

Alex Pavlov² (pavlov@lasp.colorado.edu)Pushker Kharecha³ (pushker@essc.psu.edu)James F Kasting³ (kasting@essc.psu.edu)¹Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd., NW, Washington, DC 20015, United States²Center for Astrobiology, LASP/University of Colorado, Duane Physics Building, 392 UCB, Boulder, CO 80309, United States³Astrobiology Research Center, the Pennsylvania State University, Deike Building, University Park, PA 16802, United States

Multi-sulfur isotope ratios (³⁴S/³³S/³²S) were determined on sulfides extracted from two late Archean carbonaceous shale units, the Mt. McRae shale (~2.5 Ga) and the Jeerinah formation (~2.7 Ga), from the Hamersley Basin, Western Australia by using the CO₂-laser fluorination line at the Geophysical Laboratory. We have measured the largest $\Delta^{33}\text{S}$ anomaly yet reported for a terrestrial sample on sulfides from 22 m core section of the Mt McRae shale. The large positive $\Delta^{33}\text{S}$, up to +6.9 ‰, is found in the lower part of the core section; the $\Delta^{33}\text{S}$ shifts to negative upward in the section to as low as -1.9 ‰. The age of the Mt. McRae shale is bracketed by 2470 and 2561 Ma. Therefore, the observed isotopic shift represents the maximum duration of 91 million years, but most likely less than 30 million years by assuming a constant sedimentation rate for the Mt. McRae shale that has average thickness of 60 m in the area. Sulfide sulfur from the Jeerinah formation also yield large $\Delta^{33}\text{S}$ anomalies ranging from -0.1 to +4.4 ‰.

Our model fundamentally follows the one proposing a strong atmospheric influence in the Archean sulfur cycle by Farquhar et al. (2000). Our new data show the large and systematic variation between $\Delta^{33}\text{S}$ and $\delta^{34}\text{S}$. This allows us to further speculate the isotopic compositions of Archean sulfur reservoirs and the manner in which the atmospheric signature was transferred to sediments. Our data are consistent with the late Archean seawater sulfate reservoir that has a negative $\Delta^{33}\text{S}$ of -2 ‰. Thus, pyrite formed via microbial sulfate reduction shows variable $\delta^{34}\text{S}$ and negative $\Delta^{33}\text{S}$. The large positive $\Delta^{33}\text{S}$ of +6.9 ‰ is likely to be a signature of deposition of sulfur aerosol, probably elemental sulfur. Our sulfur isotope data is best explained by mixing of those two components. Atmospheric deposition of elemental sulfur requires an anoxic atmosphere, and subsequent burial and preservation of the signature into pelagic sediments would have been favored in an anoxic and iron-rich ocean in the late Archean Earth.

B71A-0734 0830h POSTER**MIF in Archean Rocks: An Evidence of S8 Aerosols in the Archean Atmosphere?**Alexander A. Pavlov¹ (303 - 492 - 4765; pavlov@lasp.colorado.edu)Shuhei Ono² (202 - 478 - 8987; s.ono@gl.ciw.edu)James F. Kasting³ (814 - 865 - 3207; kasting@essc.psu.edu)Douglas Rumble² (rumble@gl.ciw.edu)¹Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, LASP, University of Colorado at Boulder, Duane Physics Building, 392 UCB, Boulder, CO 80309-0392, United States²Geophysical Laboratory, Carnegie Institution of Washington, Geophysical Lab Carnegie Institution of Washington 5251 Broad Branch Rd., NW, Washington, DC 20015-1305, United States³Department of Geosciences, The Pennsylvania State University, Department of Geosciences, The Pennsylvania State University, 443 Deike Building, University Park, PA 16802, United States

Mass-independent fractionation (MIF) of sulfur isotopes has been reported in sediments of Archean and Early Proterozoic Age (>2.3 Ga) but not in younger rocks (Farquhar et al. 2000; Mojzsis et al., 2002). Furthermore, Farquhar et al. (2001) showed that sulfur MIF can be generated in atmospheric photochemical reactions (SO₂ and SO photolysis). In our previous work (Pavlov and Kasting, 2002), we demonstrated that in atmospheres with O₂ concentrations > 1E-5 PAL (present atmospheric level), all sulfur-bearing species would have passed through the sulfate reservoir before being incorporated into sediments, so any signature of MIF would have been lost. Therefore, the Archean atmosphere should have been essentially anoxic. However, insufficient experimental data on the details of sulfur MIF in the photochemical reactions did

not allow us to constrain the Archean sulfur cycle quantitatively.

Recently, Ono et al. (2002) reported large positive mass-independent anomalies (D33S up to +6.9 per mil) in the core samples from two carbonaceous shale units (2.5 - 2.7 Ga). Here we show that the anoxic Archean atmosphere is a necessary but not sufficient condition to explain this new geologic data.

Even if the Archean atmosphere were anoxic, the exchange between the reduced (H₂S, HS etc.) and oxidized (SO₂, H₂SO₄) sulfur species would have been fast. In our simulation, we have used a one-dimensional photochemical isotopic model (Pavlov and Kasting, 2002) to simulate this exchange. We show that the initially large D33S signature, acquired during SO₂ and/or SO photolysis (at about 9-10 km) would have been significantly decreased (to less than +2 per mil) in the gaseous sulfur species, as they would reach the ground level. Hence, it is highly unlikely that gaseous sulfur bearing species could deliver large positive MIF into Archean rocks.

We propose that the large D33S signature can be explained consistently if the reduced sulfur aerosols (S₈) were present in the anoxic Archean environment. Our model predicts S₈ formation at about 5 - 6 km. Once formed, the S₈ aerosols would not exchange isotopes with the rest of the atmosphere and could deliver large D33S to the ground essentially intact.

We find that the magnitude of D33S in S₈ aerosols should have been a strong function of S₈ atmospheric abundance, what in turns allows us to constrain the redox state of the Archean atmosphere and the SO₂ outgassing rate. Important climatic and biological aspects of the S₈ aerosols will be discussed.

B71A-0735 0830h POSTER**Measurements of CH₄ Mixing Ratio and D/H and ¹³C/¹²C Isotope Ratios in Atmospheric Samples from Continental United States**Stanley C Tyler¹ (949-824-2685; styler@uci.edu)Henry O Ajie¹ (949-824-5755; hoajie@uci.edu)Allison A Gotoh¹ (949-824-1998; aagotoh@uci.edu)Andrew L Rice² (206-616-4658; arice@ocean.washington.edu)¹University of California, Irvine, Earth System Science Dept., Irvine, CA 92697-3100, United States²University of Washington, Department of Oceanography, Seattle, WA 98195-5351, United States

We report δD and $\delta^{13}\text{C}$ measurements of atmospheric CH₄ from air samples collected bi-weekly from fixed surface sites in the United States. Our fixed surface sites are located at the mid-continental site Niwot Ridge, CO (41°N, 105°W) and a Pacific coastal northern hemispheric site receiving strong westerlies, Montaña de Oro, CA (35°N, 121°W). Data from multi-year bi-weekly sampling provide information relating seasonal cycling of CH₄ sources and sinks in background air, provide a record of long term trends in CH₄ mixing and isotope ratio related to atmospheric CH₄ loading, and may reveal information on regional sources of CH₄. Measurements of $\delta\text{D}\text{-CH}_4$ average $-93\pm 3\text{‰}$ (versus V-SMOW) at Niwot Ridge from 1999 through 2001 and $-97\pm 4\text{‰}$ at Montaña de Oro from 2000 through 2001. Annual seasonal cycles observed at both sites are $6\text{-}7\text{‰}$, exhibiting strong anti-correlation with CH₄ mixing ratio seasonality that appears to be largely sink-driven (i.e. through reaction with OH). More extensive time series in $\delta^{13}\text{C}\text{-CH}_4$ average $-47.2\pm 0.1\text{‰}$ (versus V-PDB) at Niwot Ridge from 1995 through 2001 and $-47.3\pm 0.2\text{‰}$ at Montaña de Oro from 1996 through 2001. In contrast to $\delta\text{D}\text{-CH}_4$, seasonality in $\delta^{13}\text{C}\text{-CH}_4$ has a relatively poor anti-correlation with seasonality in CH₄ mixing ratio, indicating significant source-driven influence. We discuss the implications of these measurements on the atmospheric CH₄ budget and detail the precision and accuracy of our data with respect international reference standards. It is our intention to have these data archived and available for modeling and advanced calculations by other atmospheric researchers in the near future.

B71B MCC: Hall C Sunday 0830h**Life and the Evolution of the Earth and Other Planetary Systems: Processes and Theories Posters (joint with H, OS, GC, PP)**

Presiding: A Kleidon, University of Maryland; S H Schneider, Stanford University; J Baross, University of Washington; M Meyer, NASA Office of Space Science

B71B-0736 0830h POSTER**Biogeochemical and ecological consequences of dissolved organic carbon released from soot particles from global firestorms at the Cretaceous/Tertiary boundary: Was the Strangelove Ocean a blackwater ocean?**Diane M McKnight¹ (303 492-4687; diane.mcknight@colorado.edu)Christian Steinberg² (stein@igb-berlin.de)Jill S Baron³ (970 491-1968; jill@nrel.ColoState.edu)¹INSTAAR, University of Colorado, 1560 30th Street, Boulder, CO 80309, United States²Leibniz Institute for Freshwater Ecology and Inland Fisheries, Mggelseedamm 310, Berlin D-12587, Germany³Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523-1499, United States

Phytoplankton productivity in the oceans was suppressed for about 200,000 years after the Cretaceous/Tertiary (K/T) boundary event, and many species of marine calcareous plankton became extinct at the boundary. Proposed causes for what has been called the "Strangelove Ocean" include acidification of oceanic surface waters and effects associated with deposition from a global cloud of firestorm ash. We evaluate the potential effects on the marine ecosystem of leaching of dissolved organic carbon (DOC) from firestorm soot particles. Based upon the quantity of soot deposited in the clay layer at the K/T boundary, we estimate that DOC concentrations in oceanic surface waters increased by at least a factor of two. These results are also supported by extrapolations based upon DOC increases in lakes and streams associated with deposition of ash in Rocky Mountain National Park from the Yellowstone fire of 1988. The soluble soot-derived humic substances would have had different chemical properties than marine humic substances, including a more aromatic character, greater absorptivity for visible light and greater quinone content. These humic substances could have acted as stress-inducing xenobiotic compounds and could have changed the physical and chemical characteristics of the marine environment. Cellular uptake of these humic compounds could have also inhibited calcite precipitation by coccolithophorids and foraminifera, contributing to the greater extinction of these species compared to dinoflagellates. Calculations show that the greater light absorption by the firestorm-derived humic substances would have decreased the depth of the mixed zone, limiting the dilution of the DOC pulse, and would have decreased the depth of the photic zone, spatially restructuring marine ecosystems.

B71B-0737 0830h POSTER**Implications for the Neoproterozoic Biological and Climatic History from Dating of the Doushantuo Phosphorites, S. China**Gry Hoffmann Barfod¹ (ghb@dlc.ku.dk); FrancisAlbarede² (Francis.albarede@ens-lyon.fr); AndrewH. Knoll³ (aknoll@oeb.harvard.edu); ShuhaiXiao⁴ (sxiao@tulane.edu); Robert Frei⁵(Robertf@geo.geol.ku.dk); Joel Baker¹ (jab@dlc.ku.dk)¹Danish Lithosphere Centre, Oester Voldgade 10, Copenhagen 1350, Denmark²ENS de Lyon, 46 Allée d'Italie, Lyon 69364, France³Botanical Museum, Harvard University, 26 Oxford street, Cambridge, MA 02138, United States⁴Department of Geology, Tulane University, New Orleans, LA 70118, United States

⁵ Geological Institute, University of Copenhagen, Oester Voldgade 10, Copenhagen 1350, Denmark

Models such as "Snowball Earth" suggest a link between Neoproterozoic glaciation events and the animal diversifications that preceded the Cambrian explosion. To evaluate such hypotheses, it is critical to resolve the precise chronology of the Neoproterozoic. As of now, ages of many Neoproterozoic sedimentary successions are only weakly constrained by bio- and chemostratigraphical correlation to successions that contain dated ash layers. Furthermore, attempts to radiometrically date sedimentary successions have had limited success. Pb-Pb and Lu-Hf dating of phosphates yield consistent ages close to 600 Ma for the Doushantuo phosphorites, South China. These age constraints are consistent with a depositional age estimate of 580 Ma \pm 20 Ma based on C-isotopic and biostratigraphic correlations (Knoll and Xiao, 1999, *Acta Micropaleontol.* 16). The dates are however significantly younger than earlier reported Rb-Sr and Sm-Nd ages (610-700 Ma) for the Doushantuo sediments, which have been ascribed to the influence from detrital clay on the measured isotope compositions. The Lu-Hf and Pb-Pb ages indicate that the exquisitely preserved animal remains found in the Doushantuo Formation predate diverse Ediacaran fossil assemblages and thus represent the earliest animal ancestry assemblage known. The Doushantuo formation lies directly above the Nantuo Tillite deposits, which is generally correlated with the "Marinoan" glaciation - the younger of the two major Neoproterozoic ice ages. Age constraints for "Marinoan" glaciogenic deposits only exist in Newfoundland and Massachusetts, where radiometric dating constrain the glaciation to be younger than 595.5 \pm 2 Ma. Compared to this date, the Pb-Pb age of 599.3 \pm 4.2 Ma for the Doushantuo phosphorites indicates that the Nantuo glaciation pre-dates the glaciation recorded in Eastern North America and therefore support the occurrence of a distinct post-Marinoan glaciation. The combination of Pb-Pb and Lu-Hf dating applied to successions with well-preserved fossils offers the best opportunity for direct dating of Proterozoic phosphatic deposits with the potential for calibrating the Neoproterozoic chrono-stratigraphical framework.

B71B-0738 0830h POSTER

Biomarkers: d13C and d15N Distribution Tightly Coupled to Nutrient Dynamics and Viral Lysing in a Microbial Mat From Death Valley, California

Ian Hewson¹ (213-740-5546; hewson@usc.edu)

Richard Archer² (303-948-4993; archerb@earth.usc.edu)

Claire Mahaffey¹ (213-740-5546; clairliv@liverpool.ac.uk)

James Scott³ (202-478-8908; j.scott@gl.ciw.edu)

Alexandre Tsapin² (213-740-6106; tsapin@earth.usc.edu)

¹ University of Southern California - Marine Biology Department of Biological Sciences, 3616 Trousdale Parkway AHF B4, Los Angeles, CA 90089, United States

² University of Southern California - Department of Earth Sciences, 3651 Trousdale Parkway 117, Los Angeles, CA 90089, United States

³ Geophysical Laboratory - Carnegie Institution of Washington, 5251 Broad Branch Road, N.W., Washington, DC 20015, United States

Extrapolations into ancient biomes make many assumptions and inferences regarding life modes and environmental habitat. While definition of a stromatolite as an extinct microbial biome by petrographic analysis is promising, Life interacts with its environment, actively manipulating energy flow across chemical disequilibria gradients, harvesting energy crucial for physiological maintenance and reproduction. Such structuring of communities in turn, leaves specific chemical/isotopic imprints related to physiological processes of prokaryotic communities specific to each oxidation/redox horizon. We examine stable isotopic d13C signals (d13C and d15N) as potential biomarkers reflecting bacterial physiology and microbial community nutrient-energy dynamics. While isotopes may reveal ancient chemical structuring of microbial mats, we also turn to invoking viral lysing of bacterial hosts in nutrient cycling within modern extreme environments as well as ancient stromatolite structures of early Earth.

Our records of d13C indicate extreme enrichment (-12) for Corg in our extant mat due to CO₂ limitation across a hypersaline diffusive barrier at the mat's surface. d15N is lowest at the mat's surface (indicating N₂ fixation) where nitrogen-fixing cyanobacteria *Microcoleus* sp. are present. Viruses are extremely abundant in the microbial mat, exceeding bacterial abundances by a factor of ten. The ratio of viruses to bacteria was very high (VBR = 39/10) compared with abundances in marine sediments. Distribution of viruses closely follows distribution of bacteria, suggesting bacteria as primary hosts. The ratio of viruses to bacteria

is inversely correlated to the concentration of organic C suggesting virus abundance is responsive to host substrate availability.

High ratios of viruses to bacteria in mid-mat horizons (2.5-3.7 cm) above increasing levels of d13C in deeper horizons, coupled with a lack of increase in bacteria, suggests that viral lysis contributes to significant downward organic C (polysaccharide exudates) transport within the mat. Subsequent accumulation of d13C as well as heavier d15N in deeper sediment (denitrification) horizons elucidates tight nutrient coupling between evaporite substrate, nitrogen fixing primary producers and downcore zones of active denitrification and sulphate reduction.

Discrepancies between d13C of ancient stromatolites (in line with C-3 photosynthetic pathways) and modern analogues (Badwater, CA) suggest a migration of microbial mats towards more extreme environments through time. A methodology for isotopically testing environmental and physiological responses in the geological record is presented here.

B71B-0739 0830h POSTER

On the Ages of Flood Basalt Events

Paul R. Renne¹ (510-644-1350; prene@bcg.org)

Vincent E. Courtillot² (33-1-44272434; courtill@ipgp.jussieu.fr)

¹ Berkeley Geochronology Center, 2455 Ridge Rd., Berkeley, CA 94709, United States

² Institut de Physique du Globe, Place Jussieu, Paris 75005, France

We review available data constraining the extent, volume, age and duration of all main continental flood basalts (CFB or traps) and oceanic large igneous provinces (LIP), going from the smallest Columbia flood basalts at ~16 Ma to the as yet ill known remnants of a possible trap at ~360 Ma in eastern Siberia. The 14 traps (CFB and LIP) reviewed form a rather unimodal distribution with an original modal volume on the order of 2.5 Mkm³. Most provinces agree with a rather simple first order model in which volcanism may last on the order of 10 Ma, often results in continental breakup, but where most of the volume (say on the order of 2/3rds) is erupted in about 1 Ma or sometimes less. This makes CFB/LIP major geodynamic events, with fluxes exceeding the total output of present day hotspots and possibly matching over shorter times scales the entire crustal production of mid-ocean ridges. The proposed correlation between trap ages and ages of a number of geological events, including extinctions and oceanic anoxia, is found to have improved steadily as more data became available, to the point that the list of trap ages may form much of the underlying structure of the geological time scale. The five largest mass extinctions in the last 260 Ma coincide (to the best resolution available) with five traps, making a causal connection between the two, through some form of catastrophic climatic perturbations, more than likely. Improvement by an order of magnitude in resolution of radiochronological or other dating techniques is of paramount importance to constrain in detail the flux history and differences between the physical, chemical and environmental characteristics of the various provinces.

B71B-0740 0830h POSTER

How Far Back in the Geological Record Is Bioalteration of Volcanic Glass Evident?

Karlis Muehlenbachs¹ (1-780-492-2827; karlis.muehlenbachs@ualberta.ca)

Harald Furnes² (harald.furnes@geol.uib.no)

Neil R. Banerjee¹ (banerjee@ualberta.ca)

¹ University of Alberta, Department of Earth and Atmospheric Sciences, Edmonton, AB T6G 2E3, Canada

² University of Bergen, Geological Institute, Allegt. 41, Bergen 5007, Norway

Ubiquitous alteration by microbes of volcanic glass from pillow lavas and tuffs has been documented in the upper 500m of in-situ modern oceanic crust. Bioalteration may be extensive enough to control the element balance between the upper oceanic crust and the hydrosphere. Such microbial processes deep within the modern crust raise questions relevant to the possible origin of life at mid-ocean ridges as well as sampling strategies for other planets. However, the evolutionary history of glass bioalteration or its preservability in the geological record is not known. We searched for evidence of ancient bioalteration of glass in L. Cretaceous to M. Proterozoic ophiolites ranging in metamorphic grade from non-metamorphosed to low greenschist to low amphibolite facies. Bio-generated textures are common in Cretaceous ophiolites where undevitrified glass is still present. These textures are similar to those found in volcanic glass of recent to old (170 Ma) in-situ ocean floor, and mimic microbes in terms of size and

shape. In the metamorphosed and completely recrystallized examples, the textural evidence of bioalteration is generally obliterated, though they may still be visible in pillow rims from little-deformed volcanic domains of low-grade greenschist facies metamorphism. Where bio-generated textures are present, element mapping invariably reveals in them organic carbon, and sometimes N, S and P. We suggest these clots may be metamorphosed remains of Ordovician microbes. Carbon-isotope signatures in the pillow lava rims from all the investigated ophiolites, show lower values than those of the adjacent crystalline parts. This phenomenon, also observed in modern pillows, may be attributed to bio-induced fractionation of carbon isotopes during preferential bioalteration of the pillow lava glass, and may further represent a feature that seems to survive metamorphism and deformation. Perhaps the Proterozoic pillows also suffered some bioalteration.

B71B-0741 0830h POSTER

Extreme Environments: Why NASA?

Michael A Meyer (202 358-0307; mmeyer@hq.nasa.gov)

NASA Headquarters, Code SE, Washington, DC 20546, United States

Life on our planet is the only known example in the universe and so we are relegated to this planet for the study of life. However, life may be a natural consequence of planet formation, and so the study of the origin, evolution, distribution and future of life may be greatly informed by planetary exploration. Astrobiology has adopted several approaches to study life on Earth, for deducing our origins, for determining the likelihood of life elsewhere, and for enabling the search for evidence of past or present life. The first approach has been the Exobiology Program, centered around understanding the origins of life and which supports individual investigator research. Second has been the construction of consortia-type research in which researchers from different disciplines focus on a larger problem. This structure began with NASA Specialized Centers of Research and Training and has grown to include the Astrobiology Institute a collection of competitively selected groups of researchers attacking problems in Astrobiology as individual teams and as a consolidated Institute. With the formation of an intellectual basis for exploring for life elsewhere, Astrobiology has initiated the competitive research and development program in instrument development (Astrobiology Science and Technology for Instrument Development [ASTID] Program) that would enable future mission instruments for the exploration of planetary bodies in the search for prebiotic chemistry, habitable environments (past or present), biomarkers, and possibly life itself. However, the act of exploring requires robust instrumentation, mobile robotic platforms, efficient operations, and a high level of autonomy. To this end, Astrobiology has started a new research activity that promotes scientifically-driven robotic exploration of extreme environments on Earth that are analogous to suspected habitable environments on other planetary bodies. The program is called Astrobiology Science & Technology for Exploring Planets (ASTEP). Through this program, we will expand the known limits to life on Earth, develop methodologies for detecting past and present life, and learn how to explore a rugged, novel environment while meeting astrobiology objectives.

B71B-0742 0830h POSTER

Microbial Diversity of Carbonate Chimneys at the Lost City Hydrothermal Field: Implications for Life-Sustaining Systems in Peridotite Seafloor Environments

Matthew O. Schrenk^{1,2} (206.616.9041; mos@ocean.washington.edu)

P.J. Cimino¹ (pjcc@u.washington.edu)

Deborah S Kelley^{1,2} (kelley@ocean.washington.edu)

John A. Baross^{1,2} (jbaross@u.washington.edu)

¹University of Washington, School of Oceanography, Box 357940, Seattle, WA 98195-7940

²University of Washington, Center for Astrobiology and Early Evolution, Box 351580, Seattle, WA 98195

The Lost City Hydrothermal Field (LCHF) is a novel peridotite-hosted vent environment discovered in Dec. 2000 at 30 N near the Mid-Atlantic Ridge. This field contains multiple large (up to 60 m), carbonate chimneys venting high pH (9-10), moderate temperature (45-75 C) fluids. The LCHF is unusual in that it is located on 1.5 my-old oceanic crust, 15 km from the nearest spreading axis. Hydrothermal flow in this system is believed to be driven by exothermic serpentinization reactions involving iron-bearing minerals in the underlying seafloor. The conditions created by such reactions, which include significant quantities of dissolved methane and hydrogen, create habitats for microbial communities specifically adapted to this unusual vent environment. Ultramafic, reducing hydrothermal environments like the LCHF may be analogous to geologic settings present on the early Earth, which have been suggested to be important for the emergence of life. Additionally, the existence of hydrothermal environments far away from an active spreading center expands the range of potential life-supporting environments elsewhere in the solar system.

To study the abundance and diversity of microbial communities inhabiting the environments that characterize the LCHF, carbonate chimney samples were analyzed by microscopic and molecular methods. Cell densities of between 10^5 and 10^7 cells/g were observed within various samples collected from the chimneys. Interestingly, 4-11% of the microbial population in direct contact with vent fluids fluoresced with Flavin-420, a key coenzyme involved in methanogenesis. Enrichment culturing from chimney material under aerobic and anaerobic conditions yielded microorganisms in the thermophilic and mesophilic temperature regimes in media designed for methanogenesis, methane-oxidation, and heterotrophy. PCR analysis of chimney material indicated the presence of both Archaea and Eubacteria in the carbonate samples. SSU rDNA clone libraries constructed from the Eubacterial DNA show that diverse microbial communities, including autotrophic microorganisms and animal symbionts, are contained within the vent structures. In concert, these results indicate that abundant and varied microbial communities inhabit different regions of the chimney structure and may be specifically adapted to the reducing, volatile-rich fluids percolating through the chimneys.

In addition to expanding the range of known deep-sea ecosystems, the microbial ecology of carbonate structures associated with hydrothermal venting at the LCHF may provide key insights into the microbiology of subsurface environments near this site. Studying the microbial communities within these systems will enable us to better understand geo-microbial processes associated with serpentine environments and perhaps allow us to expand our search for life elsewhere in the universe.

B71B-0743 0830h POSTER

Preserving the Record of Life in the Solar System

John D Rummel (202-358-0702; jrummel@hq.nasa.gov)

NASA Headquarters, Office of Space Science, Code S, Washington, DC 20546, United States

We have yet to discover, much less characterize, all of the environments on Earth that support life. Not surprisingly, our ability to make general statements about the distribution and characteristics of life is limited, and inferences about life's origins—even on this planet—are circumscribed. The potential that there exist extraterrestrial habitats in which life may be found drives certain aspects of space exploration, and the identification of extraterrestrial environments in which Earth organisms could survive is one strategy in establishing the existence of life on other worlds. Hence, deficiencies in our knowledge about life environments here limit our concepts of where to look for life outside of the Earth. But other factors also may limit our ability to learn general lessons about life as we identify and explore life environments here and elsewhere. In particular, each separate living environment can be viewed as containing unique data about the capabilities, distribution, and origin of life—data that may be lost or destroyed by the introduction of biological contamination

from other sites. This paper will address issues associated with avoiding such cross-contamination in solar system exploration, and while exploring restricted sites on Earth. While identifying specific sites of concern on other worlds, it will illustrate the role of experiments in synthetic environments in informing the precautions that must be taken to preserve the secrets of life that exploration seeks to uncover.

B71C MCC: 132 Sunday 0830h Water, Energy, and Carbon Exchange in Forest Systems I (joint with A, H, GC)

Presiding: B Law, Oregon State University; P Thornton, National Center for Atmospheric Research; D Baldocchi, University of California, Berkeley

B71C-01 0830h INVITED

Ecological Controls on Land-Atmosphere Exchange

Michael L. Goulden¹ (mgoulden@uci.edu); Marcy E Litvak² (mlitvak@mail.utexas.edu); Greg Winston¹ (gwinston@uci.edu); Scott D Miller¹ (sdmiller@uci.edu); Ed Read¹ (eread@uci.edu); Rob Elliot¹ (jelliott@uci.edu)

¹Department of Earth System Science, UC Irvine, 220 Rowland Hall, Irvine, CA 92697-3100, United States

²Department of Integrative Biology, 316 BioLabs, Austin, TX 78712, United States

We have been using long-term eddy covariance to investigate the patterns of energy and CO₂ exchange between the atmosphere and a freshwater marsh in California, and also between the atmosphere and a series of boreal forest stands in Manitoba, Canada. Most researchers believe that ecological phenomenon, such as plant herbivore interactions and interspecific differences in plant life-history strategy, are relatively unimportant in determining the interannual and landscape patterns of Land-Atmosphere exchange. However, we have found that interactions between plants and herbivores exert a large control on the interannual patterns of energy and CO₂ exchange in the freshwater marsh, and that interspecific differences in plant strategy are critical for understanding the landscape scale patterns of energy and CO₂ exchange in the boreal forest. Despite a relatively constant climate and flooding regime at the California marsh, annual Carbon balance varied by 6 tC ha⁻¹ or more from year to year. These deviations were caused in part by variation in herbivory by rodents and insects. Likewise, peak CO₂ uptake by boreal forest stands recovering from fire differed less than expected, with a 4-year-old stand assimilating CO₂ at rates comparable to that by middle aged stands, and faster than that by old stands. These patterns reflect differences in the life history strategies of the dominant plants, with the youngest stands dominated by fast growing ruderals, the middle aged stands dominated by fast growing competitive species, and the old stands dominated by slow growing stress tolerant species.

B71C-02 0845h

Seasonal Variations in Carbon, Water and Energy Fluxes in an Oak/Grass Savanna and in Photosynthetic Capacity of Oak Leaf in California

Liukang Xu¹ (510-6422421; lkxu@nature.berkeley.edu)

Dennis Baldocchi¹ (510-6422874; baldocchi@nature.berkeley.edu)

¹University of California, Berkeley, 151 Hilgard Hall, Dept. of Environmental Science, Policy and Management, Berkeley, CA 94720, United States

We present the results of measurements on flux and ecophysiology from two co-existing Ameriflux sites, a grazed annual grassland site and an oak/grass savanna site, located at the foothill of Sierra Nevada in California. The two sites are about 2 km apart, and have a Mediterranean climate with wet, cold winter and dry, hot summer. The predominant tree species is blue oak (*Quercus douglasii*) and grasses are C₃ species. The main objective of the study is to investigate the roles of high temperature, soil moisture and plant functional type on the carbon, water vapor and energy exchanges between

ecosystems and atmosphere. Continuous measurements of carbon and water vapor fluxes over and under the oak/grass savanna ecosystem started in April 2001 and over the annual grassland ecosystem in October 2000. Meteorological and soil parameters (air temperature, radiation, VPD, precipitation, soil moisture etc.) were also measured. Grass leaf area index (LAI), predawn water potential and gas exchange (A/Ci curve) of oak leaf were measured at 1-2 weeks intervals.

The annual grass germinates in late Oct after receiving a substantial rainfall and senesces in early May due to the soil drought development. Flux results show that daytime carbon uptake and latent heat flux (LE) at the grassland and understorey of the savanna followed closely grass LAI, which in turn was controlled by soil moisture content. Nighttime ecosystem respiration was found to track closely to the daytime photosynthetic rate, indicating the importance of photosynthetic assimilates allocation for respiration. During the dry summer, when the grass was dead, virtually all the available energy was partitioned into sensible heat (H). Small positive values of F_{CO2} were observed. We also observed large pulse ecosystem respiration after rain events during non-growing season. In our ecosystems with very low NEP, such rain events might be one of major environment forcings that cause larger inter-annual variability in NEE.

There are large differences in energy balance and partitioning over the two co-existing ecosystems. Net radiation balance (R_n) over the grazed grassland peaked (around 600 W m⁻²) as early, at the end of April, just before the grass senescence. While for the oak-grass savanna, R_n peaked (around 700 W m⁻²) more or less around summer solstice. More than one-third of the total energy exchange was attributed to the understorey throughout the season.

Oak tree leaf out occurred in late March, and it senesced in mid-Oct. From gas exchange measurements, it was found that maximum carboxylation rate (V_{cmax}) shows a strong seasonality. Peak V_{cmax} of over 120 μmol m⁻²s⁻¹ was reached shortly after the leaf full expansion in the early summer, but lasted less than a month. Then there was a progressively decrease followed by a senescence reductions in V_{cmax} during the middle and late summer. In contrast, Ball-Berry slope and marginal water cost of carbon gain are relatively constant over the whole season, even under severe drought when the predawn water potential of leaves dropped to -6.8 MPa. The constancy of the marginal water cost suggests that stomata still operate optimally under drought condition. It is clear from results that the seasonality of these photosynthetic parameters must be taken into account for long-term modeling carbon exchange between terrestrial ecosystems and atmosphere to accurately simulate GPP.

B71C-03 0900h

Large Carbon Uptake by an Unmanaged 250 year-old Deciduous Forest in Central Germany

Alexander Knohl¹ (+49 3641 643727; aknohl@bgc-jena.mpg.de)

Ernst-Detlef Schulze¹ (dschulze@bgc-jena.mpg.de)

Olaf Kolle¹ (okolle@bgc-jena.mpg.de)

Nina Buchmann¹ (buchmann@bgc-jena.mpg.de)

¹Max Planck Institute for Biogeochemistry, Carl-Zeiss-Promenade 10, Jena 07745, Germany

Unmanaged forests at a late stage of successional development are considered to be insignificant as carbon sinks, since in theory, assimilation is thought to be balanced by respiration. However, little experimental evidence for this hypothesis exists so far for forests at the ecosystem scale. Therefore, we performed continuous eddy covariance measurements of carbon dioxide over an unmanaged beech forest in the Hainich National Park in Central Germany as part of the EU project CARBOEUROFLUX. This forest shows typical characteristics of an advanced forest with large dead wood pools, a diverse stand structure and a wide tree age class distribution, up to 250 years.

Large carbon uptake rates up to 40 μmol m⁻² s⁻¹ were measured in summer while typical nighttime carbon losses were at around 4 μmol m⁻² s⁻¹. Consequently, this forest was a large carbon sink over two years, with 528 g C m⁻² yr⁻¹ in 2000 and 496 g C m⁻² yr⁻¹ in 2001. Daytime summer fluxes were strongly controlled by photosynthetic photon flux density (R² = 0.8 - 0.9), with minor effects of the ratio of diffuse to total downward radiation or the vapor pressure deficit. Nighttime CO₂ fluxes were mainly controlled by soil temperature (R² = 0.7) and soil moisture. In addition, high nighttime CO₂ fluxes (4 - 6 μmol m⁻² s⁻¹) were found directly before and during bud break in spring as well as just after leaf fall of both years (2000 and 2001), reflecting stand physiology corresponding to phenological changes, independent of soil temperature.

To increase confidence in these unexpected high carbon sinks, the usual quality checks such as stationarity tests and u_s correction were performed. In addition, measurements of wind profiles at 5 heights within