**SIO 75 Earth History Spring 2024**

This course follows SIO 50 to delve into the history of Earth’s geology and biology, addressing how we know about the changing sequence of Earth’s consolidation, initiation of the biosphere, tectonics, and climatology. A central thesis is that life has fundamentally shaped Earth from its minerals and tectonics to its atmospheric composition and recycling of Earth materials.

**Your instructors**

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Office Hours: M 10-11 am (Dick--Ritter 300C) and Th 10-11 am (Anna--TBA)

**Learning Objectives:**

* The rate of recycling of Earth materials has sped up over time, thanks to biological evolution.
* The rock types common on Earth have changed in response to cooling of the planet and biologically mediated geochemical changes in Earth’s surface environment.
* Atmosphere oxygenation, triggered by the evolution of oxygenic photosynthesis, has transformed Earth’s mineralogy, tectonics, weathering, and animal physiology.
* Earth’s plates have cycled between super-continent assembly and dispersion with implications for the planet’s sea level, climatology, and biodiversity.
* Earth’s biodiversity is mostly microbial and appeared before Earth has a rock record, while multicellular life mostly evolved in the past 500 million years.
* Analogs to most ancient ecosystems still exist on the modern Earth, but many familiar animals and environments—humans, the great whales, tunas, grasslands, cacti—are geologically young.

**Structure of the Course**

The class is built around two lectures/week and a Friday laboratory session as well as two ~hour excursions and one Saturday Field trip. Specifically:

* There is a ***short quiz for each Wednesday lecture*** period (10 pts each)
* Students will ***construct a timeline of major Earth events*** over the Quarter (10 pts/week).
* There will be a formal ***in-class midterm and final*** (each 100 pts).
* There is one Saturday ***Field trip*** to Split Mountain Gorge in Anza Borrego (April 6) and an in-class walk to the SIO Beach. All focus on describing local geology and tectonics; each are worth 50 pts. Because SIO trips are local, you can make this up on your own, but we strongly suggest doing the trips with the instructors or a fellow student who has already seen the geology to help fill in the details.
* ***Lab sections*** (50 pts each) occur during the regular class period on Fridays, and are a principal way for you to observe and interpret rocks, fossils and data sets that tell the story of Earth History. While there is ***no class textbook***, we have assigned readings and videos relevant to each lecture; both labs and lecture materials are drawn from these readings. The readings are designed to help with the quizzes and amplification of the material in the lectures. The class is loosely based on the structure of Prothero D.R., and Dott, R.H. Jr. 2010. Evolution of the Earth (8th ed) McGraw Hill. Hence, if you want a textbook, this is the one to buy.

**Late Policy:**

This class has a lot of ways for you to work with the instructors, but the pace also means we will be buried if assignments are not turned in when they are due. We do make exceptions for extenuating circumstances—just talk to us in advance of deadlines and we will try to make reasonable accommodations. The weekly quiz (10 pts each) is assigned on Tuesday (as an automatically graded Canvas Multiple choice question) and is due on Wednesday; it cannot be made-up afterward. Labs and field trip reports are due the week after they are assigned. After the due date, they can be turned in the following week for a maximum of 25 pts out of the original 50 pts. Timeline assignments are also due the week after they are assigned (for a full 10 pts), and likewise will be worth 5 pts for one week after the assigned due date. Labs and timeline assignments more than two weeks late will not be graded.

**Lecture Structure:**

All lectures are divided into ~12 minute “Quarters” presented as slide decks that will be available on Canvas. ***Please note*** that slides are accompanied by “presenter notes” that elaborate on the material on the slide. The presenter notes also refer to material in the readings/videos that you can look at for further clarification. Most lectures will feature class discussion at the end (the 4th Quarter)--typically interpreting rocks, fossils, or data sets using the information from the initial part of the lecture or the assigned readings/videos.

Syllabus: **Lecture Lab Field Trips**

Week 1 1. Geologic Time

**1st Quarter**: History of our understanding of deep time; **2nd Quarter:** Relative and absolute dates; **3rd Quarter**: Paleontology (and extinctions) as an early indicator of deep time; **4th Quarter**: If you landed on Earth 300 years ago, how would you tell how old the Earth is and when things happened in its history? What is your evidence for Earth with a history, or an “Old” Earth?

2. Sedimentary Rocks

**1st Quarter**: Sediments come in “Clastic”, “Biogenic” and “Evaporite” varieties; **2nd Quarter:** Sediment color, fossils and sedimentary structures are important indicators of the original environment of deposition. **3rd Quarter**: Sediments are deposited as beds; **4th Quarter**: Interpret these depositional environments—what kinds of sediments are likely to accumulate in different places?

Lab: Rocks indicative of Facies

Match the rock specimens against their likely facies.

Sat Field Trip: A Rift Sequence: Split Mt Gorge

Week 2 3. Stratigraphy

**1st Quarter**: Stratigraphy is the description of the layered sequence of sedimentary and volcanic rocks.; **2nd Quarter:** “passive margins”, rift zones, foreland basins and wrench basin; **3rd Quarter**: Sequences in different tectonic settings reflect accommodation, amount of magmatism, topography, and climate. **4th Quarter**: Discussion about stratigraphic sequence—what is going on in each of these examples?

 4. Telling Geologic Time

**1st Quarter**: The absolute timescale**; 2nd Quarter: i**sochrons; **3rd Quarter**: there are non-radiometric clocks too; **4th Quarter**: Discussion—here is a real magnetic inclination data set from Site 1218 (Eq. Pacific) with several biochronologic markers. Compare these data with the accepted global Geochronology. How old are points A, B and C?

Lab: Biostratigraphy

Make smear slides of deep-sea sediments to match the presence of discoasters against a known biochronology.

Week 3 5. Fossils

**1st Quarter**: Fossils are the remains of the bodies or behavior of organisms, **2nd Quarter:** “Trace fossils” and chemical fossils; **3rd Quarter**: Fossils record evolution—Natural Selection acts on variation to select those variants that enable one individual to outproduce another; **4th Quarter**: Inferences for different fossil specimens—what were the energetic, oxygen needs and motility of animals through geologic time?

6. Formation of Continents

**1st Quarter**: Formation of the Earth and Earth’s oldest rocks; **2nd Quarter:** Greenstone belts and first continental crust; **3rd Quarter**: appearance of blueschist and subduction tectonics; **4th Quarter**: Discussion (with samples): A modern continental crust sequence—what rocks (as hand specimens) goes where in the crust? How do you know? Role of water & pressure.

 Lab: Fossils

Basic styles of preservation, why are some shells preserved better than others? Some examples of trace fossils.

Week 4

7. Earth’s Early Ecosystems

**1st Quarter**: The first organisms on Earth; Controversial and enigmatic; **2nd Quarter:** Stromatolites indicate the presence of microbial communities; **3rd Quarter**: The atmosphere is initially without abundant free oxygen but there is diverse evidence for O2 by 2.5 Ga; **4th Quarter**: Discussion of implications of an oxygenated atmosphere.

8. The Proterozoic-Phanerozoic Transition

**1st Quarter**: Initial oxygenation triggers the Paleoproterozoic “Snowball Earth”; **2nd Quarter: The Snowball Earth model**; **3rd Quarter**: Fossil record is likely poor for the first animals **4th Quarter**: Discussion of a sequence of rocks representing Snowball Earth.

Lab: Record of Earth’s Atmosphere

Comparison of rocks that have significance for Earth atmosphere and ocean composition. Red bed, BIF; Sulfides; Stromatolite; Supermature Quartzite; Cyanobactera compression fossils

Week 5 Midterm

9. The Cambrian Explosion

**1st Quarter**: The first multicellular eukaryotes; **2nd Quarter:** First animals and the significance of burrowing ; **3rd Quarter**: The “Cambrian Explosion” represents ~50 Ma of diversifying animal life; **4th Quarter**: Why are Cambrian animals so well skeletonized? Why do flat-pebble conglomerates become extinct?

Lab: Ediacaran and Cambrian Animals

Examples of animals with questions on their preservation, and defenses—a comparison of ecology of trilobites. How to recognize a fake fossil?

 Field Trip: La Jolla Cove

Week 6 10. The Great Unconformity

**1st Quarter**: The great unconformity; **2nd Quarter:** Much of our pre-180 Ma record is that of Epicontinental seas; **3rd Quarter**: How to recognize unconformities and transgressive surfaces? **4th Quarter**: Why are shell beds so abundant in the fossil record?

11. The Tectonic Cycle

**1st Quarter**: Supercontinent formation & paleogeography; **2nd Quarter:** Salt and oil;  **3rd Quarter**: active margins, terranes, Exotic Terranes and foreland basins; **4th Quarter**: Discussion of geologic and fossil evidence of Pangea and its breakup. Implications of the formation of supercontinents—what kinds of rocks do we associate with supercontinent formation?

Lab: Wegner’s fossil evidence for continental drift

Mesosaurs in Namibia & Brazil; *Paradoxites* in Africa and Massachusetts; *Hyrachotherium* in Asia and Wyoming; Fusilinids (Exotic terranes).

Week 7 12. Paleozoic communities

**1st Quarter**: Trends in skeletonization and burrowing in the Paleozoic; **2nd Quarter:** first plants and forests; **3rd Quarter** Arthropods and vertebrates become terrestrial as well; **4th Quarter**: Discussion of the implications of Forests—these change Earth’s climate by burying CO2 as wood that eventually becomes coal drawing down CO2 to initiate glaciation and increasing the weathering of terrestrial rocks (making clay) that increases marine productivity and improves burial of CO2.

 13. Dinosaurs

**1st Quarter**: Diapsid and synapsid radiations start in the late Paleozoic and diverge in the Jurassic; **2nd Quarter:** experiments in flight; **3rd Quarter**: Radiation of reptiles in the oceans; marine turtles, ichthyosaurs, plesiosaurs and mosasaurs/pliosaurs; **4th Quarter**: Discussion: what is similar and what is different about dinosaurs and the marine life of the time, compared to today?

Lab: Dinosaurs & Mammals

Comparison of diapsids and synapsid skulls—feeding—stabbing, mashing, grinding, ripping; lever arms in the skull affect bite force; bone provides protection of the brain (or not).…

Week 8 14. Mammals

**1st Quarter**: The Mammalian strategy—hair, nurture young, tooth specialization; **2nd Quarter:** Cretaceous “chalk” seas and the rise of biogenic production of carbonate; **3rd Quarter**: the Western Interior Seaway and the Laramide Orogen; **4th Quarter**: Discussion: How can you drill through granite and hit oil?

15. Impacts & Large Igneous Provinces

**1st Quarter**: Definition of Mass extinctions; **2nd Quarter:** some extinction drivers; Question: how can we know about any of these—what kind of evidence can we seek?; **3rd Quarter**: evidence for Impacts & LIPs; **4th Quarter**: Discussion: Why didn’t everybody die?

 Lab: The K/Pg Boundary Event

Evidence for an impact—ejecta, impact melts, Pooks Pebbles; redeposition (the K/T Cocktail), why is there more impact ejecta east of the crater than west of it? Before and after of foraminifer assemblages;

Week 9 16. The Greenhouse World

**1st Quarter**: Greenhouse climates have implications for the state of the world; **2nd Quarter:** PETM is an analog to present; **3rd Quarter**: Disappearance of Tethys ocean, collision of India with Asia; **4th Quarter**: Discussion about implications of the record of the PETM sediment core—particularly for Ocean acidification, greenhouse warming and GHG release.

Lab: Dike Rock & Poway Conglomerate and Southern Calif Tectonics

(Tide is -0.3 at 9:05 am)

Field trip to see the Poway Conglomerate and play with Tanya Atwater’s kinetic models of the Borderland.

17. The Glacial World

**1st Quarter**: Cenozoic climate evolution—forests to grassland to desert, polar ice sheets; Why this drying trend? **2nd Quarter**: Evidence of glaciation; **3rd Quarter**: Radiation of mammals.; Appearance of whales, elephants; & horses; **4th Quarter**: Discussion of Whale evolution—the recent rise of the Giants in last million years

Week 10 18. Humans--Appearance of primates

**1st Quarter**: Human ancestors are “bushy”; **2nd Quarter**: human evolution is not linear**; 3rd Quarter**: Near modern humans radiate out of Africa multiple times; **4th Quarter**: Discussion of the NAT’s Cerudi Mammoth butchery site.

 19. The Anthropocene

**1st Quarter**: The time of elevated human impacts on Earth; **2nd Quarter:** But human induced change starts much earlier; **3rd Quarter**: The most lasting signatures of the Anthropocene will be visible into the distant geologic future; **4th Quarter**: Thought experiment for discussion: which of these will be the most recognizable to a future paleontologist, say 20 Ma from now?

 Lab: The Future Record of Us

Anthropogenic soil, fate of brick, concrete & plastic; Worked stone—why does this last and last? Deducing behavior from human skulls.