33RD ANNUAL GRADUATE STUDENT COLLOQUIUM

DEPARTMENT OF GEOSCIENCES

THE PENNSYLVANIA STATE UNIVERSITY

APRIL 18-20, 2001

541 DEIKE BUILDING

The Graduate Student Colloquium is a forum where students present their research or research proposal to faculty, friends, and peers. The Colloquium is hosted by the Department of Geosciences and is open to undergraduate and graduate students in the College of Earth and Mineral Sciences. The format stimulates research discussion and allows students to practice for national meetings. This helps Penn State maintain and strengthen its reputation at national meetings for high quality talks and posters with visual appeal. To encourage our commitment to excellence, cash awards are presented for top presentations. Awards are based on abstract quality, scientific content, and presentation.

The committee wishes to thank participants for their commitment to the Colloquium. We also thank Rudy Slingerland and Kevin Furlong for departmental support and prize money. Great thanks are extended to this year's faculty judges for their time and assistance.

Committee Members 2001: Sarah Das, Matt Hurtgen Jennifer Nemitz, Dave Reusch, Pete Sak, Matt Spencer, Yumiko Watanabe, Cindy Werner, and Dorothy Vesper

POSTER PRESENTATIONS – WEDNESDAY MORNING

Presenter	Advisor	Title
Sarah Das	Richard Alley	TEMPERATURE VARIABILITY AT SIPLE DOME, WEST ANTARCTICA, DERIVED FROM SSM/I AND SMMR BRIGHTNESS TEMPERATURES, ECMWF RE-ANALYSES AND AWS RECORDS
Jennifer Eigenbrode	Katherine Freeman	LATE ARCHEAN BIOMARKERS IN CARBONATES FROM THE HAMERSLEY BASIN, PILBARA CRATON, WESTERN AUSTRALIA
Ellen Herman	Lee Kump	MICROBIAL MATS AS SELF-REGULATING SYSTEMS
Christie Rogers	Terry Engelder	MECHANISM FOR CLOSELY SPACED JOINT PROPAGATION IN THE NAVAJO SANDSTONE, ZION NATIONAL PARK, UTAH
Dorothy Vesper	William White	TRANSPORT OF TRACE CONTAMINANTS TO A KARST SPRING DURING STORM EVENTS
Jamie Whitlock	Kevin Furlong, Tanya Furman	GEOCHEMICAL SIGNATURES OF THE MENDOCINO TRIPLE JUNCTION MIGRATION: IMPLICATIONS FOR MAGMA PETROGENESIS

TEMPERATURE VARIABILITY AT SIPLE DOME, WEST ANTARCTICA, DERIVED FROM SSM/I AND SMMR BRIGHTNESS TEMPERATURES, ECMWF RE-ANALYSIS AND AWS RECORDS

Sarah Das
Advisor: Richard Alley

Siple Dome, West Antarctica (81.65° S, 148.81°W) is the location of a recent deep ice-coring project as well as numerous other glaciological and climate studies. We are interested in understanding the seasonal temperature cycle at Siple Dome. This will improve our ability to interpret the paleotemperature record from stable isotopes, borehole thermometry, melt-layer thermometry and physical stratigraphy of the Siple Dome ice cores. These paleoclimate proxies are sensitive not only to mean annual temperature, but to seasonal and annual temperature variability. We are also interested in understanding controls on seasonal to decadal scale climate processes and variability in the Siple Dome / Ross Embayment sector of West Antarctica and how these have changed through time.

We produced a 20-year surface temperature record at Siple Dome by merging data from Automatic Weather Station (AWS) air temperature records (1997-1999), European Centre for Medium-Range Weather Forecasts (ECMWF) re-analyses (1979-1993), and emissivity-corrected brightness temperatures from the Special Sensor Microwave/Imager (SSM/I) (1987-1999) and the Scanning Multichannel Microwave Radiometer (SMMR) (1978-1987). We find good agreement in both mean annual temperature and variance between most of the overlapping records. An exception is the first half of the SSM/I record (1989-1994) which contains unreasonably low emissivity-corrected surface temperatures. These are a result of two drops in emissivity (in 1989 and 1992) caused by changes in the structure of the firn which lower the emissivity values (the first by grain coarsening and the second resulting from the formation of an ice layer in the surface following a melt event). Our results show that there is high seasonal to inter-annual variability in both mean temperature and variance over the study period. Mean annual temperatures range from 245 K to 254 K. Mean summer (DJF) temperatures range from 259 K to 267 K and mean winter temperatures range from 229 K to 245 K. Fluctuations in temperature variance occur on a five year cycle, and appear to correlate with the Southern Oscillation Index.

LATE ARCHEAN BIOMARKERS IN CARBONATES FROM THE HAMERSLEY BASIN, PILBARA CRATON, WESTERN AUSTRALIA

Jennifer Eigenbrode
Advisor: Katherine Freeman

Little is known about the extent of microbial metabolic diversity in the Archean. Detection of indigenous molecular fossils and the assessment of the isotopic expression of carbon and sulfur in sediment give us the potential to reach an improved understanding of microbial evolution and its role in biogeochemical cycles. Here we report the distribution of hydrocarbon biomarkers detected in diamond drill core carbonate samples of a late Archean (2.8-2.5Ga) rock succession from the Hamersley Basin on the Pilbara Craton, Western Australia. Our data suggest the preservation of molecular fossils from metabolically diverse ancient ecosystems of carbonate environments.

Bitumen from rocks of the WRL1, RHDH2a, and SV1 drill cores were extracted under tightly controlled and monitored laboratory conditions. The sample set is comprised of rocks of shallow and deep-water facies from a carbonate platform, and stromatolitic carbonate and shale facies from either a lacustrine or restricted marine basin. The 2.7-billion year period between sedimentation and biomarker analysis means extra-ordinary measures must be taken to make certain an indigenous and syngenetic relationship exists with the host rock. Biomarkers are preserved in these rocks and generally exhibit maturity and environmental signals that are consistent with geology and presumed thermal history of the samples.

Biomarkers identified in carbonates include *n*-alkanes, monomethylalkanes and a range of steroids and hopanes. These observations are similar to those by Brocks et al. (Science, 285, 1033-1036, 1999) on shales from the same rock succession. The presence of 2α-methylhopane in all samples supports the antiquity and widespread presence of oxygenic photosynthesizers (i.e. cyanobacteria). Diverse saturated steranes and aromatic steroids indicate the sterol biosynthetic pathway, most characteristic of the Eukarya domain, had evolved by 2.72 Ga. Biomarkers never before detected in Archean samples, include several homologous series of dimethylalkanes and, most significantly, the trace presence of 3b-methylhopane, a biomarker for methylotrophic and acetogenic bacteria.

Dimethylalkanes, common in modern and lithified microbial mats, were detected in both shallow and deep-water carbonates but, most strikingly, only in laminated lithologies. Their presence in Archean rocks supports a microbial mat interpretation of laminae and a syngenetic relationship with the host rock. In composition, a plethora of organisms have been associated with mats, including aerobic and anaerobic photosynthesizers, chemoautrophs, and heterotrophs, consistent with the diverse metabolisms suggested by the distribution of biomarkers in these rocks.

MICROBIAL MATS AS SELF-REGULATING SYSTEMS

Ellen K. Herman
Advisor: Lee Kump

We have adopted a numerical model of microbial mat biogeochemistry (*de Wit et al., 1995, FEMS Microb. Ecol. 17:117-136*) to investigate the properties of this important ecosystem. Specifically we are interested in the ability of the microbial mat ecosystem to regulate nutrient and light availability, and to damp the effects of external and internal stresses. The persistence of these ecosystems for billions of years on Earth, and the likelihood of their existence elsewhere, depends in part on their resilience to environmental perturbation.

A number of scenarios are being investigated, including the response of mats to diurnal and seasonal variations in light availability, and changes in specified heterotrophic activity (aerobic respiration and anaerobic sulfate reduction). Of relevance to studies of the Archean Earth are simulations where the mat is subjected to reduced (and elevated) surface O_2 concentrations and UV light intensity. Various stabilizing feedback loops exist; their sensitivity to various parameters is investigated quantitatively.

MECHANISM FOR CLOSELY SPACED JOINT PROPAGATION IN THE NAVAJO SANDSTONE, ZION NATINOAL PARK, UTAH

Christie Rogers
Advisor: Terry Engelder

Lateral relief of stress as predicted by the stress shadow model preempts the development of joint zones by any mechanism that appeals to a joint normal stress. However, joint zones may constitute many high permeability pathways in reservoir settings thus making the search for a mechanism causing such joint zones important to industry. The flat lying Navajo Sandstone (Jurassic) in Zion National Park contains large straight canyons that exhibit regular spacing of approximately 500 m. These canyons form geomorphic slots by differential erosion of one or more joint zones that extend from the top to the base of the 500 m thick Navajo Sandstone. A two-stage process is required for the development of the joint zones at Zion. First, regularly spaced vertical joints propagated in intact Navajo Sandstone and relieved lateral confining stress possibly during the uplift and concomitant stretching of the Colorado Plateau. The pattern of early jointing led to a bed thickness to slot spacing ratio of approximately one. A 500 m spacing represents joint saturation in the Navajo Sandstone as explained by a stress-shadow model. Second, joint zones developed when small cracks in the zone of lateral stress relief were subjected to gravity induced shear tractions causing the propagation of wing cracks. These small cracks result from tensile stress concentration and principal stress rotation associated with the preferential erosion of slot canyons, thus representing a feedback loop between erosion and joint zone development.

TRANSPORT OF TRACE CONTAMINANTS TO A KARST SPRING DURING STORM EVENTS

Dorothy Vesper
Advisor: William White

Contaminated ground water often escapes conventional monitoring techniques in karst aquifers due to the localization of flow in solution conduits. An alternative approach successfully used in such locales is spring monitoring [1-2]. Metal transport typically occurs in association with particulates. Hence in karst aquifers, where the transport of sediments varies with storm flow [3-4], the associated metal concentrations can be expected to vary likewise. This work extends our understanding of how and when trace elements are discharged at karst springs.

Aqueous samples were collected over storm events from three karst springs along the Kentucky-Tennessee border. The region is underlain by the near-horizontal limestones of the Mississippian St. Louis and Ste. Genevieve formations. Both digested and filtered aliquots were analyzed from each sample. Chemographs, illustrations of chemistry through time, were generated using sample times, precipitation data, hydrographs, and analytical concentrations.

The chemographs for the digested samples illustrate the signatures of two separate water sources. As expected, elements resulting from limestone dissolution are elevated during base flow and diluted during storms. During storms, iron and aluminum (Al)-rich event water is discharged at springs. Concentrations of trace elements lead, chromium, nickel, arsenic and cadmium are elevated coincident with the event water. Strong correlations exist between Al and the trace elements in the digested samples. Filtered samples contain lower concentrations of these elements and only poor correlations between these and Al.

The introduction of event water strongly alters the chemistry of some karst springs by two means. Mixing of base flow water with the event water dilutes the high-carbonate chemistry present in aquifer storage. The arrival of Al-rich water, with the accompanying trace elements, may be due the increased velocity and enhanced sediment-carrying capacity during storm periods. The trace elements have chemographs that generally mimic the Al chemograph, suggesting that their transport is either coupled with Al or similar in mechanism. Their correlation with Al in the digested samples, and their absence in the filtered samples, further supports this conclusion. In summary, the data support the hypothesis that, in karst aquifers, the majority of trace metal transport occurs episodically during storm events and is facilitated by association with mobile sediments.

References: [1] Quinlan J. F. (1989) U.S. EPA EPA 600/X-89/050. [2] Field M. S. (1993) J. Enviro. Sys. 22, 1-26. [3] Atteia O. and Kozel R. (1997) J. Hydrology 201, 102-119. [4] Mahler B. J. and Lynch F. L. (1999) J. Hydrology 214, 165-178.

GEOCHEMICAL SIGNATURES OF THE MENDOCINO TRIPLE JUNCTION MIGRATION: IMPLICATIONS FOR MAGMA PETROGENESIS

Jaime Whitlock
Advisors: Kevin Furlong and Tanya Furman

Since ~29 Ma, the Mendocino triple junction (MTJ) in California has been moving to the northwest, leaving a slab window in its wake. North of the triple junction, the Cascade volcanoes show typical subduction-related arc volcanism. South of the triple junction, the Coast Range volcanics erupt following the passage of the MTJ and the opening of the slab window.

To date, only the Clear Lake volcanics of the Coast Ranges have been considered in a combined tectonic/geochemical framework. Within the geochemistry of these volcanics we see a change from a depleted to a more enriched magma source. We hypothesize that as the slab is removed, the first melts are still tapping fluxed lower crustal material. As the system matures, this fluxed slab-component will decrease volumetrically over time. This allows enriched mantle, previously trapped under the subducting slab, to passively upwell and be expressed in the geochemistry of the erupted lava.

We intend to create a tectono-magmatic model that takes into account the geochemical consequences of forming a slab window. We will return to sample at Quien Sabe (9.5 – 11.5 Ma). With these samples and those already collected at Clear Lake (.1 – 2.25 Ma), Sonoma (2.5 – 5.2 Ma), Berkeley Hills (8.5 – 10.2 Ma), and Tolay (11.8 – 13 Ma), we have a full temporal suite of geochemistry for the Coast Range volcanics. We will first examine the geochemistry for each individual volcanic system. Is there a transition, similar to what we see at Clear Lake, from a depleted to more primitive magma source? Next, we will take advantage of the wide temporal range that these samples offer and determine whether there has been any long-scale systematic change in the slab window that can be gleaned from the geochemistry.

ORAL PRESENTATION SCHEDULE - THURSDAY MORNING

Time	Presenter	Advisor	Title
9:45	Christine Gans	Kevin Furlong	NUMERICAL MODELING OF STRIKE-SLIP FAULTS AS APPLIED TO THE HAYWARD FAULT, CA
10:00	Rocco Malservisi	Kevin Furlong	DYNAMICS OF THE EASTERN CALIFORNIA SHEAR ZONE
10:15	Amy Whitaker	Terry Engelder	APPLICATION OF THE CENTROID MODEL IN STRUCTURAL GEOLOGY: THE EFFECT OF LOCAL STRUCTURE AND STRATIGRAPHY ON JOINT DEVELOPMENT IN THE OUACHITA BELT AND ARKOMA BASIN
10:30	**Break**		
10:45	Joe Comisky	Peter Flemings	PETROPHYSICAL ANALYSIS OF A DEEPWATER GULF OF MEXICO TURBIDITE SAND, GREEN CANYON 65, OFFSHORE LOUISIANA
11:00	Aaron Janssen	Peter Flemings	THE IMPACT OF ACQUISITION AND PROCESSING ON 3-D SEISMIC REPEATABILITY: AN EXAMPLE FROM THE BULLWINKLE FIELD, GREEN CANYON 65
11:15	Nate Kaleta	Peter Flemings	TIME-LAPSE (4D) SEISMIC INVESTIGATION OF THE I3 SAND, KILAUEA FIELD, GREEN CANYON BLOCK 6, OFFSHORE LOUISIANA
11:30	Alastair Swanston	Peter Flemings	IMAGING PRODUCTION OF TURBIDITE RESERVOIRS THROUGH TIME-LAPSE SEISMIC ANALYSIS AT BULLWINKLE, OFFSHORE GULF OF MEXICO

NUMERICAL MODELING OF STRIKE-SLIP FAULTS AS APPLIED TO THE HAYWARD FAULT, CA

Christine Gans
Advisor: Kevin Furlong

Recent studies of Bürgmann, 2000, on the Hayward Fault, part of the Hayward-Rogers Creek fault system located east of San Francisco, propose that the northern portion of this fault creeps over the entire depth range. Interferometric synthetic aperture radar (InSAR) data from 1992 to 1997 were used to measure deformation and thus the creep rate. Further, a boundary element model was employed to model the effects of 'locking' portions of the fault at various depths. If the Hayward fault is indeed creeping for its entire depth in the northern 20 km, then large-scale earthquakes could not independently occur there. Therefore, earthquake risk assessments for the area must be reevaluated.

This research focuses on the interactions between the locked and creeping portions of faults, and their controls. Using a 3-D finite-element modeling program (TECTON), various models were designed to help determine the driving mechanisms for fault propagation.

Based on preliminary results, creep in faults appears to be a function of connection with the visco-elastic layer. In order to obtain creep velocities in the range observed on modern faults, such as the Hayward fault, the fault must extend to the visco-elastic layer. This conclusion supports Bürgmann's creep rate observations on the Hayward fault.

DYNAMICS OF THE EASTERN CALIFORNIA SHEAR ZONE

Rocco Malservisi
Advisor: Kevin Furlong

While the San Andreas faults system (SAFZ) is the main feature that marks the Pacific/North America plates boundary, a significant amount of the relative motion (~20%) is accommodated along the ECSZ. The relative rigidity of the Sierra Nevada-Great Valley block (Dixon et al., 2000), indicates that at least at the upper crust level, the relative displacement between Pacific and North America plates has been partitioned between these two primary shear zones. In contrast with the SAFZ, the ECSZ is not manifest as a single large offset fault in the upper crust. Nevertheless, GPS observations show the typical pattern of a well defined shear boundary with the velocity gradient clearly focused within a narrow transition zone between the Sierra block (SN) and the western Basin and Range (BR). The width of this transition zone increases northward as the deformation is spread across a broader area. The regional heat flow mimics this pattern as the transition from the low surface heat flow in the SN block to high heat flow in the BR becomes broader to the north as well. The close correlation between surface deformation and observed surface heat flow suggests that the strain is accommodated in the region corresponding to a hot and weak lower crust/upper-mantle. Using a FEM, we have analyzed the role that a contrast in the rheological and mechanical properties between the SN block and the BR plays on the deformation along the ECSZ. We developed a FEM that simulates the rheological properties of continental lithosphere, with an elastic layer (upper crust) overlying a viscoelastic layer (lower-crust/upper-mantle). The model illustrates the importance of the viscosity of the lower-crust/upper-mantle and demonstrates the effect upper crust faulting has on producing the deformation patterns highlighted by the GPS observations. An analysis of the boundary conditions can also give us insight on the driving forces involved in the rigid translation of the SN block. The results suggest that the localization of the strain producing the ECSZ can be controlled by a significant change in the mechanical/rheological property of the lithosphere on the eastern side of the SN block (ECSZ). Model results show that the SN block can be driven by a balance between the shear coupling on the San Andreas system and the forces produced by the transpressive plate boundary at the Transverse Ranges section of the Pacific/North America plates boundary.

APPLICATION OF THE CENTROID MODEL IN STRUCTURAL GEOLOGY: THE EFFECT OF LOCAL STRUCTURE AND STRATIGRAPHY ON JOINT DEVELOPMENT IN THE OUACHITA BET AND ARKOMA BASIN

Amy Whitaker
Advisor: Terry Engelder

A reconnaissance study of jointing in the Ouachita fold belt and the southernmost Arkoma basin was conducted in summer 2000. We characterized the jointing style in outcrops by orientation, joint density and surface morphology. The lithology of each outcrop was described in terms of sand induration, sand to shale ratio and bed thickness. A few oriented samples were collected. Sand bodies within the sequence were not observed to be laterally continuous. From the joint data, the mean joint orientation and degree of clustering about the mean were determined for each outcrop. The joint data were grouped by the formation and the tectonic setting in which they occur. The map pattern suggests that joint orientations in the Ouachitas are influenced by the structural province in which the jointing occurs. Within a structural province, differences in host rock lithology seem to effect variations in the orientations of the mean joint vectors.

With further analysis I hope to better resolve a.) the regional pattern of jointing in the Ouachita belt, b.) structural and sand-body geometry, and c.) sandstone diagenesis and strain. The guide for further work is the hypothesis that sand continuity and proximity to tectonic structures coupled with sedimentation rate and a component of tectonic compaction generated the fluid pressure to drive the joints in the Ouachitas. Specifically, I will test the applicability of the centroid model set forth by Stump (1998) for isolated sand bodies in the Gulf of Mexico to Ouachita sediments. If sand-body geometry, diagenesis and structural position a correlate with joint density, elevated pore pressure generated via the centroid model may be the mechanism driving the joints. The centroid model predicts that the sand structural high is more overpressured than the shale at an equivalent depth and the sand structural low is less overpressured than the shale at an equivalent depth. Depending on the structural geometry of the sand unit, the overpressure in the sand unit may intersect the fracture gradient (Stump, 1998).

Reference:
Stump, B.B., 1998, Illuminating basinal fluid flow in Eugene Island 330 (Gulf of Mexico) through in situ observations, deformation experiments, and hydrodynamic modeling: Unpublished Masters thesis, The Pennsylvania State University, 121 pp.

PETROPHYSICAL ANALYSIS OF A DEEPWATER GULF OF MEXICO TURBIDITE SAND, GREEN CANYON 65, OFFSHORE LOUISIANA

Joseph Comisky
Advisor: Peter Flemings

Petrophysical analysis of the Bullwinkle J-Sands provides insight into a number of processes, namely, fluid flow and seismic imaging. Fluid flow in the highly compressible J-Sands is stress-controlled and can be imaged through time with 3-D seismic data.

A time-lapse seismic study using two 3-D data sets acquired in 1988 and 1997 shows considerable dimming of seismic amplitudes in the J2 hydrocarbon reservoir due to production effects. These production effects include compaction and water imbibition. A combination of well production data and pulsed-neutron logs are used to track the movement of water during this production period. A Gassmann fluid substitution model, calibrated using well data, predicts an increase in acoustic impedance of 15% in areas where water sweep has occurred. Seismic modeling of this increase in impedance through time shows a 50% decrease in seismic amplitude, verifying the results seen in the time-lapse study.

The highly compressible nature of the J-Sands also has implications in reservoir simulation and flow properties. Porosities, calculated from wireline density logs, decrease from 33% to 30% over a vertical depth range of 1200 ft feet in the J3 sand. This 10% decrease in porosity results in a 58% decline in permeability (3.3 to 1.4 D). The decline in porosity and permeability is interpreted to result from the changing stress state in the reservoir and not because of lithlogic change (e.g. composition, size, or sorting). This in-situ compaction along structure is a natural deformation experiment from which we estimated values for bulk and pore compressibility. Compressibilities estimated from well data are one order of magnitude larger than those measured in lab tests. This discrepency is a result of higher non-elastic strain in the reservoir through geologic time than what is measured in the lab.

THE IMPACT OF ACQUISITION AND PROCESSING ON 3-D SEISMIC REPEATABILITY: AN EXAMPLE FROM THE BULLWINKLE FIELD, GREEN CANYON 65

Aaron Janssen
Advisor: Peter Flemings

The Bullwinkle oil field is located on the continental shelf/slope boundary about 241 kilometers to the southwest of New Orleans. Since 1984, four separate 3-D reflection seismic surveys have been acquired over the field. This rich data space provides a unique opportunity to characterize the repeatability of 3-D seismic surveys.

Comparing multiple vintages of seismic data has become an important tool for direct imaging of hydrocarbon production in producing oilfields (seismic reservoir monitoring). However, these separate vintages of seismic data will also show differences unrelated to hydrocarbon production. These undesirable differences can be attributed to inconsistencies in data acquisition and processing parameters. Our goal is to understand which differences can be attributed to hydrocarbon production and which are due to inconsistencies in acquisition and processing parameters.

To aid in this distinction, a normalization procedure is performed on the data to correct for differences in and wavelet phase and bandwidth, as well as amplitude differences. The two normalized datasets are then subtracted. The result is a difference dataset, which has hopefully captured the hydrocarbon production image and attenuated other differences.

This study presents the results of this normalization procedure applied to two pairs of datasets. The first is a difference between two surveys acquired orthogonally at the same calendar time (1988) before any hydrocarbon production. The differences observed in these orthogonal surveys will allow us to estimate what differences can be attributed to the differing shooting direction.

The second normalization investigated the difference between a post-production survey acquired in 1997 and one of the two 1988 surveys. The result of this normalization has been interpreted in terms of fluid flow related to hydrocarbon production.

A statistical comparison of the variability in the two difference volumes suggests that production effects are indeed visible in the 1997-1988 difference volume. The two 1988 surveys also reveal significant differences where no production has occurred.

TIME LAPSE (4-D) SEISMIC INVESTIGATION OF THE I3 SAND, KILAUEA FIELD, GREEN CANYON BLOCK 6, OFFSHORE LOUISIANA

Nate Kaleta
Advisor: Peter Flemings

Two volumes of legacy seismic data are used to investigate time-lapse (4D) amplitude changes in the I3 reservoir of the Kilauea Field, Green Canyon Block 6, offshore Louisiana. Normalization of the 1985 and 1995 seismic volumes includes rebinning, bulk shifting, bandpass filtering, Wiener filtering, and amplitude scaling using parameters derived in a downdip aquifer volume. This aquifer volume is located structurally below the gas-water contact and is assumed to be free from production effects. After normalization, 4D amplitude differences are correlated to production from the I3 reservoir.

Difference maps for the I3 sand show significant time-lapse dimming (amplitudes decreased). This dimming is located between the original gas-water contact and the perforations of the A16 well. Production data show the A16 well produced no water in 1985 and 2,000 barrels of water per day at the time of the second seismic survey. The area where amplitudes dimmed is interpreted to be a region swept by water between seismic surveys. Production from the I3 sand caused the gas-water contact to migrate updip and in 1995 this contact was at the same elevation as the A16 perforations. The increase in water saturation in the I3 pores increased the acoustic impedance and resulted in the time-lapse amplitude decrease.

IMAGING PRODUCTION OF TURBIDITE RESERVOURS THROUGH TIME-LAPSE SEISMIC ANALYSIS AT BULLWINKLE, OFFSHORE GULF OF MEXICO

Alastair Swanston
Advisor: Peter Flemings

Two three-dimensional seismic surveys over the Bullwinkle Field (Green Canyon 65, Gulf of Mexico) acquired eight years apart for exploration and production purposes show significant differences that can be attributed to production effects in turbidite reservoirs. The water-drive J2 sand, which has accounted for over 50% of the total production, exhibits a significant down-dip decrease in seismic amplitude with time ("dimming"). This correlates to an increase in water saturation due to upward migration of the oil-water contact during production. Brightening with time occurs in many up-dip regions. Production data suggest that gas exsolution and a corresponding decrease in acoustic impedance may lead to this time-lapse brightening.

A normalization approach was performed in order to maximize the similarity between the two surveys, which were acquired and processed using different methodologies. This included re-binning, global shifting, frequency filtering, amplitude matching and the application of a least-squares Wiener cross-equalization filter. The variability of the differences between the normalized surveys in a region unaffected by production was used to identify changes in the J2 horizon that have a high probability of being due to production effects. The results of the analysis will be compared with reservoir simulation and Gassmann Fluid Substitution modeling in an attempt to evaluate the production characteristics of the Bullwinkle J-Sand reservoirs.

ORAL PRESENTATION SCHEDULE - THURSDAY AFTERNOON

Time	Presenter	Advisor	Title
1:30	Heather Buss	Susan Brantley	AFM INVESTIGATIONS OF PITTING ON SILICATE SURFACES BY A SOIL BACTERIUM
1:45	Melinda Foland	Katherine Freeman	INVESTIGATION OF ECOSYSTEM RESPONSE TO ENVIRONMENTAL CHANGES THROUGH BIOMARKER AND STABLE ISOTOPE ANALYSIS
2:00	Robin Guynn	Susan Brantley	EFFECTS OF BACTERIA AND ORGANIC LIGANDS ON IRON ISOTOPE FRACTIONATION AND TRACE METAL RELEASE DURING MINERAL DISSOLUTION
2:15	**Break**		
2:30	Matt Hurtgen	Michael Arthur	THE SULFUR ISOTOPIC COMPOSITION OF TRACE SULFATE ASSOCIATED WITH NEOPROTEROZOIC "CAP CARBONATES" FROM NAMIBIA AND SOUTH AUSTRALIA: IMPLICATIONS FOR A SNOWBALL EARTH
2:45	Andres Marin	Susan Brantley	THE RELEASE OF Mo AND Fe FROM SILICATES BY *AZOTOBACTER VINELANDII*
3:00	James Moran	Katherine Freeman, Chris House	EXPLORING ANAEROBIC METHANE OXIDATION IN PURE LABORATORY CULTURES
3:15	Nikolai Pedentchouk	Katherine Freeman	DISTRIBUTION OF 1,2,3,4-TETRAMETHYLBENZENE IN FLASH PYROLYZATES OF KEROGEN FROM LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS, WEST AFRICAN RIFT BASINS

AFM INVESTIGATIONS OF PITTING ON SILICATE SURFACES BY A SOIL BACTERIUM

Heather Buss
Advisor: Susan Brantley

Understanding the effects of microbiota on mineral alteration requires the ability to recognize the effects of bacteria-promoted dissolution on mineral surfaces. We have utilized atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS) to investigate surfaces under bacteria colonies. In order to observe the effects of long-term growth of microbes on mineral surfaces, however, microbes must be removed from the surfaces without chemically or physically changing the surface.

In this study, monocultures of the soil bacterium *Bacillus mycoides* were incubated for 13 and 77 days in an iron-deficient medium in the presence of hornblende glass planchets. The hornblende glass was synthesized in order to prepare a chemically homogeneous and smooth surface similar to the iron-silicate mineral hornblende. Such smooth surfaces aid us in recognizing features attributable to bacteria. *B. mycoides* is known to produce siderophores that enhance removal of Fe from hornblende. Removal of bacteria with CO_2 snow-cleaning and four detergents (sodium tetraborate, sodium pyrophosphate, sodium dodecyl sulfate (SDS), and Triton X-100) was tested. Based on AFM and XPS analyses, SDS was chosen for further use.

To determine the mechanisms of pitting, hornblende glass planchets were incubated in buffered, pH-neutral growth medium with *B. mycoides* for 46 days with parallel abiotic experiments using desferrioxamine mesylate (DFAM, a commercially available siderophore) or oxalic acid instead of bacteria. Weekly sampling and analysis of all sample solutions (with and without bacteria) revealed more release of Fe, Al, and Si in the DFAM experiments than the others, and negligible changes in pH. AFM analyses reveal widespread, small etch pits (<50 nm deep, <50 nm wide) on the DFAM-exposed surfaces and localized, larger etch pits (60-120 nm deep, ~900 nm wide) on the bacteria-exposed surfaces. Surfaces exposed to oxalic acid are un-pitted and appear identical to control surfaces.

We conclude that chelation of iron by siderophores rather than by organic acids are responsible for the etch pits. Additionally, the distribution of pits and strong bacterial attachment to the surfaces suggest that pitting is related to colonization; for example, the pits may be due to high concentrations of siderophores contained in glycocalyx.

INVESTIGATION OF ECOSYSTEM RESPONSE TO ENVIRONMENTAL CHANGES THROUGH BIOMARKER AND STABLE ISOTOPE ANALYSIS

Melinda Foland
Advisor: Katherine Freeman

We hope to test plant ecosystems response to changes in atmospheric CO_2 since the Last Glacial Maximum (LGM). Previous work has suggested significant CO_2 changes lead to shifts from C3 plant ecosystems to ones dominated by C4 plants. However, C4 plants conserve moisture better and have a competitive advantage over C3 plants under arid conditions suggesting water avalibility is an additional factor in ecosystem change. Biomarkers, which are compounds that can be directly related to specific precursor biological compounds, and stable isotopes are used to elucidate the relationship patterns of ecosystem response in four sediment cores form Mesoamerican lakes.

The lake pollen records indicate the study sites have experienced different moisture conditions since the last glacial maximum. Three of the lakes are positioned on the Neo Volcanic Axis of Mexico: Lake Zempoala (pollen analysis in progress), Lake Patzcuaro (drier than at LGM), and La Piscinia de Yuriria (mixed episodes of dry and wet periods). The Fourth lake is located in Guatemala: Lake Quexil (wetter than at LGM).

Similar studies of African lakes show a distinct shift in C3/C4 plant input since the LGM (Street-Perrott *et al*., 1997, Huang *et al*., 1999) and this shift is attributed to increasing atmospheric CO_2 levels. Our study, however, does not show distinct shifts in plant inputs expected if CO_2 were the sole determining factor. δ13C analysis of plant wax alkane biomarkers show different trends for each lake, and indicate CO_2 is not the controlling factor in ecosystem change as suppositioned by past work. Changes in aridity may play an important role. Regional differences in aridity in Mesoamerica may not have been great enough to produce a significant signal, however, the overall differences in aridity between Mesoamerica and Africa may be the key to understanding the differing results of these studies.

EFFECTS OF BACTERIA NA ORGANIC LIGANDS ON IRON ISOTOPE FRACTIONATION AND TRACE METAL RELEASE DURING MINERAL DISSOLUTION

Robin Guynn
Advisor: Susan Brantley

There has been a great deal of interest lately in iron isotopes as biomarkers. If microorganisms are important to the cycling of iron in the environment, then they may cause fractionation of iron isotopes, which could be used to detect microbial activity in both ancient and modern sediments. In order for this to be considered a useful and reliable biosignature, more needs to be understood about the causes of iron isotope fractionation. We have conducted experiments using hornblende and soil samples collected from Gore Mountain, NY to study iron isotope fractionation in a natural system and how microorganisms might be involved in this process.

Samples of the hornblende were leached in the presence of bacteria and organic ligands of varying strengths. After six days of incubation, solutions without bacteria or ligands contained 300ppb iron, while solutions with bacteria contained 2400ppb iron. The concentration of iron in solution with organic ligands ranged from 270 to 600ppb. We have also monitored the concentrations of other metal nutrients in solution in our bacterial experiments to determine the effect of bacteria on dissolution of these metals.

The $^{56}Fe/^{54}Fe$ ratio of iron dissolved without bacteria or ligands is similar to that in the hornblende. The $\delta^{56}Fe$ for iron in solution with bacteria is about –0.7‰ relative to the hornblende. The $\delta^{56}Fe$ for iron dissolved with organic acids ranges from –0.2 to –0.6‰ with the stronger ligands having more negative values. We believe there may be a kinetic isotope effect associated with the formation of complexes between iron and organic ligands at mineral surface.

The exchangeable and oxide fractions of the soil were extracted and analyzed for iron isotope composition. There is a 1‰ difference between the $\delta^{56}Fe$ values for these fractions. The oxide $\delta^{56}Fe$ is similar to that of the hornblende, while the exchangeable $\delta^{56}Fe$ is closer to that for the iron in solution with bacteria in hornblende dissolution experiments.

NEOPROTEROZOIC "CAP CARBONATES" FROM NAMIBIA AND SOUTH AUSTRALIA: IMPLICAITONS FOR A SNOWBALL EARTH

Matt Hurtgen
Advisor: Michael Arthur

The present study employs a method for analysis of the sulfur isotopic composition of trace sulfate extracted from carbonates in order to document secular variations in the sulfur isotopic composition of Neoproterozoic oceanic sulfate and to assess variations in the sulfur cycle that may have accompanied the 'Snowball Earth'. The sensitivity of $\delta^{34}S_{sulfate}$ to biogeochemical change makes it a candidate to evaluate aspects of the "Snowball Earth" hypothesis, particularly whether or not the oceans were effectively isolated from riverine runoff as the result of long-term global sea-ice cover.

Trace sulfate from carbonate samples in Namibia (Rasthoff, Gruis, Ombaatjie and Maieberg Fms) and South Australia (Nuccaleena Fm) were analyzed for their sulfur isotopic composition. Dramatic positive excursions, reaching 40‰, appear stratigraphically above some, but not all (Hurtgen, personal communication), of the glacial intervals in what have been termed 'cap carbonates.'

We suggest that the large positive $\delta^{34}S_{sulfate}$ excursions found in some Neoproterozoic cap carbonates are consistent with hypothesized "Snowball Earth" events, although, there are other mechanisms that may facilitate these large shifts in $\delta^{34}S_{sulfate}$. If the Earth's oceans were blanketed with ice and the hydrologic cycle shutdown, riverine delivery of relatively depleted $\delta^{34}S_{sulfate}$ (ca. 6-10‰) from the continents via pyrite weathering and/or evaporite dissolution would essentially cease. Assuming that sufficient organic substrates existed to allow sulfate-reducing bacteria to continue to preferentially dissimilate ^{32}S and that the sulfide was precipitated as pyrite (available Fe), the isolated oceanic reservoir of sulfate would become progressively enriched in ^{34}S. Hoffman *et a*l. (1998) have suggested that the duration of the snowball event may have been 8 million years. Such a long period of isolation might facilitate a significant decrease in the mass of the oceanic sulfate reservoir. During deglaciation, deepwater overturn would supply ^{34}S-enriched sulfate to surface waters. As the hydrologic cycle resumed and perhaps rapid input of sulfate was reestablished, the $\delta^{34}S_{sulfate}$ of oceans would gradually or perhaps rapidly return to more typical values of 20‰ over tens of millions of years.

THE RELEASE OF Mo AND Fe FROM SILICATES BY *AZOTOBACTER VINELANDII*

Andrés Marín
Advisor: Susan Brantley

Azotobacter vinelandii is a widespread, Gram negative, obligately aeorobic bacterium that fixes nitrogen no-symbiotically. In order to fix nitrogen, Azotobacter must acquire Fe (III) and Mo to serve as the metal co-factors in the nitrogenase enzyme. However, in aerobic systems at neutral pH, the availability of inorganic Fe (III) is too low to maintain bacterial life (Fe (III)=10^{-17} M). In order to acquire these metal cations for growth, *A.vinelandii* produces several siderophores. Siderophores are low molecular weight organic molecules with a high affinity for iron. These siderophores are produced in response to varying levels of iron availability and scavenge, bind and aid in the uptake of Fe. As Fe and Mo have a similar charge:radius ratio, siderophores also can form stable complexes with Mo. However, it remains uncertain how microbes acquire Fe and Mo and the role that siderophores play in the acquisition of metal cations from solid substrates.

We have run batch experiments in an Fe- and Mo-free Burk growth medium to investigate the release of Fe and Mo from a silicate material with and without *Azotobacter*. From our results, we infer that *Azotobacter* produced siderophores when cultured in the absence of dissolved Fe. After removal of cells from solution and addition of fresh honblende glass, Fe and Mo were released similarly into solution for all flasks that had contained bacteria, suggesting that siderophores promoted glass dissolution and release of both Fe and Mo. To confirm that siderophores are responsible for the release of metals into solution, we shall compare the results from similar experiments with strain P100 which produces no known siderophores to those of strain OP which produces all known siderophores.

Hornblende is a ubiquitous primary igneous and metamorphic mineral present in many soils. Elucidating the relationship between *Azotobacter* and common soil minerals such as hornblende will lead to a better understanding of factors controlling soil fertility and transition metal biogeochemistry .

EXPLORING ANAEROBIC METHANE OXIDATION IN PURE LABORATORY CULTURES

James Moran
Advisosr: Katherine Freeman and Chris House

Understanding the global carbon cycle is crucial for the analysis of both past and future environments and climate. Methae plays a significant role in the earth's carbon budget. Recent investigations have revealed a possible anaerobic sink for methane. Biomarkers extracted from methanogens isolated in anoxic sediments have been sufficiently depleted in $\delta^{13}C$ to suggest methane as the only possible carbon source for the organisms, indicating methanogenic methane consumption. Microscopic imaging and in-situ growth investigations have uncovered a proposed symbiotic relationship between sulfate-reducing bacteria and methanogens leading to anaerobic methane oxidation by methanogens. Further, thermodynamic data suggests the process is favorable under conditions of low hydrogen concentrations. The process is estimated to consume up to 90% of the methane produced in anoxic marine systems, making it a significant aspect of the global methane and carbon budgets.

To date, there has been no direct laboratory evidence showing that a symbiotic relationship between these two organisms is capable of anaerobic methane oxidation. Pure methanogen and sulfate-reducer cultures are being grown to test this hypothesis. The cultures are combined under an artificially 13C-enriched methane atmosphere. Incorporation of the label into the methanogen biomass can be traced by stable isotope analysis of the culture. Analysis of carbon dioxide present in the cultures has not shown any enrichment, indicating any incorporation of labeled methane into the methanogen is not immediately released as carbon dioxide. Future analysis will focus on this and additional microbial pairs and consider the $\delta^{13}C$ of the bulk biomass in the system as well as the $\delta^{13}C$ of methanogen-specific Archaeols extracted from methanogen membranes. Replicating anaerobic methane oxidation in a laboratory setting is the first step in understanding the enzyme kinetics, chemical intermediates, genetic components, and rates of this process.

DISTRIBUTION OF 1,2,3,4-TETRAMETHYLBENZENE IN FLASH PYROLYZATES OF KEROGEN FROM LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS, WEST AFRICAN RIFT BASINS

Nikolai Pedentchouk
Advisor: Katherine Freeman

Factors controlling organic matter (OM) production and preservation are of great interest to petroleum industry and scientific community, because the understanding of these factors provides information regarding the quality and quantity of sedimentary OM as well as refines the knowledge about various fluxes that regulate the global carbon cycle. Previous work in Lower Cretaceous West African basins resulted in the identification of changes in primary productivity as an important factor in preservation of organic matter (OM). However, the importance of marine influence on OM sedimentation and preservation as well as the extent of anoxia during the deposition of OM in these basins is still unresolved. The purpose of the present study is to provide a better understanding of these factors by characterizing OM fraction released from kerogen by flash pyrolysis (610ºC, 10 sec).

We analyzed 22 samples representing several stratigraphic intervals from three basins (Gabon, Congo, and Angola) in West Africa. Preliminary analysis of data revealed that pyrolyzates contained various amounts of 1,2,3,4-tetramethylbenzene (1,2,3,4-TMB) in all samples. In general, the 1,2,3,4-TMB/tridecane ratios increased with section depth in all formations. The most significant changes were observed in Gabon (from 0.15 to 0.50 over 420 m of section and in Angola (from 0.13 to 0.37 over 220 m). In addition to large-scale variations, small-scale differences were also observed.

We are currently investigating the possibility of photic zone anoxia and significant influence of marine OM sedimentation in West African basins. Earlier work in these basins allowed making a comparison between changes in 1,2,3,4-TMB/tridecane ratio and inorganic redox proxies as well as biomarkers that indicate marine OM sedimentation. In general, we identified a correspondence between increases in 1,2,3,4-TMB/tridecane ratio and anoxic conditions as indicated by V/Cr and Ni/V ratios in the Congo Basin. At the same time, there is almost no relationship between 1,2,3,4-TMB/tridecane ratios and the distribution of C30 proportional sterane values (indicator of marine OM sedimentation) in all three basins.

Identification of the sources of 1,2,3,4-TMB may prove crucial to constraining the influence of anoxia and the importance of inputs from marine vs. lacustrine biota in West African Basins. Our current work involves identification of additional compounds (e.g., 1-ethyl-2,3,6-trimethylbenzene and other isorenieratane derivatives) and compound-specific isotopic analyses that may provide unambiguous information with respect to the origin of this compound.

ORAL PRESENTATION SCHEDULE - FRIDAY MORNING

Time	Presenter	Advisor	Title
9:45	Dimitri Abbado	Rudy Slingerland	THE ORIGIN OF RIVER ANASTOMOSIS: FLOODPLAIN SEDIMENTATION IN AN ANASTOMOSING REACH
10:00	Achim Hermann	Mark Patzkowsky	MOVING CONTINENTS, CHANGING ATMOSPHERIC PCO_2 LEVELS, AND EKMAN PUMPING: A COMPUTER MODEL ANALYSIS INVESTIGATING GLOBAL COOLING DURING THE LATE ORDOVICIAN
10:15	Jane Lock	Kevin Furlong	LANDSCAPE RESPONSE TO THE MENDOCINO CRUSTAL CONVEYOR, NORTHERN CALIFORNIA COAST RANGES
10:30	Scott Miller	Rudy Slingerland	THE ROLES OF ASPECT AND LAND SLIDING IN THE EROSION PROCESSES IN BEDROCK CHANNELS ON A GROWING FOLD
10:45	**Break**		
11:00	Beth Pratt	Doug Burbank	BEDROCK INCISION RATES AND SEDIMENTARY FLUX - DATA FROM STRATHS AND FILL TERRACES, MARSYANDI RIVER, NEPAL
11:15	Peter Sak	Donald Fisher	DIFFUSION MODELS FOR WEATHERING RIND GENESIS
11:30	Courtney Turich	Katherine Freeman	DEPTH DEPENDENT TRENDS IN DEPOSITION AND DIAGENESIS IN THE LOWER CAPITAN REEF, SLAUGHTER CANYON, GUADALUPE MOUNTAINS, NEW MEXICO

THE ORIGIN OF RIVER ANASTOMOSIS: FLOODPLAIN SEDIMENTATION IN AN ANASTOMOSING REACH

Dimitri Abbado
Advisor: Rudy Slingerland

An anastomosing river is a network of interconnected sinuous channnels separated by floodplains. In general, anastomosing rivers are characterized by low gradient, high sediment load (fine to coarse sand) and irregular discharge. The goal of the present study is to define the causes of anastomosis in the upper reach of the Columbia River (CR) and to characterize the constructional processes of its floodplains.

The study reach extends 60 km from the Spillimacheen River, a major tributary, to the town of Golden, BC. A GPS survey was conducted along the reach and bed load was sampled every 2 km. The number of levee brakes (crevasses) and the area of associated deposits (crevasse splays) as well as the number of active channels and the valley width were computed from aerial photos. Topographic and turbidity maps, as well as a sediment budget during a one-flood cycle were carried out on a selected floodplain.

On the basis of our observations the study reach can be divided into a high-anastomosing (2-5 channels) and a low-anastomosing (1-2 channels) sub-reaches. In contrast with the low-anastomosing portion, the high-anastomosing reach is characterized by relative high valley slope, a high number of crevasse splays, larger crevasse splay area, a wide valley, and a medium to coarse sand channel bedload. The floodplain result aggrading 3mm/y but aggradation >10cm were measured at the inlet crevasse splay.

How can we explain these geomorphologic and sedimentary associations? Our hypothesis is that the large sediment input of the Spillimacheen River tributary during summer snow melting cannot be transported by the lower competence of the CR. This provokes a rapid aggradation of the channel bed that increases the probability of levee overtopping and crevasse and splay formation. The high number of crevasse splays promotes the formation of new channels through floodbasins, thereby explaining the higher anastomosed character of the reach.

COMPUTER MODEL ANALYSIS INVESTIGATING GLOBAL COOLING DURING THE LATE ORDOVICIAN

Achim Herrmann
Advisor: Mark Patzkowsky

The Late Ordovician is characterized by a short-lived (less than 1 Myr), yet severe, glaciation that was accompanied by a mass extinction. We performed a series of sensitivity experimets with an AGCM (GENESIS v2.0) to assess the impact of paleogeography on global cooling during this time period. The experiments consisted of runs with Caradocian (454 Ma) and Ashgillian (440 Ma) paleogeographic reconstructions under a range of atmospheric pCO_2 levels (18x, 15x, 10x and 8x pre-industrial pCO_2).

We find that under the prescribed boundary conditions the paleogeographic changes during the Late Ordovician were necessary for glaciation. For all pCO_2 levels, the Caradocian experiments yielded higher annual mean temperatures than Ashgillian experiments. Furthermore, all Caradocian simulations remained virtually free of extensive snow covers and global mean temperatures stayed above freezing. However, as previous studies have shown, under Ashgillian paleogeography the threshold for glaciation is 8x-10x PAL. This indicates that without the unique paleogeographic setting of the Late Ordovician, the glaciation could not have occurred, even under atmospheric pCO_2 levels as low as 8x pre-industrial.

In addition, we used the model atmospheric wind field outputs to compute wind stress curl induced upwelling/downwelling in the ocean for the climate simulations. The vertical velocity at the base of the Ekman layer gives an indication of Ekman pumping and thus an indication of potential productivity. Preliminary results indicate that the change in wind patterns in response to lower pCO_2 levels and paleogeography lead to higher upwelling rates in higher latitudes and North of the equator during the Ashgill, especially during the summer months of the Southern Hemisphere. The increased productivity could have led to a positive feedback loop, since the increased productivity could have led to a drawdown of pCO_2 by removing CO_2 via deposition of organic matter. More rigorous analysis of all simulations will have to be performed in order to see if the overall upwelling and thus productivity is a general feature of this study.

LANDSCAPE RESPONSE TO THE MENDOCINO CRUSTAL CONVEYOR, NORTHERN CALIFORNIA COAST RANGES

Jane Lock
Advisor: Kevin Furlong

Triple junction migration produces rapid and dramatic changes in the tectonic regime driving crustal deformation. In the case of migration of the Mendocino triple junction (MTJ), Furlong and Govers (1999) predict a spatially and temporally varying pattern of uplift via a mechanism termed the Mendocino Crustal Conveyor (MCC). We suggest the evolution of the northern California Coast Ranges and the complicated drainage patterns observed, are a response to this uplift function of the MCC.

The MCC model, motivated by recent crustal models that show substantial crustal thickening associated with MTJ migration, predicts a topographic response in the northern California Coast Ranges which includes two topographic highs that migrate with the triple junction. The migration causes an area to experience constantly varying rates of uplift. Evidence for this MCC-predicted uplift is seen in the topography and drainage patterns in the northern California Coast Ranges. Broadly, there are two large drainage divides observed in the Coast Ranges that are coincident with divides predicted by the crustal conveyor model. These divides separate northwest from southeast flowing streams, are topographically low, and often display wind gaps once occupied by through-going NW-SE channels.

Investigating the interplay between tectonics and the surface response allows us to test and extend the MCC to regions of the Coast Ranges less well imaged by crustal seismic observations.

THE ROLES OF ASPECT AND LANDSLIDING IN THE EROSION PROCESSES IN BEDROCK CHANNELS ON A GROWING FOLD

Scott Miller
Advisor: Rudy Slingerland

The current paradigm in landscape evolution holds that fluvial incision of bedrock-floored channels limits overall denudation rates and controls whether hillslopes become sufficiently steep for landsliding. Incision rates in drainage basin headwaters are increased only when base-level changes (e.g., from rock uplift along a range-bounding fault) are transmitted from downstream. Most analyses of bedrock channels to date have attempted to determine whether incision rates in such channels are governed by a unique law, such as the stream-power erosion law. These studies typically assume that a particular erosional mechanism is predominant or that the various contributing mechanisms are uniform from basin to basin.

A geographic information systems analysis of air photographs and a high-resolution (10 m) digital elevation model of Wheeler Ridge, CA - an actively growing fold near the San Andreas fault - shows compelling evidence that the above assumptions are drastically simple. Landslides and other forms of mass wasting are apparently more frequent on south-facing hillslopes. Channels near the headwaters of these south-facing basins are less steep than channels in their north-facing counterparts, yet appear to have erosion rates that are faster by more than a factor of two. This difference can be explained as the result of (1) higher sediment flux rates (abrasional tools) through fluvial channels in the basins with frequent landslides or (2) debris flows, in which case these are colluvial channels. The results of the current study, however, suggest that hillslope processes (e.g., mass wasting) can directly amplify channel incision rates. Something as simple as slope aspect, which can increase the probability of shallow landsliding, can thus influence bedrock channel erosion. In other cases, landsliding in headwaters can be caused by stream incision transmitted upstream from the base of the fold—the local base level. This is not surprising. What is surprising is the possibility that a “wave” of erosion that propagates up the channnel network to its tips, due to a base-level fall, might become amplified and possibly “reflected” downstream some distance.

BEDROCK INCISION RATES AND SEDIMENTARY FLUX– DATA FROM STRATHS AND FILL TERRACES, MARSYANDI RIVER, NEPAL

Beth Pratt
Advisor: Doug Burbank

Perched straths and fill terraces provide evidence of the Late-Pleistocene to Holocene geomorphic evolution of the Marsyandi River, Central Nepal and provide a means to calibrate numerical models of fluvial systems. The river can be divided into three main reaches: 1) a bedrock region that cuts across the main Himalayan Divide, 2) a 70-km-long region of alluvial channel south of the main orogenic front, and 3) another portion of bedrock channel where the river flows through the Mahabharat Range (a 2000-m-high range situated above the Main Boundary Thrust). Cosmogenic radionuclide dating of perched bedrock straths gives river incision rates of 1.7± 0.2 mm/yr in the Mahabharat and >10mm/yr in the Main Himalaya. The current excess stream power model for this area predicts higher rates (~5 mm/yr) for the Mahabharat and lower ones (7-9 mm/yr) for the Main Himalaya. These real field data allow a rare opportunity to calibrate umerical models of fluvial systems. Stratigraphy and radiocarbon dating show that the fill terraces formed rapidly from large-scale, non-local debris flows and course-grained fluvial deposits ≥ 40 Ka. The profile of these Late Pleistocene fill terraces is 2.5 ± 0.2 m/km steeper than the modern river profile. While this could reflect differential uplift of ~1 mm/yr over the terraces' 25 km extent, it is more likely a natural slope response to a higher Qsed/Qwater ratio during a period of glaciation. Models of alluvial channels by both Einstein and Bagnold predict that this ratio would need to change by only 1.5-2 to generate the observed change in slope. There is mounting evidence for increased glaciation in the Himalayas 30-60 Ka. Remnant moraines in the upper reaches of the Marsyandi indicate that sufficient sediment could have been stored in that region to account of the material now deposited in the terraces. Although terrace formation is due to a sediment flux in excess of the river's carrying capacity, their preservation extent is dictated by structure. Only fragments of terraces remain in areas of active uplift/incision.

DIFFUSION MODELS FOR WEATHERING RIND GENESIS

Peter Sak
Advisor: Don Fisher

Weathering-rind thicknesses were measured on 249 basaltic andesite clasts collected from a flight of four alluvial fill terraces (Qt 1, Qt 2, Qt 3, and Qt 4) preserved along the Pacific coast of Costa Rica. Mass balance calculations suggest that the conversion of unweathered core material to porous rind material is iso-volumetric and Zr and Ti are immobile. The hierarchy of cation mobility (Ca > K > Na > Mg > Si > Al > Fe > Ti), determined using mass transport components ($\tau_{j,w}$), appears similar to other tropical weathering profiles.

The rate of weathering rind growth as a function of time is evaluated using both linear and shrinking core diffusion models. Age estimates are indistinguishable between the two models. In both models the rate-limiting step in weathering rind development is diffusion through the rind. In the absence of a calibration point where both rind thickness and age are known, ranges of known age are used to calculate the diffusion parameter, κ: $7.1 \times 10^{-12} > \kappa > 2.6 \times 10^{-12}$ cm^2 sec^{-1}.

Assigning Qt 1 (mean rind thickness 5.8 ± 0.3 cm) to oxygen isotope stage 7 (ca. 230 ka) yields a diffusion parameter of 4.5×10^{-12} cm^2 sec^{-1}. Using this diffusion parameter and the measured rind thicknesses, Qt 2 (mean rind thickness 4.2 ± 0.3 cm) is assigned to stage 5e (ca. 125 ka), Qt 3 (mean rind thickness 2.9 ± 0.1 cm) is assigned to stage 3d (ca. 60 ka) and Qt 4 (mean rind thickness 0.9 ± 0.1 cm) is assigned to the post-6ka Holocene sea-level highstand (6 ka). A diffusion parameter of 4.5×10^{-12} cm^2 sec^{-1} satisfies the available independent age constraints, and predicts ages coincident with eustatic highstands, as expected for these terraces.

DEPTH DEPENDENT TRENDS IN DEPOSITION AND DIAGENESIS IN THE LOWER CAPITAN REEF, SLAUGHTER CANYON, GUADALUPE MOUNTAINS, NEW MEXICO

Courtney Turich
Advisor: Katherine Freeman

The Capitan reef complex is exposed in the Guadalupe, Glass, and Apache Mountains of west Texas and New Mexico. The Permian Capitan reef formed a prograding margin along the Delaware Basin in an equatorial, epicontinental sea during the Upper Guadalupian. Preserved in evaporites that subsequently eroded, the shelf to reef basin profile is exposed by a series of canyons that now bisect the reef. This structural and erosional history allows study of an ancient reef system where modern topography approximates ancient bathymetry.

In the lower Capitan reef, at depths 10 to 15 m below the outer shelf/reef transition, millimeter-scale laminae and aragonite botryoids dominate the samples. Aragonite botryoidal cement appears only in sample 10-15 m below the outer shelf/reef transition. Appreciable wave energy transported sediments out of the upper section of the reef leaving pore space available for many generations of microbial encrustations and aragonite cement to fill primary framework porosity. At depths greater than 15 m below the outer shelf/reef transition, thick accumulations of micrite dominate the rock. Occlusion of primary porosity was contemporaneously with reef growth.

Carbon and oxygen stable isotopic compositions of fossil sponges, micrite, sediment, and sparry calcite form a co-varying linear trend. Diagenesis has altered marine components, but the original isotopic compositions may be reflected in the marine end members. With increasing depth in the reef, sparry calcite becomes enriched with respect to $\delta^{13}C$ and $\delta^{18}O$. Meteoric fluids penetrated the reef-rock and precipitated sparry calcite. At the top of the reef, this sparry calcite has an isotopically light, characteristically meteoric composition. With increasing depth, rock-water interaction led to the precipitation of sparry calcite with an isotopically heavy, characteristically marine isotopic composition.

ORAL PRESENTATION SCHEDULE - FRIDAY AFTERNOON

Time	Presenter	Advisor	Title
1:30	Dave Reusch	Richard Alley	AUTOMATIC WEATHER STATION SAND ARTIFICIAL NEURAL NETWORKS: IMPROVING THE INSTRUMENTAL RECORD IN WEST ANTARCTICA
1:45	Matt Spencer	Richard Alley	DEVELOPING A BUBBLE-SIZE-PALEOCLIMATIC INDICATOR FO GLACIER ICE
2:00	Huiwen Xue	Dennis Lamb	THE EFFECTS OF HNO_3 ON CLOUD FORMATION
2:15	**Break**		
2:30	Brandon Dugan	Peter Flemings	SEDIMENTATION AND OVERPRESSURE ON PASSIVE CONTINENTAL MARGINS: IMPLICATIONS FOR SLOPE STABILITY, DRILLING, AND GAS HYDRATES
2:45	Xiaoli Liu	Peter Flemings	PSTAR: INSIGHTS INTO FLUID FLOW AND OVERPRESSURE
3:00	Jacek Lupa	Peter Flemings	FLOW FOCUSING IN TURBIDITES ON THE GULF OF MEXICO SLOPE

AUTOMATIC WEATHER STATIONS AND ARTIFICIAL NEURAL NETWORKS: IMPROVING THE INSTRUMENTAL RECORD IN WEST ANTARCTICA

David Reusch
Advisor: Richard Alley

A deeper understanding of Antarctic meteorology is one key to improved interpretation of the ever growing body of ice-core-based paleoclimate records from this region. Automatic weather stations (AWS) currently provide the only year-round, direct measurements of weather on the ice sheet. As the spatial coverage of the network has expanded year to year, so has our meteorological database. Unfortunately, many of the records are relatively short (less than 10 years) and/or incomplete (to varying degrees) due to the vagaries of the harsh environment. Recent developments in climate downscaling in temperate latitudes suggest it may be possible to use GCM-scale meteorological data sets (e.g., ECMWF reanalysis products) to both fill gaps in the AWS records and extend them back in time to create a uniform and complete database of West Antarctic surface meteorology (at AWS sites). Artificial neural network (ANN) techniques are used to predict known AWS data (e.g., temperature, pressure) using large-scale features of the atmosphere (e.g., 500 mb pressure height). Once trained, the ANN can predict from the GCM-scale data for periods where AWS data are not available. Results will be presented from work with Ferrell AWS, located on the Ross Ice Shelf (77.91° S, 170.82° E).

DEVELOPING A BUBBLE-SIZE PALEOCLIMATIC INDICATOR FOR GLACIER ICE

Matt Spencer
Advisor: Richard Alley

Models for the densification of firn (which is the transitional state of solid water between snow and glacier ice) can be used to investigate numerous glaciologically important issues. Using a firn model, we propose to construct a bubble-size paleoclimatic indicator to infer past mean-annual temperatures or accumulation rates (given one, we propose to be able to find the other). We propose to use this paleoclimatic indicator to then examine anomalous past climate states using the Siple Dome and Taylor Dome, Antarctica, ice cores, and to calibrate climate reconstructions derived from stable water isotopes.

Average grain area in a firn column increases linearly with time as a function of temperature. Unfortunately, at depths below the firn-to-ice transition, deformation alters average grain size, disrupting any record of past climates that growth rates might have otherwise betrayed. However, at the firn-to-ice transition density, where the pore space becomes isolated from the atmosphere above and where grains are not yet affected by deformation, the average history of grain-growth rates during firn densification becomes locked in the ice by way of bubble number and size. At the pore close-off density there should be ~1 bubble per grain, and the average bubble volume will be directly proportional to grain size. Bubble records from ice cores will therefore reveal the number of grains at the time of pore close off. Using a firn densification model and an accumulation-rate history, bubble-number-density records can be inverted to constrain estimates of past mean-annual temperature.

The bubble-size model should allow investigation of anomalous climate states implied by ice cores. There are areas of the core that are believed to represent times of significantly reduced accumulation, as revealed by isotope fractionation and abnormally large bubble sizes. Additionally, with an independent estimate of past temperature available, the bubble-size model should allow calibration of the stable water-isotope record that is currently used to infer past surface temperatures at the site of precipitation.

THE EFFECTS OF HNO_3 ON CLOUD FORMATION

Huiwen Xue
Advisor: Dennis Lamb

Soluble trace gases, such as HNO_3, play an important role in the evolution of aerosol and cloud particles. For example, it is suggested that the activation of Cloud Condensation Nuclei (CCN) is affected by the presence of HNO_3. Another process affected by HNO_3 is the evaporation and growth kinetics of aerosol and cloud particles. This study is an experimental investigation of the evaporation and growth kinetics of HNO_3/H_2O droplets in the lab.

A single charged droplet is suspended inside of an electrodynamic levitation cell. A horizontal flow of nitrogen with controlled amounts of water vapor is continuously introduced into the cell. A computer feedback control system (I-Scan) is used to control the horizontal and vertical DC voltages required to balance the Stokes drag force and the gravitational force on the droplet, thereby keeping the droplet at the center of the cell. The radius of the droplet is determined from two independent methods: Mie scattering theory and the applied DC voltages on it.

The experimental data show that the presence of HNO_3 can prolong the lifetime of the droplets significantly compared to pure water droplets exposed to subsaturated conditions. Model calculations used to fit the data show that the first stage of fast evaporation or growth of the droplets is due to a preferential evaporation or condensation of H_2O. The time scale of H_2O to approach equilibrium in this stage is substantially smaller than that of HNO_3. After this initial stage, the droplets quickly attain a steady state with respect to composition, resulting in proportionate fluxes of H_2O and HNO_3 away from the droplets. The time scales of H_2O and HNO_3 to approach equilibrium by mass transfer are essentially the same in the second stage.

SEDIMENTATION AND OVERPRESSURE ON PASSIVE CONTINENTAL MARGINS: IMPLICATIONS FOR SLOPE STABILITY, DRILLING, AND GAS HYDRAGES

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Undercompacted sediments offshore New Jersey, along the Blake Ridge, and in the Gulf of Mexico are interpreted to represent fluid overpressures that begin near the sea floor. These pressures help control the stability of the slope, contribute to shallow-water flows, and potentially affect the distribution of gas hydrates. Rapid sedimentation along continental margins can generate fluid pressures that approach the lithostatic stress and low effective stresses that contribute to slope instability and flow focusing in shallow permeable lenses. The magnitude of overpressure depends on sedimentation rate, permeability, and the geometry of the hydrodynamic system. Overpressure is generated because pore fluids cannot escape during rapid deposition of low permeability strata so pore fluids support a majority of the overburden. This is recorded in the sediments as an undercompaction signature. Shallow-water flows redistribute these pressures within aquifers, which can create slope stability problems and potential drilling hazards.

We document these phenomena with observations and analysis of the New Jersey continental slope, the Blake Ridge, and the deepwater Gulf of Mexico. Borehole geophysical and core data from offshore New Jersey show that the slope is undercompacted. This is interpreted to represent fluid pressures that approach 95% of the overburden stress. Sedimentation-compaction modeling predicts effective stresses and pressures that match those inferred from porosity data. The model predicts slope failures will begin on the lower slope where Miocene strata are covered by thin Pleistocene silt, which is consistent with observations. We explore shallow-water flow problems at the Ursa basin, Gulf of Mexico. Numerical simulations predict that rapid fluid migration within a shallow sand layer, dipping at 2 degrees, yields fluid expulsion and nearly lithostatic fluid pressures at the structural high. The model simulates normal compaction downdip, in contrast to undercompaction and at the structural high. Undercompaction along the Blake Ridge is also interpreted to represent overpressure. One-dimensional sedimentation modeling predicts that undercompaction and overpressure are associated with clay-rich zones that were rapidly deposited, and are not associated with hydrate or free gas zones.

PSTAR: INSIGTS INTO FLUID FLOW AND OVERPRESSURE

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PSTAR is a MATLAB program that solves the analytical solutions for 2-D steady state flow past an elliptical, isolated lens when it is either much more permeable or much less permeable than the surrounding matrix. PSTAR can provide a first order insight on the overpressure distribution around a sand conduit or salt barrier. A more permeable sand lens 'short-circuits' the flow in the neighborhood, focusing fluid at one end and releasing it at the other. Adjacent to the sand, the overpressure is elevated near the structural high, while the overpressure is depressed near the structural low. The salt sheet will be a permeability barrier to the subsurface fluids flow, which will exaggerate the overpressure of the section underlying salt and mitigate the overpressure of the section overlying salt. These two effects will result in a tremendous increase of overpressure across the salt. The pressure gradient in the subsalt layer regresses with depth until a more regional gradient is achieved, although still overpressured.

FLOW FOCUSING IN TURBIDITES ON THE GULF OF MEXICO SLOPE

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On the slope of the Gulf of Mexico, rapid deposition of low permeability Pleistocene sediments has resulted in overpressures originating near the seafloor and increasing at near lithostatic gradients with depth. At GC 65, a slope mini-basin, overpressures can reach 85% of the maximum principle stress at the top of turbidite sands. We believe flow focusing along the turbidite sand bodies leads to these high overpressures. Fluids are channeled from the bottom of structure to the top, decreasing the effective stress at top of structure and compacting the sands at bottom of structure. Porosity measurements taken from core and wireline data reinforce this interpretation, with porosity varying from 34