Earth System Evolution-ESS-2303- Course Syllabus

Crucial environmental and biological changes occurred during the Precambrian-Cambrian transition. In this course we will review some key factors which may have influenced the emergence of animals using known fossil evidence, geochemical and sedimentological data and paleogeographic reconstructions. In addition, we will take a look at geologic events that resulted in progressive climate cooling over the past 55 Ma, ultimately leading into the ice age climate cycles.

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Class Schedule: Tuesdays 3-5pm. Room DV1160 (Mississauga Campus)

Course requirements:

1. Oral presentations:

Each student gives 2 “conference-style” presentations based on the suggested key papers but also on additional papers to properly cover the topic. Presentations are 30 minutes in length and are followed by a class discussion lead by the student presenter. Key papers for each topic are to be read by all students. The student discussion leader will also ask questions to the class, and participation is graded so all students must read the papers and be prepared to discuss the topic!

2. Papers:

Each student is responsible for one term paper. All term papers are due April 4th. Topics will be distributed randomly at the beginning of the first class from the list of topics below. Papers should be 10 pages (11 maximum), double spaced. The number of pages does not include references/tables etc…
Note: Topics for the oral and written assignments are the same, term paper topic will be selected from one of the two oral presentation topics at the beginning of the course.

3. Participation:

Each student is expected to read the key papers, to prepare questions and to participate in the class discussion.

4. Marking scheme: 40% presentations, 40% paper, 20% participation.

Course Schedule:

Date	Instructor	Topic
January-10	Halfar and Laflamme	Introduction to class and Intro lecture on Cenozoic Climate evolution
January-17	Laflamme	Presentation Rodinia
January-24	Halfar	Presentation Paleocene-Eocene Thermal Maximum
January-31	Laflamme	Presentation Neoproterozoic ocean chemistry
February-07	Halfar	Presentation Glaciation of Antarctica and Greenhouse-Icehouse Transition
February-14	Laflamme	Presentation Snowball Earth
February-21	Reading Week	NO CLASS
February-28	Halfar	Presentation: Tibetan Plateau
March-07	Laflamme	Presentation: Neoproterozoic and the evolution of animals
March-14	Halfar	Presentation: Isthmus Panama
March-21	Laflamme	Presentation: Ediacaran Extinction and Cambrian Explosion
March-28	Halfar	Presentation: Arctic glaciation
April-04	Laflamme	Presentation: Origin of Skeletons

Key papers to be read by all students

Laflamme topics:

1) **Rodinia and Neoproterozoic Continental Configurations**
    a. Evans, D.A., 2009. The palaeomagnetically viable, long-lived and all-inclusive Rodinia supercontinent reconstruction. Geological Society, London, Special Publications, 327(1): 371-404.
    b. Cawood, P.A., Wang, Y., Xu, Y. and Zhao, G., 2013. Locating South China in Rodinia and Gondwana: A fragment of greater India lithosphere?. Geology, 41(8):903-906.
2) **Neoproterozoic Ocean Chemistry:**
    a. Halverson, G.P. et al. 2005. Toward a Neoproterozoic composite carbon-isotope record. GSA Bulletin 117(9-10): 1181–1207.
    b. Macdonald F. A. et al., 2013. The stratigraphic relationship between the Shuram carbon isotope excursion, the oxygenation of Neoproterozoic oceans, and the first appearance of the Ediacara biota and bilaterian trace fossils in northwestern Canada. Chemical Geology 362: 250–272.
3) **Snowball Earth:**
    a. Hoffman, P. F., A. J. Kaufman, G. P. Halverson, and D. P. Schrag. 1998. A Neoproterozoic snowball earth. Science 281(5381):1342-1346.
    b. Rooney, A.D. et al. 2014. Re-Os geochronology and coupled Os-Sr isotope constraints on the Sturtian snowball Earth. PNAS 111: 51-56.
4) **Neoproterozoic and the Evolution of Animals:**
    a. Narbonne, G. M., Xiao, S., and Shields, G. 2012. The Ediacaran Period. Geologic Timescale, 427-449.
    b. Xiao, S., Narbonne, G.M., Zhou, C., Laflamme, M., Grazhdankin, D.V, Moczydłowska-Vidal, M., and Cui, H. 2016. Toward an Ediacaran Time Scale: Problems, Protocols, and Prospects. Episodes: 39 (4): 540-555.
5) **Ediacaran Extinction and Cambrian Explosion:**
    a. Darroch, S.A.F., Sperling, E.A., Boag, T.H., Racicot, R.A., Mason, S.J., Morgan, A.S., Tweedt, S., Myrow, P., Erwin, D.H. and Laflamme, M. 2015. Biotic replacement and mass extinction of the Ediacara biota. Proceedings of the Royal Society B 282: DOI: 10.1098/rspb.2015.1003
    b. Smith, E.F., Nelson, L.L., Strange, M.A., Eyster, A.E., Rowland, S.M., Schrag, D.P. and Macdonald, F.A., 2016. The end of the Ediacaran: Two new exceptionally preserved body fossil assemblages from Mount Dunfee, Nevada, USA. Geology, 44(11): 911-914.
    c. Schiffbauer, J.D., Huntley, J.W., O'Neil, G.R., Darroch, S.A.F., Laflamme, M., and Cai, Y. 2016. The latest Ediacaran wormworld fauna: Setting the ecological stage for the Cambrian explosion. GSA Today 26: 4–11.
6) **Origin of Skeletons**
    a. Porter, S.M. 2011. Calcite and aragonite seas and the de novo acquisition of carbonate skeletons. Geobiology 8: 256–277.
    b. Brennan, S.T., Lowenstein, L.T., and Horita, J. 2004. Seawater chemistry and the advent of biocalcification. Geology, 32: 473-476.

Halfar Topics

1) Cenozoic Climate evolution:

Zachos, J., Pagani, M., Sloan, L., Thomas, E., and Billups, K., 2001, Trends, rhythms, and aberrations in global climate 65 Ma to present: Science, v. 292, p. 686-693.

2) Paleocene-Eocene Thermal Maximum:

Zachos, J.C., Röhl, U., Schellenberg, S.A., Sluijs, A., Hodell, D.A., Kelly, D.C., Thomas, E., Nicolo, M., Raffi, I., Lourens, L.J., McCarren, H., and Kroon, D., 2005, Rapid acidification of the ocean during the Paleocene-Eocene thermal maximum: Science, v. 308, p. 1611-1615.

Zeebe, R. E., Zachos, J. C. & Dickens, G. R. Carbon dioxide forcing alone insufficient to explain Palaeocene–Eocene Thermal Maximum warming. Nature Geoscience 2, 576-580 (2009).

3) Glaciation of Antarctica

Lawver, L.A., Gahagan, L.M., 2003, Evolution of Cenozoic seaways in the cirum-Antarctic region, Palaeogeography, Palaeoclimatology, Palaeoecology, 198, 11-37.

Coxall, H.K., Wilson, P.A., Pälike, H., Lear, C.H. and Backman, J., 2005. Rapid stepwise onset on Antarctic glaciation and deeper calcite compensation in the Pacific Ocean. Nature, 433: 53-57.

4) Greenhouse-Icehouse Transition:

Tripati, A., Backman, J., Elderfield, H. & Ferretti, P. Eocene bipolar glaciation associated with global carbon cycle changes. Nature 436, 341-346 (2005).

Katz, M. E., Miller, K. G., Wrigth, J. D., Wade, B. S., Browning, J. V., Cramer, B. S. & Rosenthal, Y. Stepwise transition from the Eocene greenhouse to the Oligocene icehouse. Nature Geoscience 1, 329-335 (2008).

5) Tibetan Plateau:

Raymo, M.E., and Ruddiman, W.F. 1992. Tectonic forcing of late Cenozoic climate. Nature 359: 117-122.

Dupont-Nivet, G., Krijgsman, W., Langereis, C.G., Abels, H.A., Dai, S., and Fang, X. 2007. Tibetan plateau aridification linked to global cooling at the Eocene-Oligocene transition. Nature 445: 635-638.

6) Arctic glaciation:

Stoll, H.M., 2006, The Arctic tells its story: Nature, v. 441, p. 579-581.

Moran, K., Backman, J., Brinkhuis, H., Clemens, S.C., Cronin, T., Dickens, G.R., Eynaud, F., Gattacceca, J., Jakobsson, M., Jordan, R.W., Kaminski, M., King, J., Koc, N., Krylov, A., Martinez, N., Matthiessen, J., McInroy, D., Moore, T.C., Onodera, J., O'Regan, M., Pälike, H., Rea, B., Rio, D., Sakamoto, T., Smith, D.C., Stein, R., St John, K., Suto, I., Suzuki, N., Takahashi, K., Watanabe, M., Yamamoto, M., Farrell, J., Frank, M., Kubik, P., Jokat, W., and Kristoffersen, Y., 2006, The Cenozoic palaeoenvironment of the Arctic Ocean: Nature, v. 441, p. 601-605.

7) Closing of Isthmus of Panama:

Driscoll, N.W., and Haug, G.H., 1998, A short circuit in thermohaline circulation: A cause for northern hemisphere glaciation?: Science, v. 282, p. 436-438.

Haug, G.H., Tiedemann, R., Zahn, R., and Ravelo, A.C., 2001, Role of Panama uplift on oceanic freshwater balance: Geology, v. 29, p. 207-210.