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Most familiar life forms on Earth live in the surface biosphere where liquid water, sunlight, and the essential chemical elements for life are abundant. However, such environments are not found on Mars or anywhere else in the solar system. On Mars, the surface environmental conditions of pressure and temperature prevent formation of liquid water. Furthermore, conditions at the Martian surface are unfavorable to life due to intense ultraviolet radiation and strong oxidizing compounds that destroy organic compounds. However, subsurface liquid water on Mars has been predicted on theoretical grounds. The recent discovery of near surface ground ice by the Mars Odyssey mission, and the abundant evidence for recent Gully features observed by the Mars Global Surveyor mission strengthen the case for subsurface liquid water on Mars. Thus, the strategy for searching for life on Mars points to drilling to the depth of liquid water, bringing samples to the surface and analyzing them with instrumentation to detect in situ organisms and biomarker compounds. The MARTE (Mars Astrobiology Research and Technology Experiment) project is a field experiment focused on searching for a hypothesized subsurface anaerobic chemoautotrophic biosphere in the region of the Rio Tinto, a river in southwestern Spain while also demonstrating technology relevant to searching for a subsurface biosphere on Mars. The Tinto river is located in the Iberian Pyrite belt, one of the largest deposits of sulfide minerals in the world. The surface (river) system is an acidic extreme environment produced and maintained by microbes that metabolize sulfide minerals and produce sulfuric acid as a byproduct. Evidence suggests that the river is a surface manifestation of an underground biochemical reactor. Organisms found in the river are capable of chemoautotrophic metabolism using sulfide and ferric iron mineral substrates, suggesting these organisms could thrive in groundwater which is the source of the Rio Tinto. The MARTE project will simulate the search for subsurface life on Mars using a drilling system developed for future Mars flight to accomplish subsurface access. Augmenting the drill are robotic systems for extracting the cores from the drill head and performing analysis using a suite of instruments to understand the composition, mineralogy, presence of organics, and to search for life signatures in subsurface samples. A robotic bore-hole inspection system will characterize borehole properties in situ. A Mars drilling mission simulation including remote operation of the drilling, sample handling, and instruments and interpretation of results by a remote science team will be performed. This simulated mission will be augmented by manual methods of drilling, sample handling, and sample analysis to fully document the subsurface, prevent surface microbial contamination, identify subsurface biota, and compare what can be learned with robotically-operated instruments. The first drilling campaign in the MARTE project takes place in September 2003 and is focused on characterizing the microbiology of the subsurface at Rio Tinto using conventional drilling, sample handling and laboratory analysis techniques. Lessons learned from this "ground truth" drilling campaign will guide the development of robotic systems and instruments needed for searching for life underground on Mars.

B51G-06 1140h INVITED

Records of our Early Biosphere Illuminate our Origins and Guide our Search for Life beyond Earth

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A scientific "mission of exploration to early Earth" will help us chart the distribution of life elsewhere. We must discriminate between attributes of biospheres that are universal versus those attributes that represent principally the outcomes of long-term survival specifically on Earth. In addition to the basic physics and chemistry of matter, the geologic evolution of rocky habitable planets and their climates might be similar elsewhere in the Universe. Certain key agents that drive long-term environmental change (e.g., stellar evolution, impacts, geothermal heat flow, tectonics, etc.) can help us to reconstruct ancient climates and to compare their evolution among populations of Earth-like planets. Early Earth was tectonically more active than today and therefore it exhaled reduced chemical species into the more oxidized surface environment at greater rates. This tectonic activity thus sustained oxidation-reduction reactions that provided the basis for the development of biochemical pathways that harvest chemical energy ("bioenergetics"). Most examples of bioenergetics today that extract energy by reacting oxidized and reduced chemicals in the environment were likely more pervasive among our microbial ancestors than are the presently known examples of photosynthesis. The geologic rock record indicates that, as early as 3.5 billion years ago (3.5 Ga), microbial biofilms were widespread within the coastal environments of small continents and tectonically unstable volcanic islands. Non oxygen-producing (non-oxygenic) photosynthesis preceded oxygenic photosynthesis, but all types of photosynthesis contributed substantially to the long-term increase in global primary biological productivity. Evidence of photosynthesis is tentative by 3.5 Ga and compelling by 2.7 Ga. Evidence of oxygenic photosynthesis is strong by 2.7 Ga and compelling by 2.3 Ga. These successive innovations transformed life from local communities that survived principally by catalyzing chemical equilibration to a globally dominant agent that created and sustained widespread chemical disequilibria in the environment and shallow crust. Major biogeochemical perturbations ca. 2.3 to 2.0 Ga, 1.3 Ga, and also 0.8 to 0.6 Ga, contributed to the irreversible oxidation of the global environment and perhaps also triggered evolutionary innovations (e.g., the development of multi-cellular biota) that became the foundations of our modern biosphere. Understanding the nature and timing of this ascent of life is crucial for discerning our own beginnings. This understanding also empowers our search for the origins, evolution and distribution of life elsewhere in our solar system and beyond. (This work was supported by the NASA Astrobiology Institute.)

B51G-07 1155h

Evolutionary and Ecological Sequelae of Mass Extinctions: Examples From the Continental Triassic-Jurassic Boundary

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The Triassic-Jurassic boundary at ~200 Ma marks one of the five major mass-extinctions of the Phanerozoic and, depending on the metrics used, was similar in magnitude to the K-T mass extinction. In continental environments about 50% of all tetrapod families are eliminated and although floral diversity change is difficult to gauge, a similar proportion of palynomorph taxa disappear at the boundary. The extinction event appears to have been very abrupt, followed by a roughly 900 ky super-greenhouse period characterized by increased precipitation. We hypothesize a series of biological consequences of the drop in diversity and associated super-greenhouse based on observations of the earliest Jurassic assemblages, largely from eastern North America. 1) The drop in diversity results in a collapse of ecological interactions that tend to stabilize the composition of regional biotas and buffer them from invading forms. Triassic assemblages show considerable biogeographic provinciality despite the existence of Pangea, but the earliest Jurassic assemblages were extraordinarily homogenous with many vertebrate genera being essentially global in distribution. 2) Initially the post-boundary terrestrial assemblages were comprised of eurytopic trophic generalists, with animal communities with few herbivores, but abundant carnivores and detritivores subsisting on aquatic-based food webs. The earliest Jurassic tetrapod footprint record is overwhelmingly dominated by the footprints of ceratosaurian theropod dinosaurs, the latter having skull characteristics usually associated at least in part with piscivory. 3) The dramatic size changes over very short periods of time were likely due to an absence of competition (i.e., ecological release). The maximum size of theropod dinosaur footprints increased by about 25% within 10 ky following the boundary, corresponding to a doubling of mass. 4) Representatives of clades with intrinsically high rates of speciation tend to form species flocks after the boundary. Species flocks of semionotid fishes dominated earliest Jurassic giant rift lakes in eastern North America, but not Triassic or later Early Jurassic lakes in the same basins. Based on footprint data, it is quite possible that there were also species flocks of morphologically similar ceratosaurian theropod dinosaurs in the Early Jurassic.

B51G-08 1210h INVITED

The astrobiology of Titan

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The known organic environments in the solar system other than the Earth and certain meteorites are in the outer solar system. Those of astrobiological potential are Europa, Titan, and comets. Titan is of interest because its nitrogen-methane atmosphere generates hydrocarbons and nitriles which fall to the surface and are protected from damaging particle and UV radiation by a thick atmosphere. Further chemistry, including in the presence of transient and localized areas of cryovolcanic- or impact-generated liquid water, may proceed on the surface in staccato fashion over geologic time. The Cassini-Huygens mission will initiate the detailed exploration of Titan in 2004, and this fall NASA solicited mission concepts for post Cassini-Huygens missions to Titan. A focus group on the astrobiological exploration of Titan has been founded by the NASA Astrobiology Institute under the leadership of the author. It will provide science rationales from an astrobiological perspective on the future exploration of Titan, i.e. beyond Cassini-Huygens, through electronic discussions and workshops. Early results of the Focus Group will be described in this talk.

URL: http://www.nai.arc.nasa.gov/institute/focus_groups.cfm

B52A MCC: Level 2 Friday 1330h

An Ecohydrological Perspective on Woody Plant Encroachment in Semiarid Regions II Posters *(joint with H)*

Presiding: **R L Scott,** USDA Agricultural Research Service**; D Breshears,** Los Alamos National Laboratory

B

B52A-1021 1330h POSTER

The Progression of Shrub Encroachment Into a Desert Grassland in Southern New Mexico from 1936-2003

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Woody plant encroachment into arid and semiarid grass-dominated landscapes has been noted in many parts of the Southwestern United States. This shrub advance has been observed on both the USDA-ARS Jornada Experimental Range (JER) and the adjacent New Mexico State University Chihuahuan Desert Rangeland Research Center (CDRRC) in southern New Mexico using varying ground survey techniques extending back to 1858. These two experimental ranges have also been imaged numerous times using aerial photography (and recently with high resolution commercial satellites) starting with USDA flights in the 1930's. Since 1936, thirty-seven separate aerial photography missions have been flown over parts of JER/CDRRC. Because rangeland remediation treatments are common in the Jornada Basin, it is difficult to find areas where no treatments, especially herbicide applications, have been employed to arrest the shrub advance. Aerial photographs were analyzed over Pasture 2 on the CDRRC where no herbicides or other treatments had been applied. There are 22 separate overflight dates covering Pasture 2 from 1936 to 2003. The aerial photos were scanned and digitized to analyze the amount of grass cover and its change over 60+ years. Despite encountering numerous difficulties in analyzing a greatly varying aerial photo data set (including varying resolutions, spectral intervals, moisture conditions, time of year of observation, and appearance of grass cover), the aerial photos provide an invaluable historic record. The grass cover obtained from remote sensing data in Pasture 2 is compared with the less frequent conventional vegetation ground surveys. The changing amounts of grass cover with time are related to various outside factors such as persistent drought periods. The rate of shrub advance across Pasture 2 has a direct influence on changes in the water, carbon, and energy cycles of these arid lands.

B52A-1022 1330h POSTER

Bush Encroachment and Soil Biochemistry: Controls and Feedbacks in Kalahari Rangelands

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In the Kalahari of Southern Africa the main ecological change following cattle-based agricultural intensification has been grass removal and bush encroachment, notably of Acacia mellifera. A conceptual 'state-and-transition' model has expressed changes to vegetation communities in Kalahari rangelands. However, many uncertainties remain as to the controls, processes and feedbacks leading to bush encroachment, due to previous inadequate spatial scales of data collection. The aim of integrated research from four sites across the Kalahari was to characterise the controls and feedbacks between ecological changes, soil properties and livestock grazing. Key research questions include: Do changes in soil water and nutrient cycling occur with, and/or cause, bush encroachment?; and, what mechanisms can explain the perceived resilience of Kalahari soils? Research includes process studies of nutrient leaching and mineralization; controlled plot studies examining the impacts of surface nutrient inputs and disturbance; local-scale analyses of spatial patterns of soil biochemistry and bush cover; and ranch-scale assessments of ecology and soil properties. The results demonstrate that bush encroachment has not been caused by, nor is it associated with, increased leaching of soil water and nutrients into the subsoil. Nutrient adsorption in the surface layer explains much of the resilience to soil chemical changes, together with the low mineralization rates that enable synchrony between nutrient availability and plant uptake by surface roots. The main encroaching bush species all have extensive surface rooting systems to enable their competitive dominance following intensive grazing. Bush encroachment is associated with increased spatial heterogeneity of surface nutrients with enhanced concentrations under bush canopies. This enrichment results from both plant canopy inputs, and the more extensive biological soil crust cover found in protected sub-canopy niches. As total nutrient concentrations are enhanced in the better-developed biological soil crusts, that are preferentially formed under A. mellifera, there is potential for a positive feedback mechanism that can explain the rapid spread of bush encroachment in Kalahari rangelands. However, encroachment could be curtailed if a nutritious grass resource is retained in the enriched sub-canopy niches. Sustainable rangeland use requires informed management to retain sub-canopy grass cover and seed resources to prevent the continued spread of A. mellifera cover.

B52A-1023 1330h POSTER

Rainfall Partitioning Within Juniper Canopies: Hydrologic Implications for Semiarid Communities

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Juniper canopies are ideally structured to intercept rainfall and redirect it to the base of the tree, thus altering the hydrology of the site. The amount of water redirected, and the amount lost to interception and evaporation, may be a significant portion of the annual rainfall. We monitored interception and rainfall partitioning in juniper canopies at 10 sites covering a 24 to 36 inch rainfall gradient over a 3 year period. Averaged over all 10 sites, about 47% of the precipitation falling on juniper trees is intercepted by the canopy of the tree and evaporated back to the atmosphere, 5% is intercepted by the litter and duff beneath the tree, and 48% actually reaches the ground surface for either recharge or plant growth. The amount of rainfall intercepted by the canopy is most affected by the intensity and duration of the storm. At high intensities, such as .5 inch over a 3 hr period, only 20% is intercepted by the canopy and litter. The remainder is available for either plant growth or aquifer recharge. When rainfall is less intense, such as 3 inches over a 19 hour period, all of the rainfall less than .5 inch is intercepted by the tree and litter. Not until nearly 1 inch of rain has fallen does an appreciable amount of water actually reach the ground surface beneath the tree. Most of the rainfall events observed over the last several years have been small events of less than .5 inches. These events, although common, do not contribute to soil water under juniper trees and are largely ineffective.

B52A-1024 1330h POSTER

How Plant Functional-Type, Weather, Seasonal Drought, and Soil Physical Properties Alter Water and Energy Fluxes of an Oak-Grass Savanna and an Annual Grassland

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Savannas and open grasslands often co-exist in semi-arid regions. How these contrasting landscapes affect the exchanges of energy remain to be quantified. Here we examine how a number of abiotic, biotic and edaphic factors modulate water and energy flux densities over an oak/grass savanna and an annual grassland that coexist in the same climate but on soils with different hydraulic properties. The net radiation balance was greater over the oak woodland than the grassland despite the fact that both canopies received similar sums of incoming short and long wave radiation. The lower albedo and lower surface temperature of the transpiring woodland caused it to intercept and retain more long and shortwave energy during the dry period. The observed differences in net energy exchange had profound impacts on canopy evaporation and sensible heat exchange. The woodland evaporated about 380 mm per year and the grassland evaporated about 300 mm per year. Differences in the water holding characteristics of the soils at the two sites account for this difference in evaporation, and provide a partial explanation why the vegetation differs at the two sites. The response of evaporation to diminishing soil moisture was quantified using information on volumetric water content, soil water potential of the root zone and predawn water potential. When soil moisture was ample, after recharging winter rains, values of latent heat flux density, normalized by the equilibrium evaporation rate, were greater for the grassland than for the oak savanna. The grassland died and quit evaporating when the water content of the soil dropped below the permanent wilting point (-1.5 MPa). The oak trees, on the other hand, were able to transpire, at low rates, under very dry soil conditions (soil water potentials down to -4.0 MPa). The trees were able to endure such low water potentials and maintain basal levels of metabolism because a few exploratory roots tapped deep water sources during the dry season and the density of the woodland remained low.

B52A-1025 1330h POSTER

Response of Stream to Variation in Vegetation in Pedernales Watershed

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Natural water level changes in an aquifer are mainly due to changes in the groundwater recharge and discharge conditions of the aquifer. Increased stream flow in response to brush removal will be most apparent in springs and small headwater streams, because small increases in subsurface flow are unlikely to create measurable in discharge of mainstream channels located downstream (Wilcox, 2002). The major objective of this study tries to estimate the flow of springs responding from brush management. In this research, we measured and reported on the flow at 30 spring sites during the summer in 2003. There are twelve springs in Blanco County, and the others are in Gillespie County. There are three spring sites with heavy salt cedar in the upper watershed, four spring sites with moderate salt cedar in the upper watershed, six spring sites with light salt cedar in the upper watershed, fourteen spring sites with grassland and oak woodland, and three spring sites in the grassland without salt cedar. Because there is significant heterogeneity of flow between different vegetation types, we regroup the amounts of flow with same interval into seven groups. The highest average amount of flow is with grassland and oak woodland, and the lowest average amount of flow is with grassland. The amounts of flow are significant different between vegetation types (Chi-Square < 0.01). Spring flow is low in grassland. More springs dried out in the sites with salt cedars or oak woodland.

B52A-1026 1330h POSTER

Climate controls on tree-grass composition and function in savannas

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Climate fluctuations are believed to trigger nonlinear vegetation dynamics in savanna, such as transition from a state of grass and wood coexistence to a persistent woody state, potentially altering land surface response to climate forcing. We examine sensitivity of wood-grass composition to climate perturbations as well as changes in evapotranspiration and productivity as a function of vegetation composition by analyzing results from numerical simulations. Experimental results from our previous work motivate a simple modeling approach to dynamics of grass and woody plant functional types. The model estimates daily carbon exchanges from soil moisture limitation of potential evapotranspiration coupled to water use efficiency, and tracks daily carbon fluxes to update vegetation fractional cover of wood and grass biomass over multiple decades. We use coherence, phase, and transfer function measures to quantify the degree of coupling between rainfall with transpiration for a range of grass and woody states. A shift in vegetation composition from grass to woody dominance decreased the coherence of transpiration with rainfall at daily to weekly timescales and increased the peak phase-lag of land surface response from 2 to 7 days. We also estimate climate controls on the rate of recovery of the wood-grass state from fire and grazing disturbances.

B52A-1027 1330h POSTER

Rainfall Simulation Study of a Hillslope Covered in Dense Juniper

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Over the last hundred years, the semi-arid region of Southwestern United States has undergone a considerable change in landscape. The region that was once primarily covered by native grass has been invaded with brushy species, such as ash juniper (cedar) and mesquite. This brush encroachment has resulted in a major effect on the hydrologic cycle. With new brush species dominating the once grass-covered landscape, new trees are believed to transpire more water on an annual basis. In addition, the tree canopy traps more water through interception, which makes the water more susceptible to evaporation. It is thought that these processes limit water infiltration into the saturated zone, which results in less groundwater recharge. An alternative belief is that these new trees promote infiltration and groundwater recharge by creating preferential flow paths via extensive deep roots, which channel water through the vadose zone to the groundwater. A current research project examines the hydrologic interactions of water and brush as a means of quantifying the amount of available water for recharge to the aquifer. This project on the Texas Parks & Wildlife Department's Honey Creek State Natural Area lies within the drainage area of the Edwards Aquifer. By using the Texas A&M above-canopy rainfall simulator, rainfall events were applied to a 7 m by 14 m plot dominated by cedar species. The research plot was instrumented to record surface runoff, lateral subsurface flow, soil moisture, canopy interception, juniper transpiration, stem flow, and through fall. To monitor lateral subsurface flow, a 2 meter deep trench was excavated at the base of the plot. Initial rainfall simulation results will be presented.

B52A-1028 1330h POSTER

The Use of the SWAT Model to Optimize Water Yield from Brush Control in the Upper Guadalupe River Basin

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The encroachment of wooded species in herbaceous dominated rangelands has caused pronounced ecological change. Plot scale studies indicate a decrease in available water due to increased evapo-transpiration from wooded species. When these effects are modeled over an entire basin, significant hydrologic impacts are observed. The results of these studies have encouraged the implementation of state subsidized brush control in several watersheds in Texas. To effectively realize such a plan, effort must be made to determine what hydrologic characteristics define optimal sites for brush control to obtain the greatest (if any) increase in water yield from removal. The influence of soil depth, slope, and brush cover were assessed using the Geographic Information Systems (GIS) version of the Soil and Water Assessment Tool (SWAT) for the Guadalupe River basin. The SWAT model was used to simulate the removal of brush species from locations that were characterized by combinations of: 1. shallow soil layers to enhance infiltration to underlying fractured substrate, 2. moderate slopes to increase runoff to stream channels, and 3. locations that are covered by the thickest extents of wooded cover. Characteristics for optimal sites were chosen by the increase in water yield for each unit area of treatment.

B52A-1029 1330h POSTER

Rainfall Simulation at the Hillslope Scale: A Technique for Understanding the Role of Shrubs in the Water Cycle

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Reducing woody vegetation cover may be an effective way of increasing water supplies in semiarid landscapes. Using public monies to subsidize the control of woody vegetation for this purpose has broad support among the public. In Texas, around 30 million dollars has been spent or appropriated for this purpose. Unfortunately, there is remarkably little scientific evidence for the efficacy of brush management for increasing water supplies. In an effort to better understand the influence of woody plants on the water cycle, we have established several hillslope-scale rainfall simulation studies. Water is applied from above the tree canopies, at various rainfall intensities, onto sloped plots measuring approximately 7 x 15 m (slope $<$ 3%); the parameters measured and recorded are transpiration, interception, soil water, lateral subsurface flow, and surface runoff. In addition, the isotopic composition of subsurface waters is analyzed. We have found that in the semiarid and rocky terrain of the Edwards Plateau, lateral subsurface flow is the dominant mechanism of runoff generation. We have also found that in areas where juniper cover is extensive, there is little surface runoff. Our investigations, although just getting under way, are beginning to shed light on how trees may potentially alter the water cycle and at what scale(s) these alterations may be important. Large-scale rainfall simulation is proving to be a useful technique for collecting detailed information on the role of woody plants in the water cycle, and we believe that simulations at scales even larger than that of the hillslope are feasible and will prove equally useful.

B52A-1030 1330h POSTER

Ecosystem Scale Fluxes of Water and Carbon in Semiarid Grassland and Shrubland

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To understand how woody encroachment into grassland influences water and carbon cycling in semiarid environments, we measure ecosystem-scale water and carbon fluxes and identify factors that control variability of the fluxes. Flux measurements are made using both the Bowen ratio and eddy covariance methods, accompanied by measurements of soil moisture and radiation. We present data from both a grassland site and a shrubland site, situated within 2 km of each other at the Sevilleta LTER site in central NM. The study includes data from three summer monsoon seasons, the time of year when rainfall and evapotranspiration (ET) are greatest and both grasses and shrubs are active. Midday available energy is higher at the grassland than at the shrubland by about 20 percent, or 80 Wm-2. At both sites, evaporative fraction (EF, the fraction of available energy partitioned to latent heating) is strongly correlated with surface soil moisture. However, the sensitivity of EF to surface soil moisture is about 30 percent lower at the grassland site. The differences in available energy and EF offset each other, yielding (1) remarkably similar time series of ET and (2) an identical relationship between ET and water content at the two sites. Decreases in soil moisture, EF, and ET are rapid at both sites, about 2-3 days. In contrast, variability in net ecosystem exchange of carbon has both a fast and slow response component. Short bursts of respiration occur after most rainfall events, whereas periods of net assimilation last for several weeks but only follow intervals with substantial rainfall.

B52A-1031 1330h POSTER

A Stable Isotope Study of Runoff Processes in a Semi-arid Shrubland

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The most direct effects that woody plant encroachment may have on local and regional hydrology include altering evapotranspiration rates; modifying runoff processes and creating different microclimate and regional climate. Over the last one hundred years, western Texas has experienced significant woody plant encroachment. Shrub control is now commonly viewed as a viable way to increase catchment water yield. However, there are few process-based studies evaluating brush removal and related water yield. The catchment water yield, recharge processes and runoff processes are directly interrelated. This project on the Texas Parks & Wildlife Department's Honey Creek State Natural Area, in conjunction with other NRCS and USGS projects, is aimed at providing insight into runoff processes over the Edwards Aquifer contributing zone on the Edward's Plateau of Texas. Field observation of runoff processes from Honey Creek Experimental Watershed led us to hypothesize that the majority of the storm runoff from that catchment is precipitation event water and overland flow dominates during the event. The isotopically-based hydrograph separation of event hydrograph indicates that an appreciable amount of pre-event water contributed to the event hydrograph. This demonstrates the importance of subsurface flow in the runoff generation in this catchment. The study site geomorphology and topography preclude the flood wave effect and saturation overland flow mixing mechanism proposed by similar studies for large amount of pre-event water discharge during the storms. However, the riparian zone and water table responses can explain such phenomenon in our study site. The results show that groundwater-surface water dynamics must be considered in water balance studies in the catchment, whether the groundwater is transient saturation, perched aquifer or water table aquifer. Groundwater-surface water dynamics should also be considered when designing a brush control project or evaluating long term brush control effects.

B52A-1032 1330h POSTER

Seasonal Water Usage by *JuniperusAshei*: Assessment With Stable Isotopes of Hydrogen and Oxygen

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The recent expansion of *Juniperus ashei* (Ashe juniper) on the Edwards Plateau of Central Texas has important implications for the ecosystem structure, productivity and hydrology of the region. Ashe juniper expansion may negatively impact the ecology and hydrology of the Edwards Plateau. The Ashe juniper's morphology, rooting habit, and ability to photosynthesize throughout the year suggests greater water loss will occur in areas where Ashe juniper is prevalent compared to areas dominated by grasses. However, past studies have reached conflicting conclusions regarding Ashe juniper's effect on the water budget. A better understanding of the patterns of Ashe juniper's water use will aid in the understanding of how the Ashe juniper affects groundwater recharge, herbaceous productivity and evapotranspirational water loss. Stable isotopes of hydrogen and oxygen from precipitation, soil water, plant xylem water, and groundwater reveal the current ecosystem hydrology. A comparison of the isotopic compositions of potential water sources and juniper stem water indicates the source water utilized by the Ashe juniper. At the Honey Creek State Natural Area, Comal County, Texas the plant, soil and spring water as representative groundwater were sampled at approximately two month intervals over an annual cycle from two adjacent watersheds and analyzed for hydrogen and oxygen isotope composition. Soils were sampled at depth intervals of 5 to 10 cm and soil water content measured. Mass balance calculations using oxygen isotope data from the dry periods of the year, late summer and winter, indicate the Ashe juniper derives between 72% and 100% of it water from groundwater. In contrast, during the wet periods of the year, spring and fall, mass balance calculations indicate that between 45% and 100% of Ashe juniper's water is derived from soil water. Hydrogen isotope data from a subset of samples are consistent with these results. Bowens ratio measurements of evapotranspiration were compared with isotope data to partition evaporative and transpirative water loss from Ashe juniper stands and grass areas. The isotope data from the dry and wet periods of the year show a seasonal shift from nearly exclusive groundwater use by the Ashe juniper during the dry season to significant soil water use by the juniper during the wet season. This seasonal shift indicates the presence of Ashe juniper can appreciably reduce groundwater resources both by lateral roots intercepting potential recharge during the wet season and direct uptake of groundwater by deep roots during the dry season. Ashe juniper will directly compete with grasses for soil water during the wet season, limiting herbaceous productivity.

B52A-1033 1330h POSTER

Strategies of Plant Water Use under Stochastic Hydrologic Conditions

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Recent papers on ecohydrology have discussed how a "tragedy of the commons" effect, in which the competitive evolutionary outcome is lower than the ecosystem optimum (e.g. maximum productivity), may arise in plants because of a trade-off between resource-uptake rate and resource efficiency. Using simple deterministic and stochastic models of soil water balance and ecosystem response to water stress, we investigate how efficient water-use strategies can evolve and persist against more aggressive but less efficient strategies of water

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use. Survival of plants and coexistence of different species is discussed in relation to their drought tolerance and water use efficiency, under conditions of temporal and spatial environmental variability

B52B MCC: Level 2 Friday 1330h

Astrobiology as a Unifying Theme for Solar System Exploration II Posters

(joint with P)

Presiding: **D Morrison,** NASA Astrobiology Institute**; B Runnegar,** University of California, Los Angeles

B52B-1034 1330h POSTER

Bugbuster: Survivability of Living Bacteria Upon Shock Compression

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Survivability of bacteria during impact events has implications both for the transport of life between planets and development of organisms on Hadean Earth and other planets during the period of heavy bombardment which ended 3.5 Gyr before the present [1]. We envision that life existed within internal rock surfaces immersed in the early ocean. We performed shock recovery experiments on live *E. coli* bacteria to determine survival rate vs. shock pressure. Samples of $2\text{x}10^7$ cells were suspended in $\sim 10^{-5}$ l of a buffer solution (TE: a 10:1 solution of Tris and EDTA), sealed into stainless steel chambers that are impacted by 1.5 mm thick flyer plates at 670-760 m s^{-1} using a 20 mm gun. Recovered liquid was mixed with a nutrient broth (LB: growth medium containing tryptone, yeast extract and NaCl) and spread on a Petrie dish containing agar (a polysaccharide growth medium extracted from marine algae *Rhodophyceae*). Recovered samples were cultured for ~16 hours at 37° C. In addition, sample bacteria studied under an optical microscope with DAPI fluorescent stain to verify presence of bacteria in shock recovered samples. Initial and reverberated shock pressures in H_2O varied from 0.2 to 2.0 and 2.4 to 14.9 GPa respectively. We modeled the bacteria cell walls with stilbene, ρ_0=1.16 g cm^{-3}, U_S=2.866+1.588u_P and the cell interiors as water. Upon initial loading the net strain imposed on *E. coli* that just caused non-survival for 10^{-6} s duration stress was 2.8. If this strain is characteristic of that tolerable by *E. coli*, we predict that shock stresses of 25 MPa, 25 kPa and 25 Pa are sustainable upon shock loading by 0.1 ms, 0.1 s and 100 s shock duration pulses. Such shock durations are induced by 2.5 m, 2.5 km and 2,500 km diameter silicate impactors. **References:** [1] Maher K.A. & Stevenson D.J., *Nature*, **331**, pp.612-614, 1988

B52B-1035 1330h POSTER

Definitive Mineralogical Analysis of Martian Rocks and Soil Using the CheMin XRD/XRF Instrument

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The search for evidence of life, prebiotic chemistry or volatiles on Mars will require the identification of rock types that could have preserved these. Anything older than a few million years will either be a rock, or will only be interpretable in the context of the rocks that contain it. The key role that definitive mineralogy plays is a consequence of the fact that minerals are thermodynamic phases, having known and specific ranges of temperature, pressure and composition within which they are stable. More than simple compositional analysis, definitive mineralogical analysis can provide information about conditions of formation, past climate, water activity, the fugacity (activity) of biologically significant gases and the like. The CheMin XRD/XRF instrument is capable of definitive mineralogical analysis. A wide variety of minerals and rocks has been analyzed utilizing 40 KV accelerating voltage and 0.25 amps beam current (10 watts). Interpretable patterns of single minerals can be obtained in a few minutes and quantifiable patterns of complex rocks can be obtained in a few hours. A CheMin flight prototype is being designed for the Mars '09 MSL opportunity. It will utilize a CCD detector based on the MER '03 camera and a miniaturized, low-power carbon nanotube field emission X-ray tube. The CheMin flight prototype will weigh less than a kilogram and will operate with as little as five watts of power (although increased power will result in shorter data acquisition times).

B52B-1036 1330h POSTER

Development and Test of a Probe to Remotely Sense Microbial Life

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Fluorescence spectroscopy is a powerful and highly sensitive tool useful for remotely searching for subsurface microbial life. Ubiquitous biomolecules in microorganisms (e.g. tryptophan and NADH) have unique autofluorescence spectra that allow them to be optically detected at low levels even in the presence of a fluorescence background from minerals. Based on this technique, we have developed and tested a first-generation Biospectral Logger (BSL); an instrument suitable for logging boreholes and aquatic environments which uses a 370 nm excitation source and a bank of seven notch-filtered phototubes to record the spectrum of microbial NADH fluorescence. The first generation BSL was constructed and tested in Lake Tahoe, where it recorded chlorophyll fluorescence that peaked at a depth of about 57 m and then decreased with depth. NADH fluorescence was found to peak and fall off with chlorophyll for shallow depths, but then began increasing again at deeper depths, which agrees with the results of independently performed cell counts. In order to optimize the discrimination between microbial life and its environment, we used a laboratory fluorimeter to map out the emission spectra of a diverse collection of microbes and minerals as a function of excitation wavelength, which we varied between 224 nm and 460 nm. Based on these data, we have planned future developments of the BSL technology that make it more selective and able to be used in more extreme environments such as deep mine boreholes, permafrost, deep-ocean settings, and ultimately Martian permafrost, where its greatly-increased sensitivity will be sufficient to detect microbial concentrations down to 1 cell/cm3 in media with relatively low background

B52B-1037 1330h POSTER

The Search for Organics (δ^{13}C and δ^{15}N) Throughout a Sub Basement Fossil Soil (Ocean Drilling Program, Leg 197): Implications for Earth/Mars deep subsurface

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Detecting organics buried deep beneath the surface of a planet is a fundamental step to constrain the presence and evolution of life on a planet. This is especially true for Mars with barren-life surface owing to extreme settings (UV flux, P atm and T). However, organics and/or viable microbes could still preserved at some deeper locations on Mars [e.g.,1]. This work presents the first nitrogen isotope (δ^{15}N) data for deeply buried Early Tertiary fossil soil Unit (Core 197-1206A-40R; 307.5-309.9 mbsf). They were RCB-cored from the volcanic basement at Site 1206 (Koko Seamount, 34°56' N; 172°9' E) during the ODP Leg 197 (Emperor Seamounts, north Pacific). These Fe-rich, palagonite-bearing soils were formed on the top of subsiding atolls and subsequently buried by lava flows in a near shore environment [2]. Burial rates higher than average subsidence rates ensured the isolation of these fossil soils in a present-day sub-basement setting and their decoupling from the ocean and the atmosphere for likely >54 Ma. Leg 197 soils contain very low, but reliable amounts of total organic carbon (TOC=0.01-0.12 %wt, ± 0.02%, N=36; [2-3]). The single fossil soil unit has stable isotope values more negative (i.e., δ^{13}C-org. = $-25.3^o/_{oo}$ to $-26.2^o/_{oo}$;[4]) and δ^{15}N-tot = $-9.5^o/_{oo}$ to $+2.5^o/_{oo}$ than those of exposed Hawaiian counterparts (i.e., δ^{15}N-tot = $>=0^o/_{oo}$ to $+8.5^o/_{oo}$). This isotopically lighter Ntot could be interpreted as bacterial fractionation throughout the N-cycle either occurred in the past (Early Eocene/Late Paleocene) and changing organic source (C-3, C-4-plants, bacterial) and N-cycle associated processes. However the existing data-set [2-4] need to be compared with microbiological data to establish the potential for these soils to serve as a suitable analog for a possible Mars near-surface/deep biosphere.

[1]Mancinelli, R.L, 2000. Planet. Space Sci., 48:1035-1043; [2] Shipboard Scientific Party, 2002, Proc. ODP, Init. Repts. 197: College Station, TX; [3] Bonaccorsi, R., 2002. EOS Trans AGU, 83(47), Fall Meet. Suppl. Abstract;[4]Meyers, P.A., 1997. Org. Geochem., 27, 5/6:213-259.

B52B-1038 1330h POSTER

The Habitability of Mars: Lessons From Ophiolites on Earth

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Ophiolite sequences, sections of lower oceanic crust and upper mantle that have been thrust onto continental craton, are located in northern and central California. These rock suites provide easily accessible outcrops that likely parallel the rock types on Mars. We have begun investigating and characterizing these sites in order to understand better the processes that may be responsible for the water chemistry, mineralogy and biology on Mars. The ophiolites found in northern and central California include the Trinity, Josephine, Coast Range and Point Sal, and all are approximately 160 million years old. These ophiolite bodies are actively serpentinizing. Fluids from serpentinizing springs are generally alkaline, with high pH and H2 contents, indicating that the mafic rock compositions control the fluid chemistry through water-rock reactions during relatively low-grade hydrothermal processes. The general reaction describing the serpentinization of olivine is given by: olivine + H2O = serpentine + brucite + magnetite + H2. We have analyzed the petrography and mineralogical composition of a number of rock samples collected from the Coast Range Ophiolite near Clear Lake, CA by electron microprobe. The remnant primary mineralogy is fairly uniform in composition, with an olivine composition of Fo90, and with pyroxene compositions of En90 for orthopyroxene and En49Wo48Fs03 for the clinopyroxene. There are several generations of alteration products, comprised mostly of serpentines that are magnesium rich, with magnetite, brucite and carbonates observed as accessory minerals. The oxidation of iron in the ferrous component of olivine (and pyroxene) results in the generation of H2, as indicated by the presence of magnetite. The formation of carbonates can be taken to indicate the presence of CO2 in the altering fluids. The H2 generated through water-rock reactions in these systems may provide an energy source for chemolithoautotrophic ecosystems, while the CO2 serves as a carbon source. The identification of several species of Archaea from these rocks, including an alkalophile, indicates that these geochemical environments do serve as habitats. We suggest that serpentinizing springs in mafic to ultramafic terranes may be the most likely areas on Mars to be habitable.

B52B-1039 1330h POSTER

Magnetic Fe,Si,Al-rich Spherules From the P-T Boundary Layer at Graphite Peak, Antarctica

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