EART 206 -Great Papers in the Earth Sciences

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Lecture: W, F 9:30-11:15 E&MS Room D258
Office Hours: F 9:30-11:30(TB) E&MS A108 , **F 1-2** (QW) E&MS A212 or by apptmt.
Website: On ecommons

This course provides an opportunity for graduate students to explore the origins of a broad range of key issues in Earth Sciences by reading and leading discussions of classic papers that have been identified by the faculty. Most of the selected papers were key in the development of modern ideas in Earth Sciences. In many instances an early classic paper is paired with a more recent paper to emphasize subsequent evolution of the original ideas and to provide a modern perspective. The instructor will lead discussions of a few of the classic papers and will provide contextual perspectives. The class also provides a chance for students to practice their critical thinking and hone their scientific presentation and discussion skills.

Grading in the class will be based on attendance, participation, and presentations that students will give on the papers. Students will choose the papers they will present at the first class meeting. Each presentation should lay out the logic and methods of the paper and cover the main conclusions. Historical context, on both the ideas and the lead authors, is relevant and welcome. **A one-page summary of main points, impact and background on the paper should be distributed to the class before each presentation**. In some cases, supplemental reading is supplied that will help presenters (and other class participants curious about the topic). Before making their presentations, students should feel free to touch base with the instructor or another faculty meeting to ensure that their thinking about the paper is on track. After the class at which the presentation is made, a copy of the presentation (electronic or paper) should be provided to QW.

All students are expected to read every assigned paper. If there are points you do not understand, ask the presenter to clarify. Reading the papers in advance is essential and instructors may ask questions (a.k.a., give **pop quizzes** at their discretion) to ensure that everyone is preparing for the presentations by reading the papers.

SYLLABUS

First Class Meeting
M 1/4
Introduction and Logistics

Age of the Earth
W 1/6

1. Kelvin, L., On the secular cooling of the Earth, *Trans. Royal Soc. Edinburgh, vol. XXIII*, 295-310, 1862.
1. Stacey, F.D., Kelvin's age of the Earth paradox revisited, *J. Geophys. Res., 105,* 13155-13158, 2000.

Supplemental Reading:
Badash, L., The age-of-the-Earth debate, *Sci. Am.*, 261, 90-96, 1989.

M 1/11

1. Patterson, C., Age of meteorites and the earth, *Geochim. Cosmochim. Acta*, 10, 230- 237, 1956.
2. Dalrymple, G.B., The age of the Earth in the twentieth century: a problem (mostly) solved, *in* Lewis, C.L. and Knell, S.J. (eds.), *The Age of the Earth: from 4004 BC to AD 2002*, Geological Society, London, Special Publications 190, 205-221, 2001.

Darwin and Evolution
W 1/13

1. Darwin, C., Chapt. 15, *Origin of Species*, 353-374, 1859.
2. Eldredge, N., and S.J. Gould, Punctuated Equilibria: An Alternative to Phyletic Gradualism, pp. 82-115, in T.J.M. Schopf (ed.), Models in Paleobiology, Freeman, Cooper and Co., San Francisco, 1972. (Punctuated equilibrium: the paper that started it all, almost.).

Supplemental Reading
3. Mayr, E., Introduction, pp. vii-xxvii, in On the Origin of Species by Charles Darwin: A Facsimile of the First Edition, Harvard Univ. Press, Cambridge, MA, 1964. (The party line on Darwin and his role, written by one of the leading evolutionary biologists of the 20th [and early 21st] century. He died in 2005 at the age of 100, having written his last book at age 97.)

M 1/18 MLK day No class.

Origin of the Moon and Solar System Dynamics (2)
W 1/20

1. Canup, Robin M. "Dynamics of lunar formation." Annu. Rev. Astron. Astrophys. 42 (2004): 441-475.
1. Canup, R., Forming a Moon with an Earth-like Composition via a Giant Impact, Science, 338, 1052-1055, 2012.
2. Cuk, M. and S.T. Stewart, Making the Moon from a Fast-Spinning Earth: A Giant Impact Followed by Resonant Despinning, Science, 338, 1047-1052, 2012.

Structure and Composition of the Earth (2)
M 1/25

1. McDonough, William F., and S-S. Sun. "The composition of the Earth."Chemical geology 120.3 223-253, 1995.
2.Williamson, E.D. and Adams, L.H., Density distribution in the Earth, *J. Washington Academy of Sciences,* vol. 13, 413-428, 1923.

W 1/27

1. Silver, Paul G., and Mark D. Behn. "Intermittent plate tectonics?" Science 319.5859 (2008): 85-88.
2. Ringwood, A. E. "Phase transformations and their bearing on the constitution and dynamics of the mantle." Geochimica et Cosmochimica Acta 55.8 (1991): 2083-2110.

M 2/1 Crust-Mantle-Core differentiation.

1. Kemp, A.J.S. et al., Hadean crustal evolution revisited: New constraints from Pb-Hf systematics of the Jack Hills zircons, *Earth Planet. Sci. Letters*, 45-61, 2010.
2. Kleine, T. et al., Rapid accretion and early core formation on asteroids and the terrestrial planets from Hf–W chronometry, *Nature*, 418, 952-955, 2002
3. Jagoutz, Oliver E. "Construction of the granitoid crust of an island arc. Part II: a quantitative petrogenetic model." Contributions to Mineralogy and Petrology 160.3 (2010): 359-381.

Hotspots and Plumes (2)
M 2/3

1. Wilson, J.T., Evidence from islands on the spreading of ocean floors, *Nature,* 197, 536-538, 1963.
1. Morgan, W.J., Convection plumes in the lower mantle, *Nature* 230, 42-43, 1971.
2. Burke, K. and Dewey, J.F., Plume-generated triple junctions: Key indicators in applying plate tectonics to old rocks, *J. Geology* 81, 406-433, 1973.

Seafloor Spreading, Reversals, Subduction and Global Tectonics (2)
W 2/8

1. Wilson, J.T., A new class of faults and their bearing on continental drift, *Nature, 207,* 343-347, 1965.
1. Vine, F.J., Spreading of the ocean floor: New evidence, *Science, 154,* 1405-1415, 1966. (TBD)
2. Atwater, T., Implications of plate tectonics for the Cenozoic tectonic evolution of western North America, *Geol. Soc. Am. Bull., 81,* 3513-3536, 1970.

Fluids in the Earth (2)
M 2/10

1. Darcy, H., The Public Fountains of Dijon, 1856. Translated by P. Brobeck, Appendix D- Determination of Laws of Water Flow Through Sand, App. 2D.
2. Neuzil, C.E., Osmotic generation of 'anomalous' fluid pressures in geological environments, *Nature, 403,* 182-184, 2000.

Supplemental Reading
1. Neuzil, C.E., Abnormal pressures as hydrodynamic phenomena, *Am. J. Sci.* 295, 742-786, 1995.

W 2/17 (2)

1. Rubey, W.W., Geologic history of sea water, *Geol. Soc. Am. Bull. 62*, 1111-1148, 1951.
2. Hirth, G. and Kohlstedt, D.L., Water in the oceanic upper mantle: implications for rheology, melt extraction and the evolution of the lithosphere, *Earth Planet. Sci. Letters 144*, 93-108, 1996.

Atmospheres, Climate and Surface Processes (1)
M 2/22

1. Arrhenius, S. S., On the influence of carbonic acid in the air upon the temperature on the ground, *Phil. Mag.*, 41, 237-276, 1896.

W 2/24 Atmospheric Evolution (2)
1. Sagan, C. and Mullen, G., Earth and Mars: Evolution of atmospheres and surface temperatures, *Science*, 177, 52-56, 1972.
1. Brocks, J.J. et al., Archean molecular fossils and the early rise of eukaryotes, *Science*, 285, 1033-1036, 1999. (see also link to commentary by Knoll: http://www.sciencemag.org/cgi/content/full/285/5430/1025)
2. Bekker, A., Holland, H.D., Wang, P.L., Rumble III, D., Stein, H.J., Hannah, J.L., Coetzee, L.L. and N.J. Beukes, Dating the rise of atmospheric oxygen, *Nature*, 427, 117-120, 2004.
2. Som, S.M., Catling, D.C., Harnmeier, J.P., Polivka, P.M. and Buick, R., Air density 2.7 billion years ago limited to less than twice modern levels by fossil raindrop imprints, *Nature, 484*, 359-362 (2012).

M 2/29 (2)
1. Hays, J.D., Imbrie, J., and Shackleton, N.J., Variations in the earth's orbit. Pacemaker of the ice ages. *Science*, 194, 1121-1132, 1976.
2. Urey, Harold Clayton, et al. "Measurement of paleotemperatures and temperatures of the Upper Cretaceous of England, Denmark, and the southeastern United States." Geological Society of America Bulletin 62.4 (1951): 399-416.

W 3/2 Building and killing mountains (2)
1. Gilbert GK The convexity of hill tops, *J.* Geol., 17, 344–350, 1909.
1. Clark, M.K, and Royden, L.H., Topographic ooze: Building the eastern margin of Tibet by lower crustal flow, *Geology, 28*, 703-706, 2000. (TBD)
2. Molnar, P., and P. England, Late Cenozoic uplift of mountain ranges and global climate change: chicken or egg?, *Nature*, 346, 29-34, 1990.
2. France-Lanord, C., and Derry, L.A., Organic carbon burial forcing of the carbon cycle from Himalayan erosion, *Nature 390*, 65-67, 1997.

Hard Times on the Planet (2)
M 3/7

1. Alvarez, L.W. et al., Extraterrestrial cause of the Cretaceous/Tertiary extinction: experimental results and theoretical implications. *Science, 208*, 1095-1108, 1980.
2. Knoll, A.H., Bambach, R.K., Payne, J.L., Pruss, S. and Fischer, W.W., Paleophysiology and end-Permian mass extinction, *Earth Planet. Sci. Letters, 256,* 295-313, 2007.

Additional reading: Schoene et al., U-Pb geochronology of the Deccan Traps and relation to the end-Cretaceous mass extinction, Science, online only as of 1/2015: http://www.sciencemag.org/content/early/2014/12/10/science.aaa0118

W 3/9 (2)

1. Harland, W.B. and Rudwick, M.J.S., The great infra-Cambrian ice age, *Sci. Am.*, 211, 28-36, 1964.
1. Kirschvink, J.L., Late Proterozoic low-latitude global glaciation: The snowball Earth, in *The Proterozoic Biosphere*, J.W. Schopf and C. Klein, Eds., p. 51-52, Cambridge U. Press, 1992. .
2. Hoffman, P.F., Kaufman, A.J., Halverson, G.P., Schrag, D.P., A Neoproterozoic snowball Earth, *Science*, 281, 1342-1346, 1998.

Supplemental Reading

Hoffman, P.F. and Schrag, D.P., The snowball Earth hypothesis: testing the limits of global change, Terra Nova, 14, 129-155, 2002.

F 3/11 (2)

1. Keeling, C.D., R.B. Bacastow, A.E. Bainbridge, et al., Atmospheric carbon-dioxide variations at Mauna Loa Observatory, Hawaii, *Tellus, 28*, 538-551, 1976.
2. Molina, M.J. and F.S. Rowland, Stratospheric sink for chlorofluoromethanes - chlorine atomic-catalysed destruction of ozone, *Nature, 249*, 810-812, 1974.