Geologic Time Notes

Earth Realms Form and Evolve

●17 BYA: Universe Begins, give or take a billion or so

●5-7 BYA: Solar System Forms

Dust Cloud Hypothesis:

1) Collapsing Stage: 'space matter', dust and light gases (H_2 and He) collapse under their own weight

2) Flattening Stage: dust cloud flattens into a disc, with an early (proto) sun forming at a denser center

3) Clumping Stage: particles of 'space matter' clump together under their own gravity to form planetesimals (miniplanets) and protoplanets (early planets), such as Earth This is similar to the material that makes up the rings of Saturn

4) Heating and Melting Stage
    *Corresponds with Hadean Eon (see below)
    *Heating caused by:
        1) Internal heat from radioactive elements
        2) heat of friction from gravity collapse
        3) external heat from meteorite impacts
    *Formation of Geosphere and Primitive Atmosphere
    *Formation of Oceans (Hydrosphere): formed mainly from H_2O gas from the mantle that was erupted by volcanoes.
    *Biosphere: formed from bacteria (next Eons: Archean and Proterozoic)

History on Earth Through Geologic Time

<u>Hadean Eon (4.0-4.5 BYA)</u>
    *Earth cooled and separated into layers: crust, mantle, core
    *Early atmosphere formed from volcanic outgassing: H_20, CO_2, CH_4, and NH_3

<u>Archean Eon (2.5BYA-4.0BYA)</u>
    *"age of bacteria"
    *First Life forms: All life unicellular
    *Oldest rocks found on the planet
    *Final stages of Earth cooling and formation of the crust
    *Radioactivity kept continental crust thin and unstable

<u>Proterozoic Eon (2.5 BYA to 545 MYA)</u>
    *Most diamonds formed
    *Oldest sedimentary rocks (~2.5 BYA)
    *Formation of ozone layer
    *cyanobacteria-- photosynthetic bacteria
    *First multicellular organisms (late 600-700MYA)
    *Jellyfish - 670 MYA

Phanerozoic Eon "Visible Life"

Paleozoic Era--"Age of Ancient Marine Life"

Cambrian Period (505-545MYA)

*first abundant skeletons
*Bottom dwellers
*Trilobites, brachiopods, echinoderms, mollusks
*Burgess Shale, British Columbia-lots of soft bodied critters and arthropods
*RODINIA

Ordovician Period (438-505 MYA

*new trilobites, brachiopods, echinoderms as well as gastropods, cephalopods, and corals
*First vertebrates: jawless fish
*Graptolites, colonial and widespread
*Acadian Mountain formation

Cambrian and Ordovician, "Age of Marine Invertebrates"

Silurian period (408-438 MYA)

*"Age of Fishes, part I"
*Early land plants
*Very warm geologic period
*Heavy colonial life: corals, algae

Devonian Period (360-408 MYA)

*"Age of Fishes, Part II"-species dominate
*First insect fossils
*First forests: Evergreens
*First amphibians
*Ural and Carpathian Mountains in Europe

Mississippian Period (360-320 MYA) and Pennsylvanian Period (320--286 MYA) (Carboniferous in Europe)

*Widespread swamps, from coal deposits
*"Age of amphibians, part I"
*First reptiles
*Sharks abundant
*Appalachian Mountains formed

Permian Period (286-245 MYA)

*Major extinction event, marked by a relatively sharp change in climate (90-95% of all life)
*Supercontinent of Pangea intact
*Extensive glaciation of southern continents

Mesozoic Era – "Age of Reptiles"
One of the warmest and most stable climates of geologic time:

Triassic Period (200 MYA--245 MYA)
- *Breakup of Pangea, opening of Atlantic Ocean
- *earliest dinosaurs: the thecodonts
- *finback dinosaurs
- *earliest mammals (rodents)
- *dinosaurs were still relatively small (prototypes)

Jurassic Period (145 MYA – 200 MYA)
- *Diversification of Dinosaurs
- *Sauropods--huge plant eaters
- *Diplodocus, Apatosaurus (Brontosaurus), Brachiosaurus, Ultrasaurus
- *Allosaurs--meat eaters
- *Armored: stegosaurus
- *First flight: Archaeopteryx

Cretaceous Period (65 MYA-145 MYA)
- *Extreme Specialization of Dinosaurs
- *Tyrannosaurus--eating machine
- *Ceratopsians: Triceratops and Monoceras
- *Ankylosaurs: advanced armored dinosaurs
- *Pterosaurs: Pterodactyl, Pteranodon
- *Hadrosaurs (duckbilled): Mammal-like behavior, herding
- *Formation of Rocky Mountains
- *First flowering plants
- ***K-T Mass Extinction**

Cenozoic Era- "Age of Mammals"--(the last 65MY)
Tertiary Period (1.65 MYA- 65 MYA)
- Early (Paleogene): Early Primates
- *Primitive horses and camels, large birds
- *Formation of the Himalayas (Start)
- *Ice forms at the poles
- Late (Neogene): Significant ice caps at the poles
- *Mammals became huge and specialized
- *Brontotherium- rhinoceros
- *Smilodon - saber tooth cat
- *Megalotherium- giant sloth

Quaternary Period (6MYA to Present)
Pleistocene Epoch (1.65 MYA to 10,000 years ago)
- *Uplift of the Sierra Nevada
- *Numerous ice ages: Worldwide glaciation
- *Large carnivores to go with big herbivores
- *Major extinction at end of epoch: All the big stuff
- *La Brea tar pits: huge mammals

Holocene (10,000 to Present)
- *Humans dominant, eruption of Cascade volcanoes

Uniformitarianism

*the laws of nature do not change with time.

*Hutton- first to discover geological time, and the first to state that the Earth is much older than 6000 years.

*Before Hutton, everyone believed in catastrophism, which states that the shape of the Earth came to be quickly and violently.

*Catastrophism was a by-product of the fact that religion was in control of most governments.

First age of the Earth

*Archbishop Ussher (4004 BC, Oct 26 at 9 am)

*Georges Cuvier (1769-1832)

>Even earlier Naturalists and Geologists subscribed to catastrophism

>early French paleontologist / naturalist : each species was obliterated by a catastrophic event

*Charles Lyell: Principles of Geology (1830 - 1833): Responsible for the acceptance of a lot of Hutton's ideas. Eloquent writer compared to Hutton.

ACTUALISM: Modern Day Uniformitarianism

*The past is also the key to the present. (The present is the key to the past)

*Igneous Rocks record thermal events. Texture relates to cooling history of the rock. Phaneritic, Glassy

*Sedimentary Rocks: reflect change in environment on the Earth's surface.

>Rises and falls in sea level

>Climate

>Change in life forms

<u>UNCONFORMITIES</u>

Angular Unconformity

a) deposit of sediments
b) tectonic event
c) erosion
d) deposition

Nonconformity: Unconformity separating younger rocks from distinctly older, metamorphosed rocks

a) tectonic event produces some sort of crystalline rock
b) uplift with erosion
c) deposition

Disconformity: Unconformity in which beds on opposite sides are parallel

a) deposition
b) erosion
c) deposition

Paraconformity

a) deposition
b) erosion
c) deposition

The Age of the Earth

Efforts to determine the age of the Earth are based on efforts to determine how long Earth has existed as a planet revolving around the Sun.
Early attempts to estimate the age of the Earth were based upon:

1) Salinity of the Oceans: John Joly concluded in 1899 that the Earth was 90 to 100 million years old. He assumed that the ocean was originally freshwater, and that sodium and other stuff came from rivers that were eroding the land.

His estimates were too low because he did not take into account the fact that the ocean salt was locked up in marine limestone

2) Thickness of Sediment: Estimates range to 150,000 m
Average rate of sedimentation: 0.3m / 1,000 yrs.
Thus, age of earth 500 million yrs

Problems: 1.Estimating sedimentation rate
2.Unconformities

3) Heat Loss: Lord Kelvin (1824-1907): Based on present rate of heat flow
*Yielded age of 20 to 40 million yrs
*Estimates were low due to the fact that the Earth's heat is produced from radioactive decay, which is not constant.

Relative Dating

SUPERPOSITION: oldest are on bottom in undeformed sediments

FAUNAL SUCCESSION: The scientific law stating that specific groups of animals have followed or succeeded one another in a definite sequence through Earth history
*critters progress in a definite and determinable order

ORIGINAL HORIZONTALITY: due to gravity, sediments are deposited in a horizontal fashion

CROSS CUTTING RELATIONSHIPS: rocks which cut across others are younger that the rock they cut.

PRINCIPLE OF INCLUSION: if rock has an inclusion, the inclusion is older.

Absolute Dating

Radiometric Dating provides a method for directly measuring Geologic Time
*Half-Life: The time it takes for half of the nuclei of the parent isotope to decay into the daughter isotope.
>Most decays are relatively short.

Parent	Daughter	Half-Life
14C	14N	5730 years
3H	3He	12.8 years
40K	40Ar	1.25 Billion Years
87Rb	87Sr	48.8 Billion Years
238U	206Pb	4.5 Billion Years

100 g of 14C @ t=0

@ t1, 50 g of 14C, 50 g of 14N >>5730 years have passed

@ t2, 25 g of 14C, 75 g of 14N >>5730 (x2) or 11460 years have passed

@ t3, 12.5 g of 14C, 87.5 g of 14N >5730 (x3) or 17190 years have passed

Total Years Passed: 17190 years

Cosmogenic Techniques: The accumulation of cosmogenic nuclei are measured.
>^{10}Be and ^{37}Cl are the most commonly used.