

GEOL 102: Historical Geology
Final Exam Review

Review Exams 1 & 2

In general, know the basic patterns of:

- ❖ The Geologic History of major sections of North America (East, Gulf Coast, Midwest/central craton, Cordillera, West Coast) throughout geologic time
- ❖ The History of Life

The Phanerozoic Time Scale (You are not responsible for the numbers) :

<u>Eon</u>	<u>Era</u>	<u>Period</u>	<u>Epoch</u>	<u>Range (Ma)</u>
Phanerozoic	Cenozoic	Quaternary	Holocene	0.011784 — 0
			Pleistocene	2.588 — 0.011784
		Neogene	Pliocene	5.3 — 2.588
			Miocene	23.0 — 5.3
			Oligocene	33.9 — 23.0
		Paleogene	Eocene	55.8 — 33.9
			Paleocene	65.5 — 55.8
	Mesozoic		Cretaceous	145.5 — 65.5
		Jurassic	199.6 — 145.5	
		Triassic	251 — 199.6	
	Paleozoic	Permian		299 — 251
			Carboniferous/Pennsylvanian	318 — 299
		/Mississippian		359 — 318
			Devonian	416 — 359
		Silurian	444 — 416	
		Ordovician	488 — 444	
	Cambrian	542 — 488		

Mesozoic Era: Triassic (Tr):

Aftermath of P/Tr extinction (return of stromatolites; braided streams dominate over meandering; low oxygen levels; very low diversity faunas; “Liliput effect”). Amniote survivors dominated by those that could deal with low oxygen (nest in burrows, lived in mountains, semi-aquatic, etc.)

Sonoman Orogeny [Third phase of Cordilleran system] (latest P-early Tr) Sonomia collides with western North America

Triassic Climates: Redbeds; Coal Gap; Megamonsoons

Tr marine life: Rise of scleractinian corals; increased ammonoids diversity; radiation of all major fish groups (many mollusk eaters; freshwater actinopterygians)

Tr flora: at beginning, spore plant (quillworts) dominate; gymnosperms recover (conifers, cycads, ginkgoes, bennettitaleans, seed ferns). *Dicrodium* flora around Gondwanan glaciers.

Tr terrestrial animals: first termites; amphibians common, rise of modern amphibians; therapsids important in earlier Tr, decrease in importance over time, first mammals arise in Late Tr; diapsid reptiles dominant groups, including marine reptiles (placodonts, ichthyosaurs, early plesiosaurs) & flying reptiles (pterosaurs); archosaurs dominant group of diapsids, including crurotarsans (croc-lineage), pterosaurs, and dinosaurs.

Newark Supergroup: rifting of Pangaea to form Central Atlantic Basin; Central Atlantic Magmatic Province (CAMP); Tr/J extinction; CO₂ peak

Mesozoic Era: Jurassic (J):

Central Atlantic basin widens, separating Pangaea into Laurasia and Gondwana

Deserts common in Early J

Nevadan Orogeny [Fourth phase of Cordilleran system] (Middle J-Early K) Subduction of Farallon plate underneath western North America; standard Andean-style orogeny. Franciscan mélangé; molasse of Nevadan Orogeny = Morrison Formation

Transgression (many epeiric seas, flooding of European Archipelago), and return to calcite seas

J marine life: Scleractinian reefs; dinoflagellates & coccolithophorids appear; coiled oysters; belemnoids; pelagic crinoids; modern-style crustaceans; teleost fish evolve & diversify; ichthyosaurs and plesiosaurs common; marine crocs

J terrestrial animals: first moths; diversification of mammals; first pterodactyloids; “Golden Age” of dinosaurs, oldest feathered dinosaurs

Development of Atlantic Coastal Plain and Gulf Coast passive margin sedimentation

Mesozoic Era: Cretaceous (K):

Development of continuous deep marine record

Break up of Gondwana (although order of South Atlantic, western Indian, eastern Indian, and Southern Ocean rifting isn't certain)

Andean Orogeny (Early K-Holocene): Pacific plate subducted by South America

Separation of Laurasia & Gondwana allows formation of circum-equatorial current; extremely high temperatures; extremely high sea levels (displacement from mid-ocean ridges plus thermal expansion); epeiric seas (such as Western Interior Seaway in North America) at post-Pangaeian high; temperature difference between poles and equators very minimal

Mid-K speed up of sea floor spreading; Long Cretaceous Normal

Black shales common on coastal shelves & in epeiric seas: deep anoxic bottom water &/or effect of extra nutrients from land (eutrophication)

Sevier Orogeny [Fifth phase of Cordilleran system] (Cretaceous) Higher speed sea-floor spreading causes lower angle subduction of Farallon by North America, deformation moves eastward

New marine sediments: chalk, diatomite, foraminiferal ooze, rudist reefs

K marine life: coccolithophorids at diversity and abundance peaks; diatoms, first planktonic foraminiferans; ammonoids flourish; Mesozoic Marine Revolution (many new predators [advanced sea urchins, drilling snails, crushing crustaceans, teleosts, starfish, etc.] leads to loss of unprotected shallow epifauna); regular and (new for the K) irregular echinoids; advanced bryozoans; inoceramids; rudists; big teleost predators; plesiosaurs still doing well; sea turtles; mosasaurs; hesperornithines

K flora: angiosperms (flowering, fruiting plants) appear in Early K, co-evolution with insects & vertebrates, diversify in Late K (including magnolias, maples, rose-relatives, grasses)

K terrestrial animals: first butterflies, wasps, ants, bees; big radiation of herbivorous beetles; mammals continue to diversify, including multituberculates & therians (marsupials & placentals and their ancestors); first snakes; diverse crocodylians & pterosaurs; herbivorous dinosaurs (incl. largest dinosaurs, horned dinosaurs, duckbills) & carnivorous dinosaurs (giant predators, omnivores, insect eaters, first definite birds: by end of K, earliest modern birds)

K terrestrial world very provincialized due to epeiric seas & continental isolation

Maastrichtian Regression

Laramide Orogeny [Sixth phase of Cordilleran System] (latest K-Eocene) Begins & ends with massive volcanism, in between immense vertical uplift (up to 18 m)

Deccan Traps volcanism

K/Pg extinction: loss of ammonoids, belemnoids, rudists, inoceramids, larger fish, plesiosaurs, mosasaurs, many mammals & crocodylians, pterosaurs, all dinosaurs other than toothless birds, bennettitalean plants. Great reduction in coccolithophorids, foraminiferans, scleractinians.

Impact at Chicxulub (iridium spike, crater, shocked quartz, tektites, ejecta deposits, tsunami deposits); phases of destruction: shockwave & tsunami; "Easy-Bake Oven"; impact winter; greenhouse summer.

Cenozoic Era: Paleogene (Pg):

Low diversity in early Paleocene, but not as bad as Early Tr.

Paleocene terrestrial life: Angiosperm trees become important; rain forests widespread; archaic placental mammals in North America, Europe, Asia, Africa; marsupials in Australasia; endemic placentals & marsupials in South America. Mammals still small-brained and flat-footed.

Paleocene-Eocene Thermal Maximum (PETM): short term (<10 kyr) increase of CO₂ by 3-4x; some extinctions, some spread of animals over northern corridors

Draining of the last epeiric sea in North America (Cannonball Sea); massive volcanism and giant lakes in West

Eocene marine life: nummulitid forams; seagrasses expand; scleractinian reefs reappear; first sand dollars; giant sharks; acanthomorph teleosts radiate; first penguins, whales, sirenians

Eocene freshwater: freshwater diatoms, teleosts, stingrays

Eocene terrestrial life: specialized land mammals with bigger brains, longer limbs; predator flightless birds & land crocs (wiped out in later Eocene by advanced mammals); first bats

Chesapeake Bay impact

Opening of North Atlantic: European-Greenland/North American link broken

Alpine Orogeny (Eocene-Miocene) Series of Gondwanan microplates collide with southern Europe

Latest Eocene: drying, cooling climate.

Oligocene: Origin of Drake Passage and Tasman Sea: isolation of Antarctica and formation of circumpolar current and Antarctic Bottom Water. World cools down. Reduction in rainforests, spread of grasslands in South America, scrublands elsewhere; advanced Asian mammals invade Europe & North America; extinctions among forams & coccolithophorids; loss of multituberculates.

Tops of Cordillera eroded; origin of Oglalla Formation

Oligocene marine life: desmostylians; first baleen and modern toothed whales;

Oligocene flora: grasslands (in Eocene in South America), appearance of grazing adaptations in mammals (tall teeth, broad flat snouts, deeper jaws, running (cursorial) limb proportions)

Cenozoic Era: Neogene (Ng):

Himalayan Orogeny (Latest K-Miocene) First subduction of Indian Ocean plate under Asia, then collision of India with Asia

Miocene marine life: pinnipeds (seals, sea lions, walrus)

Dispersal of terrestrial animals: connections between Afroarabia & Eurasia and between Asia & North America (over Beringia) → The “World Continent”; South America, Madagascar, Australasia still isolated.

Late Miocene (~7-6 Ma): erosion of Himalaya absorbs much of CO₂ in atmosphere, reducing greenhouse and further cooling world. Shift from mostly C₃ plants to C₄ grasslands.

Erosion uncovers underlying Appalachian structures: modern topography

Messinian Salinity Crisis

Complex Neogene Western North American tectonics:

- Exhumation of the Rockies (late Miocene)
- Uplift of Colorado Plateau (middle Miocene)
- Yellowstone Hotspot volcanism, including:
 - Columbia River Traps (17.5—6 Ma)
 - Snake River Basalts (Pliocene)
 - Various supervolcano eruptions from middle Miocene onward
- Basin & Range Extension (25-15.4 Ma)
- Sierra Nevada uplift (~4 Ma)
- Change in sense of motion of plate boundaries in California
- Pacific Coast Ranges: volcanic arcs & folded mountains (~7 Ma onward)

Ng terrestrial life: meadow flora (grasses & composites) and fauna (various insects; rats & mice; toads & frogs; songbirds; colubrid snakes; raptorial birds); hominoid (“apes”) radiate; around ~7 Ma, hominins (human-apeman lineage) move out into expanding grasslands

Cenozoic Era: Quaternary (Q):

Glacial/Interglacial cycles driven by the Milankovitch Cycles

Formation of Isthmus of Panama → Oceanic Conveyor Belt → North Atlantic Deep Water

Q marine life: diversity drops; success of cold-adapted forms

Great American Interchange: South American mammals move north, “World Continent” mammals move south and displace most native South American forms

Q flora: tundra & mammoth steppe biomes

Q terrestrial animals: evolution of the “woolies”

Glacial Phases: ice sheets expand; eustatic sea level drop; rivers carve channels to edge of continental shelf; connections between lands; biomes move equatorward

Deglaciations: fast transitions (~5-25 years); ice sheets retreat; eustatic sea level rise; river channels flood into estuaries; biomes move poleward; glacial drift left behind

Interglacial Phases: drift becomes soil

Homo moves out of Africa in mid-Pleistocene; radiations in Asia & in Europe; *Homo sapiens* evolves in Africa by ~200 ka; moves out of Africa ~60 ka; “Great Leap Forward”; spreads across planet

Megafaunal extinctions

Deglaciation from Last Glacial Maximum; formation of many glacial lakes; Younger Dryas event (shutdown of Oceanic Conveyor Belt)

Neolithic Revolution (~10.5 ka): farming technology. Humans transform landscape, add sediment & nutrients to runoff (causing eutrophication), add greenhouse gases

Future:

Fission “fuel” of tectonics will eventually run out; loss of nutrients to Earth’s surface

By -1000 Ma, Sun will be too hot for liquid water on Earth

By ~-6000 Ma, Sun will enter Red Giant phase, and engulf Earth