12.490 Seminar in Astrobiology and Geobiology

Course Structure

Each student will choose a theme for discussion for one to two sessions from the suggested list below or by own. The student will select one recent significant paper and two to four papers for supplementary readings, and prepare one page handout for a summary and to discuss significance of the paper. He/she will prepare 15 minutes introduction, and lead a discussion for the week.

For students taking a course for credits, grades will be based upon preparation and participation to the discussion.

Suggested Themes

Deep Biosphere
J.S. Lipp, Y. Morono, F. Inagaki, K.U. Hinrichs, Significant contribution of Archaea to extant biomass in marine subsurface sediments, Nature 454(2008) 991-994.

J.F. Biddle, S. Fitz-Gibbon, S.C. Schuster, J.E. Brenchley, C.H. House, Metagenomic signatures of the Peru Margin subseafloor biosphere show a genetically distinct environment, Proceedings of the National Academy of Sciences of the United States of America 105(2008) 10583-10588.

Sulfur on Mars
S.S. Johnson, M.A. Mischna, T.L. Grove, M.T. Zuber, Sulfur-induced greenhouse warming on early Mars, Journal of Geophysical Research-Planets 113(2008).

Halevy, M.T. Zuber, D.P. Schrag, A sulfur dioxide climate feedback on early Mars, Science 318(2007) 1903-1907.

Weiss, B. P., D. L. Shuster, S. T. Stewart (2002) (2002) Temperatures on Mars from 40Ar/39Ar thermochronology of ALH84001, *Earth Planet. Sci. Lett.*, **201**, 465-472.

Methane on Mars
Geminale, V. Formisano, M. Giuranna, Methane in Martian atmosphere: Average spatial, diurnal, and seasonal behaviour, Planetary and Space Science 56(2008) 1194-1203.

Early Oxygen
P.G. Falkowski, L.V. Godfrey, Electrons, life and the evolution of Earth's oxygen cycle, Philosophical Transactions of the Royal Society B-Biological Sciences 363(2008) 2705-2716.

L.R. Kump, The rise of atmospheric oxygen, Nature 451(2008) 277-278.

Early Ocean-crust jack Hill Zircon
J.W. Valley, J.S. Lackey, A.J. Cavosie, C.C. Clechenko, M.J. Spicuzza, M.A.S. Basei, I.N. Bindeman, V.P. Ferreira, A.N. Sial, E.M. King, W.H. Peck, A.K. Sinha, C.S. Wei, 4.4 billion years of crustal maturation: oxygen isotope ratios of magmatic zircon, Contributions to Mineralogy and Petrology 150(2005) 561-580.

E.B. Watson, T.M. Harrison, Zircon thermometer reveals minimum melting conditions on earliest Earth, Science 308(2005) 841-844.

Y. Amelin, D.C. Lee, A.N. Halliday, Early-middle Archaean crustal evolution deduced from Lu-Hf and U-Pb isotopic studies of single zircon grains, Geochimica Et Cosmochimica Acta 64(2000) 4205-4225.

M. Menneken, A.A. Nemchin, T. Geisler, R.T. Pidgeon, S.A. Wilde, Hadean diamonds in zircon from Jack Hills, Western Australia, Nature 448(2007) 917-U915.

A.A. Nemchin, M.J. Whitehouse, M. Menneken, T. Geisler, R.T. Pidgeon, S.A. Wilde, A light carbon reservoir recorded in zircon-hosted diamond from the Jack Hills, Nature 454(2008) 92-U93.

Sulfidic oceans: evidence and implications

Canfield, D. E., 1998. A new model for Proterozoic ocean chemistry. Nature 396, 450-453.

Kump, L. R., Pavlov, A., and Arthur, M. A., 2005. Massive release of hydrogen sulfide to the surface ocean and atmosphere during intervals of oceanic anoxia. Geology 33, 397-400.

Arnold, G. L., Anbar, A. D., Barling, J., and Lyons, T. W., 2004. Molybdenum isotope evidence for widespread anoxia in mid-proterozoic oceans. Science 304, 87-90.

Evidence for early life

Allwood, A. C., Walter, M. R., Kamber, B. S., Marshall, C. P., Burch, I. W., 2006, Stromatolite reef from the Early Archaean era of Australia, Nature, 441, 714-718.

Tice, M. M., and D. R. Lowe. 2004. Photosynthetic microbial mats in the 3,416-Myr-old ocean. Nature 431:549-552.

N. Noffke, N. B. D. B. R. M. H. D. J. P. S. 2008. An actualistic perspective into Archean worlds – (cyano-)bacterially induced sedimentary structures in the siliciclastic Nhlazatse Section, 2.9 Ga Pongola Supergroup, South Africa. Geobiology 6:5-20.

Putative biosignatures in ALH84001

Weiss, B. P., S. S. Kim, J. L. Kirschvink, R. E. Kopp, M. Sankaran, A. Kobayashi, and A. Komeili (2004) Magnetic tests for magnetosome chains in Martian meteorite ALH84001, *Proc. Natl. Acad. Sci. USA*, **101**, 8281-8284.

McKay D. S., Gibson E. K., ThomasKeprta K. L., Vali H., Romanek C. S., Clemett S. J., Chillier X. D. F., Maechling C. R., Zare R. N. (1996). "Search for past life on Mars: Possible relic biogenic activity in Martian meteorite ALH84001". *Science* **273**: 924–930.

D. C. Golden, D.C. Golden, D.W. Ming, R.V. Morris, A.J. Brearley, H.V. Lauer Jr., A.H. Treiman, M.E. Zolensky, C.S. Schwandt, G.E. Lofgren, *et al.* Evidence for exclusively inorganic formation of magnetite in Martian meteorite ALH84001, American Mineralogist, May 1, 2004; 89(5-6): 681 - 695.

Climate on early Earth

J. F. Kasting and J. L. Siefert, Life and the Evolution of Earth's Atmosphere, 2002,*Science* **296**, 1066-1068

Kasting, J.F., Methane and climate during the Precambrian era, 2005, Precambrian Research, 137, 119-129.

Life on icy moons

Parkinson, C. D., Liang, M.C., Yung, Y. L., and Kirschvink, J. L., 2008, Habitability of Enceladus: Planetary Conditions for Life, Origins of Life and Evolution of Biospheres, 38(4), 355-369.

McKay, C., An Approach to Searching for Life on Mars, Europa, and Enceladus, 2007, Space Science Rev., 135, 49-54.

A. Sharma, J. H. Scott, G. D. Cody, M. L. Fogel, R. M. Hazen, R. J. Hemley, and W. T. Huntress Microbial Activity at Gigapascal Pressures *Science 2002 295:1514-1516;*

Evolution of metabolisms

Late Archean rise of aerobic microbial ecosystems, J. L. Eigenbrode and K. H. Freeman (2006), *PNAS* **103**, 15759-15764

Xiong, J., W. M. Fischer, K. Inoue, M. Nakahara, and C. E. Bauer. 2000. Molecular Evidence for the Early Evolution of Photosynthesis. Science **289:**1724-1730.

Ueno, Y., Yamada, K. , Yoshida, N., Maruyama, S., Isozaki, Y., Evidence from fluid inclusions for microbial methanogenesis in the early Archaean era, Nature, 440, 516-519.

Philippot, P., M. Van Zuilen, K. Lepot, C. Thomazo, J. Farquhar, and M. J. Van Kranendonk. 2007. Early Archaean Microorganisms Preferred Elemental Sulfur, Not Sulfate. Science 317:1534-1537.