GEOL 102: Historical Geology
Final Exam Review

Review Midterms 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 the Interactions of Earth & Life & Atmospheres
- The History of Life

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

Eon	Era	Period	Epoch	Range (Ma)
Phanerozoic	Cenozoic	Quaternary	Holocene	0.011784 — 0
			Pleistocene	2.588 — 0.011784
		Neogene	Pliocene	5.333 — 2.588
			Miocene	23.03 — 5.333
		Paleogene	Oligocene	33.9 — 23.03
			Eocene	56.0 — 33.9
			Paleocene	66.0 — 56.0
	Mesozoic	Cretaceous		145.0— 66.0
		Jurassic		201.3 — 145.0
		Triassic		252.2 — 201.3
	Paleozoic	Permian		298.9 — 252.2
		Carboniferous/Pennsylvanian		323.2 — 298.9
			/Mississippian	358.9— 323.2
		Devonian		419.2 — 358.9
		Silurian		443.8— 419.2
		Ordovician		485.4 — 443.8
		Cambrian		541.0 — 485.4

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 (near-shore and also pelagic forms such as 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; CO_2 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. Fransiscan mélange; 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 continue to diversify, including multituberculates & therians (marsupials & placentals and their ancestors); 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-Pangaean 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; first snakes; diverse crocodilians & 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 & crocodilians, 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.

<u>Cenozoic Era: Paleogene (Pg):</u>

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 CO_2 by 3-4x; some extinctions, some spread of animals over northern corridors, associated with flood basalts due to break up between Greenland and Europe and beginnings of the North Atlantic

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

Complete 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 Ogallala Formation

Oligocene marine life: desmostylians; first baleen and modern toothed whales; first pinnipeds (group that later produced seals, seal lions, walruses)

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

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 CO_2 in atmosphere, reducing greenhouse and further cooling world. Shift from mostly C_3 plants to C_4 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)

Miocene: peak diversity of whales, modern sharks

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, homininans (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 ~250 ka; moves out of Africa in a big way ~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), adding greenhouse gases; the "Anthropocene"

<u>Future:</u>

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