

History of the Earth - GLY 302 - Spring 2011

Final Exam Review and Brief Notes

early - mid Paleozoic life

after the Cambrian Revolution's experiments, life settled into "standard" Paleozoic patterns
"the Paleozoic big three" brachiopods, bryozoans, crinoids
active invertebrate swimming predator: nautiloid cephalopods
reef builders: tabulate corals & stromatoporoid sponges
extinctions (and adaptive radiations) through time

periodic flooding of the continents

major, unconformity-bound sedimentary sequences on continents including much marine strata
result of large scale, long period (slow) transgression-regression cycles
apparently caused by changing rates of seafloor spreading

Appalachian Mountain Building - From One Supercontinent to Another

In the aftermath of the breakup of Rodinia, 4 major continental masses existed

Laurentia (ancestral North America)

Gondwana (contained cores of Africa, South America, India, Australia, and Antarctica)

Baltica (ancestral northwestern Europe)

Siberia (northern Asia)

Taconic Orogeny (Late Ord)

metamorphic belt (e.g., Manhattan Schist) + clastic wedge

caused by collision with volcanic island arc

evidence: basaltic volcanic rx found with deformed sedimentary rocks

(e.g., the amphibolite [metamorphosed basalt] in Central Park)

Acadian Orogeny (Dev)

metamorphic belt

extensive granite from melting in deepest hottest parts of the orogen

(e.g., granites of "The Granite State" and Maine)

clastic wedge (Catskill redbeds)

same as Caledonide Orogeny in NW Europe

The Old Red Sandstone of Britain equivalent to the Catskill redbeds

Acadian/Caledonian Orogeny the result of collision of Laurentia w/ Baltica (NW Eur)

New continent formed: "Laurussia"

Appalachian Orogeny (Penn-Perm)

produced the folds of the Appalachian Valley & Ridge province

blocks of deep basement rock uplifted - Grenvillian gneisses of the metamorphic highlands

high mountains, metamorphism beneath, clastic wedge forms on flank

Ouachita Orogeny in south-central North America, Mauritanide Orogeny in NW Africa

Hercynian Orogeny in southern Europe, Uralian Orogeny in Urals Mountains bet. Europe & Asia

All of these orogenies (Appalachian - Uralian) occurred at the end of the Paleozoic as a result of continental collisions that produced the supercontinent Pangea

Late Paleozoic glaciation: spread of forests (evolution of airborne fertilization) and enhanced weathering due to continental collisions & mountain building removed CO₂ from atmosphere

Evolution of Vertebrates - Part I, The Fishes

vertebrates are phylum chordata, subphylum vertebrata

oldest chordates were pikaia of the middle Cambrian

oldest vertebrate fossils (scales of jawless fish) are from the upper Cambrian

vertebrates have backbone and braincase

jawless fish (agnathans) had cartilage skeletons, some had bony plates on the head

lampreys and hagfish are about the only remaining jawless fish

Placoderms probably evolved in the Silurian (common in Devonian)

had jaws but no teeth - jaws modified into tooth-like shapes

cartilage skeletons and bony plates armoring their head

some very large predators

now extinct

Acanthodians probably evolved by the Silurian

cartilage skeletons

more streamlined form than placoderms

probably ancestors of the bony, ray-finned fish

now extinct

Sharks, rays & skates probably evolved by the Silurian, common in Devonian

cartilage skeletons

produce thousands of enamel covered teeth in their lifetime

sharks, rays, and skates still survive very successfully

Bony Fish - Ray-fins evolved in the Devonian (from acanthodian!?)

bony skeleton

fine bones support fins

ray-fins are the most diverse of all fish

Bony Fish - Lobe fins evolved in the Devonian

bony skeleton

muscular fleshy lobes support finer bones of the fins

the modern coelacanth and a few others still survive

Invasion of the Land

problems in adapting to life on the land (support, drying out, reproduction)

first land plants (ferns) and land animals (amphibians) need water for reproduction

age of fossil evidence for first land plants (late Ord. spores)

and first land animals ("bugs")

first tetrapods (Late Dev)

Carboniferous: Age of "Amphibians"

first amniotes: Carboniferous

difference between amphibian and amniote eggs

sauropsid and synapsid amniotes

Permian drying (Pangea vast interior dry regions & rain shadows plus glaciation (cool/dry)

led to the dominance of seed ferns (the first gymnosperms) and synapsids

gymnosperms ("naked seeds"), such as modern conifers, use airborne fertilization

Permian: Age of the "Reptiles"

dominant "reptiles" were the synapsids (they didn't give rise to any modern reptiles)

early, primitive synapsids: pelycosaurs; later, more advanced synapsids: therapsids

Permo-Triassic mass extinction - the biggest known - apparently related to flood basalts two pulses, the first, smaller (but very large) at the time of a large flood basalt in China the second (largest) at the time of massive flood basalts in Siberia (largest in the Phanerozoic) All together, 90-95% of all marine species (80-85% of all marine and terrestrial species) and 75% of all vertebrate families became extinct by the end of the Permian including, last of the trilobites, tabulate & rugosan corals

Mesozoic Life - Age of the Dinosaurs

early Triassic low fossil diversity then re-diversification (adaptive radiation)
mollusk bivalves, echinoids, scleractinian coral become dominant seafloor invertebrates
therapsid (synapsids) remain dominant land animals in Triassic
all therapsids (except mammal lineage) became extinct in the Triassic-Jurassic event
dinosaurs and other sauropsids became dominant after Triassic-Jurassic mass extinction
mass extinction occurred at time of major volcanic activity with early rifting of Pangea
Mesozoic sauropsids included: turtles, crocodiles, lizards, snakes
marine reptiles (ichthyosaurs, plesiosaurs)
flying reptiles (pterosaurs)
dinosaurs (evolved Middle Triassic)
dinosaurs (hole in the hip-socket) evolved Middle Triassic
(saurischians="lizard hipped" & ornithischians "bird-hipped")
birds evolved in the Jurassic from some small, saurischian (lizard-hipped), raptor
Archaeopteryx: the oldest bird fossils
mammals evolved from a branch of the therapsids in the Late Triassic
remained small throughout the Mesozoic
Dinosaurs became extinct at end of Cretaceous (Cretaceous-Tertiary mass extinction)
all except the birds, which had evolved in mid Jurassic from a group of dinosaurs

Cretaceous-Tertiary (K/T) mass extinction

killed dinosaurs, ammonites and many others
evidence for cause: iridium anomaly, glass spherules, shocked quartz
Chixulub crater off Yucatan
tsunami deposits in Caribbean and Gulf Coast
charcoal in western US
- all above point to meteor impact (not extraordinary volcanism) as cause of extinction
"nuclear winter" scenario (smoke & ash obscures sun, it gets cold, plants die, herbivores die...)

Pangea Breakup

Triassic-Jurassic rift basins (e.g., Newark Basin)
half-grabens filled with sedimentary strata (redbeds) and basaltic lava flows
oldest ocean crust in Atlantic between Africa and North America: mid Jurassic ~ 170 m.y.
passive margin sequence developed on the margins of the now separate continents
petroleum: central Atlantic was restricted seaway during Jurassic, climate was arid
extensive salt deposits in subsurface of present day Atlantic and Gulf coast continental shelf
salt diapirs rising through overlying strata have formed petroleum traps
Gondwana began to break up soon after separating from Laurasia (N. Amer + Eurasia)
S. Amer + Africa, then India, then Australia, then New Zealand unzipped from Antarctica
between 155 and 85 m.y. ago (Jurassic & Cretaceous)

Western Cordillera

western margin of N. Amer had been passive margin since Rodinia breakup
Devonian Antler Orogeny indicates a change to active margin, convergence, subduction
Jurassic and Cretaceous saw a great increase in rate of subduction-related igneous activity
Late Cretaceous Sevier Orogeny indicates increasing friction/compression

Latest Cretaceous - Eocene Laramide Orogeny:

massive compression, folding, thrust & reverse faults all the way across western 1/3 of
North America, all the way to the Front Range of the Rocky Mountains

Hypothesis:

Jur-Cret: N. Amer. starts moving west away from new Mid-Atlantic ridge
rate of subduction increase, rate of igneous activity increases

Late Cret. N. Amer. getting closer to midocean ridge (East Pacific Rise)
young ocean crust harder to subduct
shallower subduction angle, more friction & compression

Latest Cret-Paleogene midocean ridge just off shore

N. Amer grinds over ocean crust that is too young, hot, and buoyant to sink
into the mantle

extreme friction and compression

North America runs over midocean ridge and subduction stops

San Andreas Fault (system) connects the remaining segments of the still subducting
midocean ridge

Basin & Range extension (normal faults) occurring since subduction of the ridge

Columbia River Flood Basalt, Snake River basalts - Yellowstone: hotspot

Alpine-Himalayan Mountain Belt

As Gondwana broke up Africa/Arabia and India drifted northward toward Eurasia
India has been colliding with southern Asia and building the Himalayas since 60 m.y. ago
southeast Asia has been squeezed out of the way

Africa/Arabia has been colliding with southern Eurasia since ~ 35 m.y. ago
building the Alps Mountains

Turkey is getting squeezed out of Arabia's way

The Mediterranean is the last vestige of the Tethys Sea

The Mediterranean basin dried up ~ 5 m.y. ago (Messinian) but then re-flooded

Climate: From the Cretaceous Greenhouse to the Cenozoic Icehouse

Cretaceous climate was very warm, no icecaps, reptiles & tropical plants at high latitude
rapid seafloor spreading (high sea level) - rapid outgassing of CO₂ - warm climate

Paleocene-Eocene Thermal Maximum (~55 m.y.) extra warm, shift to light carbon isotopes
possibly caused by release of methane stored as slushy ice (clathrate) on seafloor

Cenozoic climate gradually descended to the ice ages

decreasing rate of seafloor spreading - decreasing CO₂ outgassing

major mountain building: Rockies, Alpine-Himalayan mountain belt

increased weathering - removal of CO₂ from atmosphere

Antarctic glaciation: opening of Drake Passage and thermal isolation of Antarctica (~35 m.y.)

glacial dropstones in deep ocean off Antarctica beginning at this time

northern hemisphere glaciation: closure of Isthmus of Panama (~ 3 m.y.)

intensification of the Gulf Stream

increased warmth & moisture caused onset of northern hemisphere glaciation???

or increased salinity caused N.Atl downwelling, decreased warmth to Arctic Ocean???

Pleistocene Ice Ages wax and wane with variations in Earth's orbital cycles and resulting small changes in solar insolation striking northern hemisphere during the summer

orbital cycles: eccentricity (100,000 yrs), tilt (41,000 yrs), precession (23,000 yrs)

evidence: oxygen isotopes in layers of marine carbonates compared to orbital calculations

some North American glacial features

terminal moraines in the midwest

terminal moraines cross New Jersey, Staten Island, Long Island, to Massachusetts

Harbor Hill & Ronkonkoma moraines of Long Island (form North Fork & South Fork)

the Hudson fjord was also carved out by glaciers

the Holocene epoch - the present and future climate

several warmer and cooler periods (e.g., Medieval Warm Period and Little Ice Age)

rapid warming since mid 19th century - the industrial revolution

Paleocene-Eocene evolutionary radiation of mammals

~22 orders of mammals rapidly evolved after dinosaurs (except birds) became extinct

mammals became dominant land animals of the Cenozoic following extinction of most dinosaurs

mammals learned to fly (bats)

mammals went back to the sea (whales & dolphins)

birds remained successful (and they are living dinosaurs!)

hominid evolution

primates evolve by Paleocene

hominoids - true apes - Oligocene

hominids - by Pliocene

Orrorin tugenensis (~6 m.y.) is oldest fossil of upright walking hominid

genus *Australopithecus* ("southern man") by ~4 m.y. ago

A. afarensis (Lucy's species)

A. africanus

A. robustus (a side branch, not on the line of descent to humans)

genus *Homo* arose by ~2.4 m.y. ago

Homo habilis ("handy man") fashioned crude stone tools

Homo erectus better stone tools, used fire, spread throughout old world

Homo Neanderthalensis in Europe by 100,000 yrs ago

Homo Sapiens in subsaharan Africa by 125,000 yrs ago

north Africa & middle east by 100,000 - 90,000 yrs ago

Europe by ~35,000 years ago

coexisted with Neanderthals for several thousand years until ~30,000 years ago

colonized North & South America around 13,000 yrs ago when glaciers broke up

North American large mammal extinctions (mammoths, mastodons, etc.)

cause: overhunting? warming climate? both?

new hypothesis: impact