Syllabus – ASTRO250 CIPS Seminar: The Roles of Water in Planetary Science

Spring 2007

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Course Website: bspace.berkeley.edu (for all readings and updates)

Location & Time: Campbell 544 Hall, Wednesday, 12:00-2:00 pm

Course Outline

*Note: * indicates CIPS research lecture before class discussion.*

1/17 Introduction to Course

Where is the Water and Where did it Come From?

Solar System Evolution- Origins of Water: Comets, Stardust, and Isotopes

1/24 Readings: (1) Javoy, M. *Where do the oceans come from?*, C.R. Geosciences, 337: 138-159, 2005. (2) McKeegan, K.D. *Isotopic Compositions of Cometary Matter Returned by Stardust*, Science, 317, 1724-1728, 2006.

Optional Readings: (1) Robert, F. *The Origin of Water on Earth,* Science, 293, 1056-1058, 2001. (2) Lisse et al. *Spitzer Spectral Observations of the Deep Impact Ejecta,*Science, 313, 635-640, 2006. (3) Drake, M.J. and Righter, K. *Determining the composition of the Earth*, Nature, 416, 39-44, 2002.

Invited Speaker: *Andrew Westphal, Space Science Laboratory, UC Berkeley

Solar System Evolution- Origin of Water during Terrestrial Planet Formation

1/31 Readings: (1) Raymond, S.N., Quinn, T., and Lunine, J.I., *Making other earths: dynamical simulations of terrestrial planet formation and water delivery*, Icarus, 168, 1-17, 2004. (2) O'Brien, D. P. , Morbidelli, A. and Levison, H.F. *Terrestrial Planet Formation with Strong Dynamical Friction*, Icarus,184, 39-58, 2006.

Optional Readings: (1) Drake, M.J. *Origin of water in the terrestrial planets*, Meteor. and Planet. Sci, 40, 1-9, 2005. (2) Morbidelli,A. et al. *Source Regions and Timescales for the Delivery of Water to Earth*, Meteor. and Planet. Sci., 35, 1309-1320, 2000.

Invited Speaker: *David O'Brien, Planetary Science Institute

Water in the Deep Earth and the Recycling of Water

2/7 Readings: (1) Jeanloz, R. *The Hidden Shore – Water Locked Deep in the Earth Might Fill the Oceans Ten Times Over*, New York Academy of Sciences, 33: 26-31, 1993. (2) Williams, Q. and Hemley R.J., *Hydrogen in the Deep Earth*, Annual Review of Earth and Planetary Science, 29: 365-418, 2001.

Optional Reading: Hirschmann, M.M., W*ater, Melting, and The Deep Earth H_20 Cycle,* Annual Review of Earth and Planetary Sciences ,doi:10.1146/annurev.earth.34.031405.125211,2006.
Discussion Leader: Arianna Gleason, UC Berkeley

Water, Ice, and Aqeuous Alteration of Surface Minerals on Mars

2/14 Readings: (1) Milliken R.E., et al, *Hydration state of the Martian surface as seen by Mars Express OMEGA II – H20 content of the surface*, JGR submitted. (2) just the introduction and conclusion of Milliken R.E. and Mustard J.F., *Quantifying absolute water content of minerals using near-infrared reflectance spectroscopy*, JGR Planets, 110 (E12): Art. No. E12001, 2005.
Invited Speaker: *Ralph Milliken, JPL/Caltech

2/21 Reading: Clifford, S.M., and Parker T.J., *The evolution of the Martian hydrosphere: Implications for the fate of a primordial ocean and the current state of the northern plains.* Icarus, 154: 40-79, 2001.
Discussion Leaders: Michael Manga with student, U.C. Berkeley

Icy Planets and Ice in Protoplanetary Disks

2/28 Reading: Jewitt D., Chizmadia L.,Grimm R.,and Prialnik, D. *Water in the Small Bodies of the Solar System*, Protostars and Planets V, Conference Papers Astrobiology Institute, University of Hawaii
Invited Speaker: *Eugene Chiang, U.C. Berkeley
Discussion Leader: Eugene Chiang with student

3/7 Readings: (1) Porco, C.C., et al. *Cassini Observes the Active South Pole of Enceladus*, Science, 311, 1393-1401, 2006. (2) Kieffer SW, Lu XL, Bethke CM, et al., *A clathrate reservoir hypothesis for Enceladus' south polar plume*, Science, 314, 1764-1766, 2006.
Optional Reading: Spencer J. and Grinspoon, D. *Inside Enceladus,* Nature, 445, 376-377, 2007.
Discussion Leader: Student

Importance/Influence of Water

3/14 *LPSC – no class*

Properties of Water

3/21 Readings: (1) Stillinger, F.H. *Water Revisited*, Science, 209 (4455): 451-457, 1980 (2) Cabane, B. and Vuilleumier, R., *The physics of liquid water*, C. R. Geoscience, 337, 159-174, 2005.
Invited Speaker: *Jared Smith, Lawrence Berkeley Lab

3/28 *Spring Recess*

Life

4/4 Readings: (1) McKay, C. *The Search for Life on Mars*, Origins of Life and Evolution of Biospheres, 27, 263-289, 1997. (2) van Theinen P., et al. *Life and Planetary Geodynamical Evolution*, in press

Optional Reading: Gaidos E. and Selsis F., *From Protoplanets to Protolife: The Emergence and Maintenance of Life*. Protostars and Planets V, Conference Papers Astrobiology Institute, University of Hawaii

Invited Speaker: *Chris McKay, NASA Ames

Interior Dynamics in Icy Planets

4/11 Readings: (1) Barr, A.C. and McKinnon, W.B., *Convection in Ice I Shells and Mantles with Self-Consistent Grain Size*, JGR, in press, 2006. (2) Han, L. and A.P. Showman, *Thermo-compositional convection in Europa's icy shell with salinity*, GRL, 32, L20201.

Optional Readings: (1) Deschamps,F. and Sotin, C. *Thermal convection in the outer shell of large icy satellites*, JGR,106, 5107-5121, 2001. (2) McKinnon. W. B. *Geodynamics of Icy Satellites*. In, Solar System Ices. B. Schmitt., C. de Bergh., and M. Festou (Eds). Kluwer Academic. 525-550, 1998.

Invited Speaker: *Amy Barr, Southwest Research Institute

Atmospheres and Giant Planets

4/18 Readings: (1) Wong, M.H., et al. *Oxygen and other volatiles in the giant planets and their satellites. In Oxygen in the Earliest Solar System: Materials and Processes*, Chapter 8 (G. MacPherson ed.), Mineralogical Society of America: Chantilly VA, submitted 2006. (2) Sloane J. Wiktorowicz, S.J. and Ingersolla, A.P., *Liquid water oceans in ice giants*, Icarus, 186, 436-227, 2007.

Optional Reading: (1) Owen, T.C. and Encrenaz, T., *Compositional constraints on giant planet formation*, Planetary and Space Science, 54, 1188-1196, 2006.

Invited Speaker: *Michael H. Wong, U.C. Berkeley

History of Sea Water and Climate

4/25 Readings: (1) Rubey, W.W., *Geological History of Sea Water An Attempt to State the Problem,* Bulletin of the GSA, 62: 1111-1148, 1951. (2) Pierrehumbert R.T, *The hydrologic cycle in deep-time climate problems*, Nature, 419 (6903): 191-198, 2002.

Discussion Leader: Sasha Turchyn, UC Berkeley

Landscape/Surface Features

5/2 Reading: (1) Head J.W., Mustard J.F., Kreslavsky M.A., et al., *Recent Ice Ages on Mars*, Nature, 426, 797-802, 2003. (2) Malin M.C., Edgett K.S., Posiolova L.V., et al. *Present-day impact cratering rate and contemporary gully activity on Mars*, Science, 314 ,1573-1577, 2006. (3) Baker, V.R., *Water and the Martian Landscape*, Nature, 412, 228-236, 2001.

Optional Reading: Craddock, R. A. and Howard, A.D. *The Case for Rainfall on a Warm, Wet Early Mars*, JGR Planets,107, doi: 10.1029/2001JE001505.

Discussion Leader: Student

TBA “Final Exam” Group Discussion / Review