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Current interest in subsurface microbiology at hydrothermal vents has resulted in greater attention being given to the characterization of new microbial species and their feedback with the sub-seafloor environment. In response to a need for integrated biogeochemical studies, we have developed a new type of experimental apparatus to study microbial processes at *in situ* pressure (250 bars) and temperature (70°C). This high-pressure open-system apparatus, modified from HPLC technology, is capable of supplying fresh media, including dissolved gases, to the system, while removing metabolic waste products. Thus, we eliminate the need to artificially elevate certain components in the fluid chemistry and allow continuous growth of the culture, maximizing interaction between the bacteria and mineral surfaces.

Preliminary pure culture experiments designed to monitor bacterial effects on mineral surfaces were completed using a new strain of denitrifying thermophilic bacteria, EX-H1. By monitoring aqueous and dissolved gas chemistry, we confirmed its use of the following energy-producing reaction during metabolism: $19H_{2(aq)} + 3NO_3^- + 5CO_{2(aq)} + 3H^+ = N_{2(aq)} + C_5H_7O_2N + 17H_{2(aq)}$ where ($C_5H_7O_2N$) represents bacterial cell mass. Reaction rates at ambient pressure were on the order of 0.02 mmolal/hr in closed system. Abiotic control experiments at pressure confirmed that mineral dissolution/precipitation reactions were kinetically inhibited at 70°C over 18 hours. Biotic experiments were successful in showing attachment of cells to the quartz fiber substrate during cell growth in the reactor. Due to insufficient residence time of fluid in the reactor (50 minutes), however, metabolic changes in fluid chemistry were slight. Future experiments will incorporate longer residence times to allow comparison of the stoichiometry and rate of the denitrification reaction with theoretical estimates. Also, we will assess the effect of microbial growth on minerals in the reactor to quantify the link between cell growth, metabolism, and the broader geochemical environment.

B22D-0186 1330h POSTER

Environmental and developmental controls of morphological diversity in a thermal spring gastropod from Coahuila, Mexico

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Isolated thermal springs and associated aquatic environments near Cuatro Ciénegas, in north-central Mexico provide an opportunity to study patterns of evolutionary diversification under extreme conditions. Significant differences in temperature, seasonality, pH, and salinities among other variables may allow for high levels of differentiation and endemism. Biological studies of the unique faunas in this type of environment may serve as analogues for extreme and/or evaporitic environments as targeted by astrobiological research.

The endemic hydrobiid gastropod *Mexipyrgus* is widely distributed in a variety of aquatic environments within the Cuatro Cienégas basin. Original description of this genus by Taylor listed six distinct species reflecting shell and anatomical features. Later revision by Hershler suggests that this diversity be reduced to one single, highly-variable species, based mainly on the morphology of reproductive structures. The systematic conflict emphasizes the need to understand the bases of morphological variation at small scales and in environmentally unusual settings.

Shells of *Mexipyrgus* were collected from six localities and the following species were identified based on Taylor's classification: *M. carranzae*, *M. escobedae*, *M. multilineatus*, and specimens intermediate in character between *M. carranzae*, *M. lugoi* and *M. mojarralis*. All specimens consisted of 4-6 whorls. Shell shape was archived by the digitization of geometrically homologous landmarks on the spire (apex, whorl sutures in apertural view) and aperture. Shell size was calculated as Centroid Size. Data were analyzed using uniform and principal warp analysis of raw landmark coordinates, followed by relative warp analysis of uniform and partial warp scores. Three separate analyses were performed for 4, 5 and 6 whorled specimens. Results indicate two different levels of variation based on individual age. Variation among 4 whorled specimens is dominated by locality: each locality is distinct from all others, regardless of individual species composition. Analysis of 5-whorled specimens reveals some locality-based differentiation, but also taxonomic (and possibly gender) differentiation. Finally, by the 6-whorled stage, the pattern of differentiation is based solely on taxonomy, with Taylor's morphospecies forming distinct and discrete groups. Another analysis conducted on the first four whorls of all specimens supports the hypothesis that location and local environmental factors are the largest influence on morphology earlier in development.

In summary, environment seems to exert a significant influence on morphology during shell development, but terminal adult morphology is largely under intrinsic (genetic) control. Resolution of the systematics and true diversity of *Mexipyrgus* will ultimately rely upon further quantitative morphological studies in addition to future population genetic studies of this genus in a variety of microhabitats.

B22D-0187 1330h POSTER

The Effect Of Aldehydic Carbonyls On Iron Sulfide Biomineral Formation

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Iron sulfides have long been recognised as important biominerals. However, attempts to identify the specific effects of microorganisms on the product iron sulfides have generally been unsuccessful. An exception has been magnetotactic bacteria which contain the thiospinel greigite (Fe_3S_4) as a functional adjunct. This ability to produce metastable Fe_3S_4 rather than stable pyrite (FeS_2) is not understood. The problem extends to fundamental biochemicals, such as the iron-sulphur proteins, which include Fe_nS_n clusters as their active centres.

We show that iron sulfides of different compositions and oxidation states are produced by the catalytic activity of aliphatic and aromatic aldehydes. The product of the oxidation of precipitated $FeS_{(am)}$ by aqueous H_2S at pH=6 between 25 and 100°C can be determined by trace quantities of aldehydes. In the absence of aldehydes the product is euhedral pyrite. In their presence the product is ferrimagnetic greigite. Other simple organic compounds have no apparent effect on the transformation, suggesting that aldehydes are the functional agent. This is confirmed by examining the relative reaction rates of aldehydes with different stereochemistries.

Compared with other mineral switches, the effect of this first observed mineral switch in the iron sulfide system is quite dramatic. In the presence of aldehydes, two thirds of the Fe(II) in $FeS_{(am)}$ is oxidised to Fe(III), but S(-II) remains unaffected. In the absence of aldehydes, the S(-II) in $FeS_{(am)}$ is oxidised to S(-I) in pyrite, but Fe(II) remains unchanged. Aldehyde recovery after reaction is in excess of 95%, and aldehydes are not consumed.

The switch works by aldehydes catalysing the formation of Fe_3S_4 from FeS and inhibiting the formation of pyrite. The catalytic effect of aldehydic carbonyl on greigite formation from $FeS_{(am)}$ is also observed for reactions with no excess aqueous H_2S. We show that removal of $FeS_{(aq)}$ clusters from solution by interaction with aqueous aldehyde inhibits pyrite formation. The effectiveness of the switch suggests that trace organics can determine the stoichiometry, crystal structure and oxidation state of the products of iron sulfide transformations.

The results have a general implication for the coupling of iron sulfides with prebiotic organic systems in the early development of life. They constrain the use of greigite as a biomarker in planetary sciences, since greigite formation need not carry any implication of intracellular activity. However, the availability of aldehyde moieties in cells suggests a possible biochemical pathway for biogenic greigite formation in magnetotactic bacteria, and why later transformation to pyrite is apparently inhibited. In sediments and soils where greigite contributes to remanent magnetism, it is possible that greigite develops through analogous extracellular processes, especially with the aldehydic products of degrading biological material.

B22E MC: 122 Tuesday 1330h

Geologic Influences on Biogeochemical Cycles II *(joint with H)*

Presiding: **J M Holloway,** U.S. Geological Survey**; J R Rogers,** University of Kansas**; S T Petsch,** Woods Hole Oceanographic Institution

B22E-01 1330h

Relict Stream Channels in the McMurdo Dry Valleys, Antarctica: Ecological Legacies Controlling Response to Climate

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In the McMurdo Dry Valleys, glacial meltwater streams feed permanently ice-covered lakes in the valley floors. Cyanobacterial mats persist through the winter in a freeze-dried state and grow when stream flow begins in summer. Algal mats are abundant in streams where streambed rocks are configured in a stone pavement, wedged together, largest flat side up, forming a smooth surface that enhances laminar flow and reduces sediment mobilization and scour. These stone pavements may form through peri-glacial processes operating over long time periods. In dry valley maps and aerial photographs, about half of the stream channel features do not currently have an obvious meltwater source. In January 1995, we began a long-term experimental reactivation of a relict channel in Taylor Valley by redirecting water from an upper stream using a low sandbag wall. Based upon aerial photographs, we estimate that the relict channel had not had carried stream flow for 20-30 years. We observed abundant algal mats growing in the stream within about a week of redirecting the flow. The algal mats in the relict channel had high or comparable growth rates to mats in other streams in the valley and have continued to grow in subsequent summers. The higher solute concentrations in the reactivated channel may have enhanced growth rates of relict algal mats. We hypothesize that the overall stability of stone pavement channels in the dry valley landscape preserves streambed habitats and possibly cyanobacterial populations capable of rapid recolonization should flow resume.

B22E-02 1345h

Microorganisms Implicated in Degradation of Organic Matter During Black Shale Weathering

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Sedimentary rocks rich in organic matter are common features of the geologic record and in general usage are termed black shales. Presence of organic matter and sulfide minerals in black shales generates a chemically reducing environment within these rocks. Once uplifted and exposed on the earths continents to surface environments, an oxidation front begins to penetrate into these rocks. Oxidative chemical weathering of black shales results in loss of organic matter and sulfides. The oxidized zone within black shale weathering profiles provides an unusual habitat for microbial activity. Although organic carbon is abundant within black shales, it occurs in a complex and chemically recalcitrant form that is less susceptible to biological degradation than simple carbon compounds. The oxidation of shale sulfide minerals generates significant acidity, such that the pH of porewaters measures <2 in some locations. Thus the organisms living within black shale weathering profile must be able to access complex carbon substrates and tolerate highly acidic conditions.

Samples were recovered from a weathering profile developed on Late Devonian New Albany Shale exposed near Clay City, Kentucky. This site has been the subject of previous studies of shale weathering and geochemistry. This study examines whether microorganisms are present within the weathering profile, if they unambiguously are accessing shale organic matter as

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a carbon source, and what the phylogenetic relationships are between these and other known hydrocarbon-degrading organisms.

Epifluorescence microscopy of samples stained with DAPI or AO or hybridized with group-specific probes confirms the presence of the three domains Bacteria, Archaea and Eucarya within environmental samples and enrichment cultures. Our research has shown that compound-specific ^{14}C analysis of phospholipid-derived fatty acid methyl esters from living enrichment cultures contain essentially zero ^{14}C, indicating that enrichment culture microorganisms are assimilating the majority of cellular carbon from the shale. Clone libraries have been generated from DNA extracted from enrichment cultures. Restriction digest of clone DNA indicates the presence of multiple organisms within enrichment cultures. Sequence analysis of clone DNA is used to identify potential members of the enrichment culture community and design refined probes to confirm the presence of these organisms in culture and environmental samples.

B22E-03 1400h

Weathering of Phosphorus in Black Shales

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Phosphorus (P) is a vital nutrient for marine and terrestrial life. Rock weathering is the ultimate source of P to the oceans, where P can be a limiting nutrient for biological production. P weathering has been examined in black shales from the organic-rich Woodford Shale, New Albany Shale and Green River Shale. At all sites, organic P and inorganic P concentrations do not significantly decrease with exposure to weathering, indicating that P weathering is incomplete prior to erosion. These data suggest that 1) P eludes weathering and may be transported to rivers unaltered, or 2) P released by weathering may be incorporated into bacterial biomass. C/P ratios decrease significantly from unweathered shale to the weathered shale at all sites, which is driven by loss of total organic C with weathering. Here we present the first characterization of organic phosphorus across a weathering profile from the Woodford Shale using solid-state CPMAS 31P NMR spectroscopy techniques, revealing that P esters are the dominant forms of P during all stages of weathering, with a lesser contribution from polyphosphates appearing in the more weathered samples. Certain P esters appear to be resistant to chemical weathering during the millions of years between deposition, uplift and erosion, possibly representing a significant long-term global sink for P.

B22E-04 1415h

Source and Fate of High Ammonium Concentrations in Thermal Waters of Yellowstone National Park, Wyoming, Montana and Idaho, USA

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Although various researchers have reported hot spring ammonium concentrations from 7 μM in the southern region of Yellowstone National Park to 15 to 63 mM NH_4^+ for Washburn Hot Springs in the northwestern caldera, little has been done to characterize the source or fate of ammonium associated with thermal waters. We measured elevated dissolved organic carbon concentrations (240 and 330 μM) in the Lower Inkpot group of Washburn Hot Springs, possibly originating from organic matter associated with underlying sedimentary bedrock. High nitrogen concentrations (2520 and 2210 ppm N) and moderate carbon (1860 and 1140 ppm C) were measured in fine-grained mineral samples from two Washburn springs. Nitrogen and carbon from this solid phase may be transported as ammonium and dissolved organic carbon by hydrothermal fluids.

The extent of microbial and/or chemical oxidation of ammonium in thermal water drainage was investigated from a high ammonium concentration, circumneutral spring at Washburn Hot Springs (pH 7 to 8; 16 mM NH_4^+) and for Nymph Creek, an acidic, moderate-ammonium concentration drainage (pH 2; 71 μM NH_4^+). Oxidized nitrogen species (nitrate, nitrite and nitrous oxide) were measured in source and drainage waters and nitrogen transformation processes were examined using laboratory incubations of sediment and water. Nitrite and nitrous oxide concentrations increased downstream in the drainage from Washburn Hot Springs, from 0.6 to 8.1 μM NO_2^- and 0.1 to 1.5 nM N_2O, but nitrate concentrations were less than 0.3 μM NO_3^- and there was no significant decrease in ammonium concentration downstream. Laboratory incubations demonstrated potential for denitrification in sediment slurries, with relatively little nitrification potential. Nymph Creek had similarly unchanged ammonium concentrations downstream from the vent area with no measurable nitrate, even though there was complete oxidation of iron and arsenic within a few meters of the vents. Hypotheses that may explain the persistence of ammonium in spring discharge include: 1) nitrification suppression by toxic concentrations of ammonium or other dissolved constituents, 2) limiting rate of nitrite oxidation relative to the rate of denitrification and 3) slow abiotic oxidation rate.

B22E-05 1430h

Sulfuric Acid Speleogenesis: Microbial Karst and Microbial Crust

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Sulfuric acid speleogenesis is a fundamental mechanism of karst formation, and is potentially responsible for the formation of some of the most extensive cave systems yet discovered. Speleogenesis occurs from the rapid dissolution of the host limestone by sulfuric acid produced from biotic and abiotic sulfide oxidation, and with the release of carbon dioxide, secondary gypsum crusts form. This crust develops predominately on the cave walls, often preserving original bedding indicators, until it finally collapses under its own weight to expose fresh limestone for dissolution. While this general speleogenetic process can be inferred from secondary residues in some caves, directly observing this process is difficult, and involves entry into an extreme environment with toxic atmospheres and low pH solutions.

Kane Cave, Big Horn County, WY, offers the unique opportunity to study microbe-rock interactions directly. Kane Cave presently contains 3 springs that discharge hydrogen sulfide-rich waters, supporting thick subaqueous mats of diverse microbial communities in the stream passage. Condensation droplets and elemental sulfur form on subaerially exposed gypsum surfaces. Droplets have an average pH of 1.7, and are dominated by dissolved sulfate, Ca, Mg, Al, and Si, with minor Sr and Fe, and trace Mn and U. SEM and EDS examination of the crusts reveal the presence of C, O, and S, as well as authigenic, doubly-terminated quartz crystals. An average δ ^{13}C value of -36 $^{o}/_{oo}$ suggests that the crusts are biogenic and are composed of chemoautotrophic microorganisms. Enrichment cultures of biofilms and acid droplets rapidly produce sulfuric acid, demonstrating the dominance of sulfur-oxidizing bacteria.

Colonization of gypsum surfaces by acidophilic microorganisms enhances acid dissolution of the limestone, and hence the growth of the cave itself. Limestone dissolution also results in mineralized crusts and biofilms that accumulate insoluble residues, which serve as sources of nutrient Fe, P, and N to the microbes. Other elements, such as Si, increase in concentration in the acid solutions and low-temperature mineral precipitation occurs.

URL: http://www.geo.utexas.edu/chemhydro/Annette/karstgeo.htm

B22E-06 1445h

Isotopic Composition of the Neolithic Alpine Iceman's Tooth Enamel and Clues to his Origin

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Five small enamel fragments from three teeth of the upper right jaw from the mummy of the Neolithic Alpine Iceman have been investigated for their isotopic composition in order to shed light on his geographic origins. Soils from approximately contemporaneous sites were sampled for comparison. Tooth enamel forms ontogenetically very early and is not re-mineralized during later lifetime (unlike with bone material). Therefore, unique insights into the Icemans childhood can be acquired. Enamel also is the densest tissue of a human body and is thus less susceptible to post-mortem alteration.

Both radiogenic (Sr, Pb, Nd) and stable isotopes (O, C) are investigated. Radiogenic isotopes allow reconstruction of the local geological background, because humans incorporate Sr, Pb and Nd from their local environment by eating local food. Stable isotopes provide information about altitude and/or position relative to the main Alpine watershed. High spatial-resolution laser-ablation ICPMS profiles reveal that most elements are distributed in a manner that is essentially similar to modern human teeth except of that La, Ce, Nd (LREE) show up to a 100-fold enrichment towards the outer enamel surface. These uptake-profiles may reflect interaction with melt water, consistent with data for the composition of samples of the Icemans skin. Biogenic apatites (enamel, bone) have very low in-vivo LREE concentrations, but take up LREEs post-mortem from the burial environment. Ice core samples from the finding site show concentrations up to 400 ppt Ce. Such high uptake of the LREEs precludes the derivation of an in-vivo Nd isotopic signal, but both other radiogenic tracers, Sr and Pb, show pristine (in-vivo) concentrations of 87 ppm and 0.1 ppm, respectively.

Strontium isotopic compositions were determined on fragments from the canine, the first and second premolar (1 - 9 mg) and two hip bone samples, utilizing three sequential leaching steps for each sample to detect possible alteration-related disturbance. Enamel fragments from three teeth are characterized by virtually similar and high ^{87}Sr/^{86}Sr ratios of 0.7203-0.7206, consistent with the compositions of crystalline gneisses and schists close to the finding site. Sites overlying bedrock built up by limestone from further south or north can clearly be excluded as the Icemans childhood area. Among the three teeth, enamel mineralized approximately during a 2-3 year interval starting with the canine at the age of 2 years. Hence, during this period, the food source for the Iceman must have remained essentially constant.

Two compact bone samples from the damaged hip region have ^{87}Sr/^{86}Sr ratios of 0.7175 and 0.7181, significantly lower than that of the enamel. The internal variation in the Icemans bone Sr isotopic composition argues for somewhat different Sr turnover times within the skeleton, but it is evident that during the last 1-3 decades of his life, food from a different region was utilized. The ^{87}Sr/^{86}Sr ratios of the initial bone leachates point towards post-mortem alteration with water having ^{87}Sr/^{86}Sr ratios higher than 0.718, consistent with that measured for contemporaneous ice samples (0.720-0.723). These Sr isotopic variations among ice samples may have implications for the post depositional (climate) history of the Icemans finding site, since it appears unlikely that substantial compositional differences among adjacent ice samples would be preserved if the site had thawed near completely during e.g. the Roman warm period.

B22E-07 1500h

Microscale Microbial-Geochemical Linkages Controlling Biofilm Metal Behaviour in an AMD Environment

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In AMD environments, biogeochemical processes involving metal solid phase capture within microbial biofilms may play a large role in controlling overall system metal transport. Our research aims to map observed metal behaviour within natural biofilms from a metal-contaminated environment as a function of changes in microbial community structure and associated shifts in internal geochemical gradients.

We have used a combined field and laboratory approach to begin characterizing biogeochemical linkages within biofilms. Biofilm and overlying water column samples were collected from May-September, 2001, from shallow surficial seepage streams at the Strathcona tailings (Falconbridge Ltd., Sudbury). In situ geochemical profiles of both the overlying water column (pH, temperature, O_2, redox, conductivity) and within the biofilms (pH, O_2, H_2S) were recorded at the time of sampling. Biofilm oxygen profiles indicated the presence of a photosynthetic surface layer, followed by rapid oxygen depletion and anoxia deeper into the biofilm. Both the O_2 and H_2S profiles inferred the presence of stratified microbial communities within the biofilms. Biofilm pH profiles indicated a small relative increase in pH with depth from the biofilm-water interface (reaching values of 4.0) compared to the overlying water column (3.4). Higher biofilm pH values reflect both intense microbial activity sufficient to impact pH even at such low ambient pH, and the creation of more favourable conditions for biofilm solid-phase metal capture.

Sulfate and silicate minerals were identified as the bulk mineral components of the biofilms by X-Ray

diffraction (XRD) analysis. These minerals, however, were not important metal sorbents. Rather, greater than 80 percent of the total Ni and Co content of the biofilms was shown to be associated with the manganese oxyhydroxide and organic/sulfide phases of the biofilm material, as determined by a sequential extraction scheme using microwave digestion. Mn oxyhydroxides were not identified even as trace mineral phases by XRD analysis; their high reactivity reflects the low pH values within the biofilms. Mn, Ni, and Co concentrations were 10^3-10^4 fold higher in the biofilms compared to the overlying water column (e.g. $[Mn]_{water}$ 60-85 nmol/mL vs. $[Mn]_{biofilm}$ 0.33-2.1 umol/g), making the biofilms effective metal scavengers.

Images and elemental analysis of the biofilms provided by a suite of microscopies (ESEM, CLSM, Epifluorescence microscopy) indicated that: 1) the biofilm surface is heterogeneous and characterized by distinct zones of mineralization; 2) biofilm-associated minerals are fine-grained and amorphous; 3) the dominant mode of microbial existence was a pod-like assemblage, and 4) Ni was associated both with the organic matrix and the minerals, confirming the results from the sequential extractions.

Our results show that complex microbial communities occur in the tailings seepage streams that create geochemical microenvironments that differ substantially from the bulk overlying water column and the underlying tailings. Metals are sequestered within the biofilms, mainly as a result of sorption to extremely reactive but trace mineral phases (Mn oxyhydroxides) and organic material. Currently, ongoing analysis investigates the microbial community diversity within the biofilm by molecular techniques (fluorescent in situ hybridization). Results from the integration of these molecular and geochemical techniques providing a mechanistic understanding of the biogeochemical processes controlling metal behaviour within AMD biofilms will be presented.

B22F MC: 122 Tuesday 1535h

Geophysiology: The Influence of Organisms on Their Geophysical Environment II

Presiding: **J Neff,** U.S. Geological Survey**; S Turner,** SUNY, College of Environmental Science Forestry

B22F-01 1535h INVITED

Geophysiology, Extended Organisms, and the Problem of Emergent Homeostasis

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Physiology may be broadly defined as the managed flow of matter, energy and information. Central to this concept is the attendant phenomenon of homeostasis, doing physiological work to balance the thermodynamically driven flows of matter, energy or information that naturally attend to living things. Organisms in general exhibit what might be termed a strong homeostasis, in which well-regulated and complex physiological machines drive the physiological fluxes of matter, energy and information within the organism and at the organisms outermost integumentary boundary. Organisms also structure their environments to manage flows of matter, energy and information between themselves and their environment. In so doing, living things constitute a sort of extended organism, in which an organisms physiology reaches beyond the outermost boundary of the skin. Geophysiologys radical promise is that physiology can arise at levels of organization higher than the organism, ranging from social insect colonies through ecosystems, perhaps even to the biosphere itself. However, a simple demonstration that organisms affect the flows of matter, energy and information in their environments is not sufficient to qualify as physiology. That amounts to a demonstration that organisms do physiological work on their environments, which is neither a radical nor a new idea. To be truly physiological, geophysiology must exhibit physiologys most essential attribute, namely homeostasis. Finding homeostasis and explaining how it works in the extended organism is geophysiologys radical challenge.

B22F-02 1555h

The effect of termites as ecosystem engineers in the humid tropics

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The effects of termites as "ecosystem engineers" in humid tropical ecosystems are manyfold and range from the modification of content and composition of organic matter in soils, changes of the soil structure, over effects on the composition of vegetation, to the enhancement of biodiversity of other organisms. An overview if given over findings of recent years with a focus on termites in Amazonian rain forests. Factors that determine termite distribution and diversity are then discussed, and the pests status of termites is shortly reviewed, on the basis of which management strategies for this particular group of soil organisms are outlined.

B22F-03 1610h

Application of in situ-produced 10Be to the study of Australian stone line induced by termite activity

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The aim of this study is to understand the genesis of a stoneline sequence located at the border of the Yilgarn Craton in southwest Austrtalia. The sequence was selected because a well-defined line of siliceous pebbles traces the limit between a typical tropical saprolite and a soil almost entirely composed of termite nests, providing an opportunity to study the role of biological processes in stoneline genesis. A roadcut along the Boyup Brook Road provided the opportunity to examine and sample a 100 m wide section of weathering mantle developed on a gently sloping hill. The sequence consists, from base to top, of three main weathering layers: a gneiss- and schist-inherited yellow saprolite that includes subvertical quartz veins ; a 10 to 20 cm thick stone line composed primarily of angular quartz pebble; and a 40 to 50 cm thick dark brown surficial soil rich in both active and dormant termite nests. The distribution of these layers does not vary significantly across the hill, but quartz rich veins are most abundant in the central part of the hill. Kaolinite and quartz are the major mineralogical components throughout the sequence. There is little variation in grain size distributions, other than a modest increase in the >63 micron fractions of surface samples due to termite activity (mixing of minerals with woody and grassy debris). Chemical and mineralogical analyses were used to characterise the weathering layers and to investigate the role of termite colonies. We determined the in situ produced 10Be contents of samples collected from a depth profile through the quartz-rich schist and of pebbles from the stoneline at distances up to 40 m from central quartz veins. The 10Be depth profile shows a simple exponential decrease with depth, consistent with attenuation of cosmic ray neutrons and erosion at a rate of 20 mMyr, consistent with rates of excavation by termites. The pebbles from the stoneline have nearly constant 10Be concentrations that are approximately three times higher than that extrapolated to the stoneline depth from the samples within the quatz vein. A discontinuous history of erosion is required to explain these observations. We suggest that ongoing chemical weathering was interupted by truncation of the hill and distribution of quartz pebbles occured over a relatively brief period during the past 100 kyr.

B22F-04 1625h

Bioturbation by Fire Ants in the Coastal Prairie of Texas

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Fire ants (Solenopsis invicta) were introduced to the US in the early part of the last century. They have spread throughout the southeastern US in the absence of native competitors and predators with a range limited by abiotic factors. Each fire ant mound contains thousands of individuals, can be large, and can be numerous enough to comprise a dominant feature of the landscape. Studies of this species have focused upon its spread, formation of single- and multiple-queen colonies, genetic structure, and impact on native fauna and human health. Some studies have analyzed native fire ant-soil interactions, but few studies have examined the process of bioturbation by introduced fire ants in native ecosystems.

Fire ants on the coastal prairie of Texas primarily are of the multiple-queen type that exhibit a much higher density of mounds than the single-queen type. Consequently, mound-building activities by fire ants can have a marked effect upon soil structure and nutrient content and may affect soil organisms and plants. Fire ant activity, mound density, mound dispersion, soil texture, soil permeability, soil moisture content, and soil nutrients were measured. Fire ants mounds are visible aboveground from April-November. Density of mounds was 117-738/ha, and average mound lifespan was 3.6 months with only 9% of the mounds remaining active throughout the entire season. Mounds were dispersed randomly. Foraging activity by fire ants was from June through October with a peak in July. Annual soil turnover was estimated by collecting and weighing mounds. There was no effect of ant mounds on soil texture, but water infiltration was higher in areas with ant mounds. Early-season samples showed no nutrient differences, but late-season samples showed that ant mounds contained higher amounts of micronutrients than random samples of soil. These data are compared to similar data on effects of mounds from native ants and from native and introduced ants in different habitats.

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Local to Landscape-Level Effects of Bioturbation by Pocket Gophers

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All continents except Antarctica host mammal species that spend virtually their entire lives belowground. Unlike the majority of small mammals that use underground dens primarily as nests, the truly fossorial forms construct extensive burrows which they use for virtually all activities. Tailings from the burrows are deposited as mounds on the surface or are redistributed into unused tunnels, such that both the burrows and the mounds generate spatially explicit, dynamic patterns of soil disturbance. These have significant effects on vegetation, soil, and hydrology of the local area.

The amount of soil moved by North American pocket gophers is astounding, ranging from 3.4 to 57.4 m3 ha -1 year-1 (with a mean across all species of 17.8). Burrows can underlay 7.5% of the ground and mounds may cover 5% to 8% of an area at any one time, and as much as 30% to 50% of an area over one year. Studies have shown that soil movement by pocket gophers is one of the major sources of sediment transport in natural systems. Furthermore, erosion patterns generated by pocket gophers are the product of complex interactions between animal energetics and foraging behavior and differ significantly from processes of purely physical origin. Recent results provide clear evidence that soil movement by pocket gophers scales non-linearly with hillslope angle in a complex fashion not predicted by physically-based models.

The soil the pocket gophers deposit on the soil surface and in their burrows differs significantly from the background soil matrix. Mounds may have higher or lower nutrient content, moisture, water-holding capacity, or organic matter than inter-mounds areas, depending on the depth from which the soil was excavated and subsequent weathering.

As much as 59% of the soil from new excavations may be backfilled into old burrows rather than placed as mounds on the surface. This soil is 15% less compact than the surrounding soil matrix, even though the rodents pack it tightly into the vacant tunnels. Mounds exhibit an even lower bulk density, 10 to 40% lower than the adjacent consolidated soil.

Gopher burrows also have major influences on water movement by concentrating runoff into fast-flowing conduits. Under certain conditions burrows can become underground pipes, funneling water from the surface. It has been suggested that this piping can generate significant erosion, eventually leading to the collapse of the burrow roof and the initiation of a surface gully. At the landscape level, areas with high mound densities exhibited greater microtopographic variation and a greater mean height than adjacent areas with lower mound densities.

The net effects of burrow excavation, backfilling, mound production, and the subsequent movement of