Great Papers in the Earth Sciences

Great Papers, EPS 281r

(Spring 2013)

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Day & time: Wednesday 3-5

Location: Geological Museum room 413

1st meeting: Wednesday Jan 30 2013, 3pm

Bibliography: Papers are linked from this document.

this document: EPS281_syllabus_2013.pdf

Announcements. Feel free to write, call, or visit us with any questions.

1 Administrative

Prerequisites: This is a basic introductory breadth course and should be accessible to all Earth and Planetary Science graduate students.

Requirements: Apart from reading all assigned papers, students will be asked to prepare presentations on one or more of the topics to be covered during the course and based on the appropriate papers posted on the course web page, and lead a discussion during class. In addition, each student not part of the presenting group turns in a one page (12pt, single spacing) discussion of the paper briefly discussing: the objective of the paper, the approach/ methods used, the main results, and what does (or does not) make the paper great.

Guidelines for student presentations

Each subject will require two presentations by the students leading the corresponding discussion. You are welcome to organize in groups of 2-3 for this purpose.

The first presentation is about 5-slides, 10 minute long, and has a minimum font size of 24. It is given the week before the subject is discussed in class. The purpose of this brief presentation is to motivate the subject, and *especially* help the other students understand the more difficult aspects of the reading material.

The second presentation is about 30-slides long, has a minimum font size of 24, and is to be used during the discussion. Please provide some background for the other students, but then get to the actual paper within 5 to 6 slides. Please show the figures and equations from the paper, explain them, and provide guiding questions. In particular, make an effort to excite a discussion about the reading material. That is, the purpose of this presentation is to guide discussion, as opposed to supporting a lecture. Note that we may not cover all $\sim$30 slides if the discussion uses all the class time, and that this would be a good indication of a successful presentation. Make sure to switch presenting between group members every slide, rather than dividing the presentation into larger blocks.

Grading: Based on presentations, discussion, participation, one page summaries, and (mandatory) attendance.

2 Overview and goals

A survey of historic breakthrough papers in all of the earth sciences, as well as modern papers that put the classics in perspective. Students engage in the material through reading, presentation, and discussion. The course has several goals. (1.) To engender an understanding and appreciation of major breakthroughs in our field. (2.) To develop skills in presenting and discussing scientific results. And (3.) to refine students' understanding of what constitutes great science.

3 Syllabus

Here are some possible topics to be covered this year. The blue links below lead to the reading material for each lecture.

- Introductory lecture and discussion

Geophysics

- Whole-mantle versus layered mantle convection (geophysics). Birch (1952) and others to be sorted out among papers in sources directory.

- Polar Wander (geophysics). Gold (1955), Goldreich and Toomre (1969) and others to be added.

- Earth Dynamo (geophysics). Read the two Wikipedia entry, then the Larmor (1919) paper and then only the highlighted parts of Bullard (1949) ?.

- Earth age and thermal history (geophysics): read the wikipedia entry about the age of the Earth, and then the England et al (2007) historical review and the short address by Kelvin 1869 ("On geological dynamics"). Finally, read our classic papers: the exchange between Perry and Kelvin (specifically the file perry_kelvin_nature_January_1895.pdf). Optional: see beginning of the two Lord Kelvin piece from 1868 to learn more about Kelvin's opinion of geologists. For many more Kelvin papers, see here.

- Plate tectonics - sea floor spreading and magnetic reversals (geophysics). Read the brief wikipedia entry on the Vine-Matthews-Morley hypothesis and the wikipedia entry on plate tectonics. Then read Hess (1959) with the suggestion of convection cells driving sea floor spreading and prediction of sea floor magnetic patterns. Then read Vine (1966) for the actual observation and interpretation of the magnetic reversals. Optional: Vine and Matthews (1963)

• Plate tectonics - rigid plate motion on a sphere (geophysics). Read first the two wikipedia entries then the few pages from the book by Wegener. All this reading so far is quite simple. Then, depending on guidelines given to class read either Wilson's 1965 which introduces transform faults; or Morgan 1968 discussing tectonic plate motion on a sphere. [Optional: The Morgan paper has a very interesting history, see the fascinating LePichon notes which tell the story of why the McKenzie-Parker paper came out first although Morgan came up with the idea (and submitted the paper) before them. McKenzie-Parker 1967 and the original 1967 Morgan notes in the file MorganTectonoph91.pdf; also Hess 1962 early on hypothesized the modern tectonic cycle and supported it with a series of astute qualitative arguments.]

Geochemistry

• Whole-mantle versus layered mantle convection (geochemistry). Relevant early papers are Alegre et al (1979), Jacobsen and Wasserburg (1979), and O'Nions et al. (1979). Closure is obtained by Alegre, Hofmann and O'Nions (1996).

• Geothermal vents and origin of life (geochemistry/ geobiology).

• Stable isotopes and paleoclimate (geochemistry) Read the two wikipedia entries on $\delta^{13}C$ and $\delta^{18}O$, and then the Urey (1948) and Epstein et al (1953) classic papers. For essentially the current interpretation of marine $\delta^{18}O$ records, see Chappell and Shackleton (1986).

• Silicate weathering and CO2 (geochemistry) Read the papers by James et al (1981) and Berner et al (1983).

Planetary

• Origin of the Moon (Planetary sciences). Read the wikipedia article and then Careron and Ward (1976) and Hartmann and Davis (1975). Optional: the different hypotheses are more clearly presented in the papers by Cameron (1986) and Canup and Ashphaug (2001) that are in the "more" directory, and we encourage you to read these papers.

Atmospheric chemistry

• Reactivity of OH (atmospheric chemistry) Read the wikipedia entry and the two brief introductory web pages from www.atmosphere.mpg.de and www.niwa.cri.nz, then our classic paper by Levy (1971); and then read pages 147-149 in the AR4 IPCC report (section 2.3.5); optional: paper by Prinn in the `more/` directory.

• Ozone hole (atmospheric chemistry). Read the Wikipedia entry on Ozone depletion, and then the two classic papers: Molina and Rowland (1974) who predicted the ozone hole and its formation mechanism, and Farman, Gardiner and Shanklin (1985) who later observed it. Finally, to get an idea of the policy process that led to the successful ban on CFCs, read the Wikipedia entry on the Montreal Protocol and the Greenpeace summary of the DuPont position on CFCs and ozone hole.

Ocean, atmosphere, climate

• Stratospheric circulation Brewer-Dobson circulation (atmospheric dynamics). Read Brewer (1949) and Cordero et al chapter 6.3 (figures are available here). Optional: An outline of the dynamics of the B-D circulation is given in the notes, with references to relevant sections and equations in the Vallis textbook.

• Ferrel cell (atmospheric dynamics).

• Abyssal ocean circulation and deep western boundary currents. (physical oceanography). Read the Stommel-Arons (1960) paper that predicted a deep southward current under the northward flowing Gulf Stream, and the observational verification paper by Swallow and Worthington (1961).

• Thermohaline circulation (physical oceanography). Read the Rahmstorf (2006) encyclopedia entry first, then the classic Stommel (1961) paper, and then the Rahmstorf et al (2005) GRL paper. Pages 1,2,8,10 in the slides of the lecture from www.phys.uu.nl contain a simpler and clearer version of the (not so complex anyway) math involved.

• The Gulf Stream (physical oceanography) Read Stommel (1948).

• Hadley cell (atmospheric dynamics). Read (A) wikipedia entry, (B) Hadley (1735), (C) Schneider (2006) until the end of section 2.1 (pp 655-663). (Possibly replace this with a discussion of the Walker circulation.)

• Chaos and weather prediction (atmospheric dynamics). Read the brief introduction to chaos and then the wikipedia entry about fractals (better read this one on-line, for the nice animations in wikipedia), and then Lorenz 1963 paper itself. Note that Lorenz does not use the terms “chaos” or “fractals” which were only coined later, yet but he clearly understands both. For a nice on-line fractals demo, see here.

• Glacial cycles (geology, climate) Read the Wikipedia entry about Milankovitch cycles (changes in the orbital parameters of the earth around the sun which affect climate). Next, read our classic paper by Hays, Imbrie and Shackleton (1976). For the personality perspective in this case read the wikipedia entry about Louis Agassiz and the article by E.P. Evans in the file “did-agassiz-discover-glacial-cycles.pdf”. Note the contrast between (1) his objection to Darwin’s ideas, his “work” on “Racial classification”, and the suspicion that he may have stolen the glacial cycle idea from someone else, and (2) the fact that he was such a beloved, admired and influential scientist (especially wikipedia entry about him).

• Greenhouse effect (climate). Read (A) from IPCC chapter 2: executive summary, sections 2.1, 2.2 (including FAQ 2.1), 2.3.1, 2.3.2; (B) Arrhenius (1896).

Geology

• Snowball, Budyko-Sellers (geology, climate). Read the two page Kirschvink (1992) paper (that's our classic this time) and then Hoffman et al (1998). Finally, read the 1 page notes file energy_balance_0d for the Budyko-Sellers model which predicted the existence of a snowball earth in 1969.

• Extinctions and the KT impact hypothesis (geology). Read (A) wikipedia entry on Chicxulub crater, (B) wikipedia entry on KT boundary, (C) Alvarez et al (1980), (D) Raup and Sepkoski (1982).

More

• Gaia! (ecology). Read the wikipedia entry, pages 1-8, until but not including the "History" section. Then read Watson and Lovelock (1983), you may find the Gaia pdf notes on the course web page to be helpful in understanding this paper. Then read Kirchner (2002) with criticism of Gaia. In your report, in addition to the usual discussion, describe one example of a biological feedback that regulates the physical environment. [Optional: Lovelock and Margulis (1973).]

• Student selected topics. Each group selects a great paper not discussed earlier and presents its significance to the class. These presentations should be ~10 slides long, take about 30 minutes, and survey the findings in the paper and discuss what makes it great.