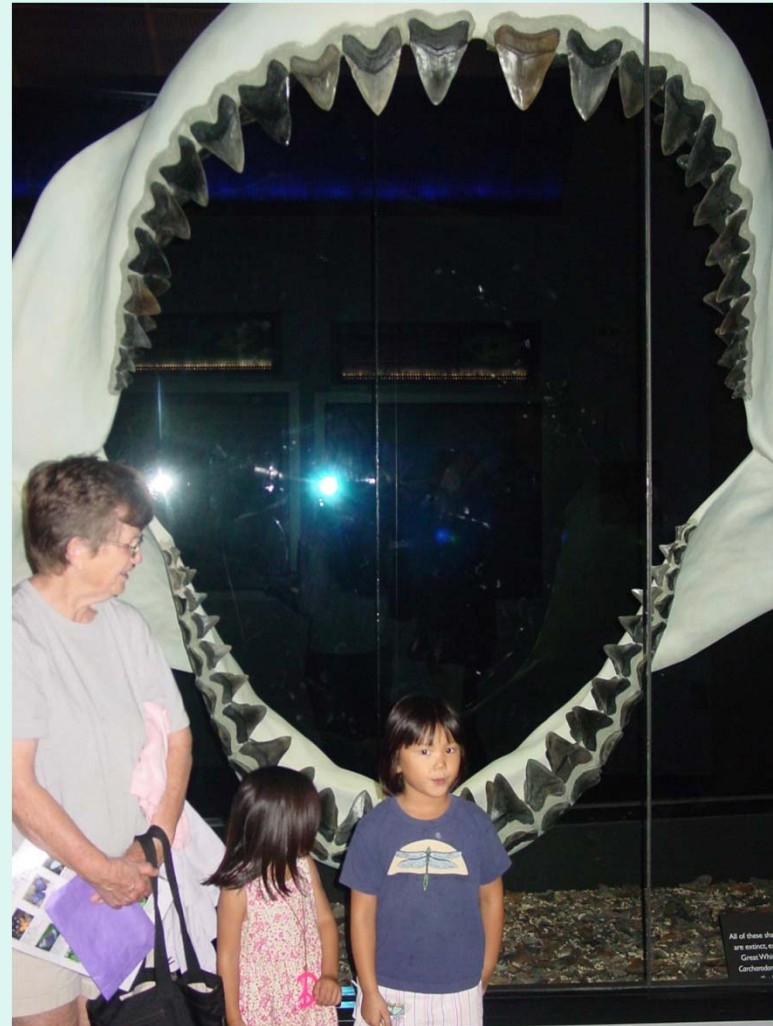
- **Geologically fossils are important because they**
 - **Aid in interpretation of the geologic past**
 - **Serve as important time indicators**
 - **Allow for correlation of rocks from different places**



Fossils: Evidence of Past Life

Conditions favoring preservation

- **Rapid burial**
- **Possession of hard parts (skeleton, shell, etc.)**



End of Chapter 8