32nd Annual Graduate Student Colloquium

Dept. of Geosciences

The Pennsylvania State University

April 12-14, 2000

541 Deike Building

The Graduate Student colloquium is a form were 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 undergraduates and graduates involved in geoscience research. The format stimulates research discussion, allows students to practice for national meeting, and helps students improve speaking skills. 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, cast awards are rewarded to the top presentations. Awards are based on abstract quality, scientific content, and presentation.

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

Committee Members 2000: Jennifer Eigenbrode, Erin Griggs, Heather Hennessey-Parizek, David Reusch, Christine Rogers, Alex Pavlov, and Yumiko Watanabe

ORAL PRESENTATION SCHEDULE - WEDNESDAY MORNING

Time	Presenter	Advisor	Title
9:00	Tom Olszewski	Mark Patzkowsky	EPISODIC TURNOVER IN LATE PALEOZOIC BENTHIC FAUNA OF THE NORTHERN MID-CONTINENT: TESTING CLAIMS OF COORDINATED STASIS
9:15	Erin Griggs	Lee Kump	THE REMOVAL MECHANISMS OF WASTEWATER-DERIVED NITRATE FROM THE GROUNDWATER OF THE FLORIDA KEYS: KEY ECOLOGY BEACH, FL
9:30	Persa Batra	Eric Barron	MODELING CLIMATE - VEGETATION FEEDBACKS
9:45	Joe Cominsky	Peter Flemings	SYNTHETIC REFLECTION SEISMOGRAM GENERATION FOR THE J SAND, GREEN CANYON BLOCK 65, GULF OF MEXICO
10:00	**Break**		
10:15	Achim Herrmann	Mark Patzkowsky	OCEANOGRAPHIC CHANGES IN THE UPPER ORDOVICIAN IN RESPONSE TO THE TACONIC OROGENY
10:30	Robin Guynn	Susan Brantley	IRON ISOTOPE FRACTIONATION IN SOILS
10:45	Michael Moreland	Peter Flemings	A DEPOSITIONAL MODEL FOR THE BULLWINKLE FIELD "J" SANDS, GREEN CANYON 65
11:00	**Break**		
11:15	David Reusch	Richard Alley	NEURAL NETWORKS AND POLAR CLIMATE: FILLING THE GRID WITHOUT DOING ALL THE WORK
11:30	Jacek Lupa	Peter Flemings	PREDICTING OVERPRESSURES IN SANDS AND SHALES IN THE DEEPWATER GULF OF MEXICO: IMPLICATIONS FOR BASINAL FLUID FLOW
11:45	Pete Sak	Donald Fisher	WEATHERING RINDS AS A CALIBRATED DATING TECHNIQUE IN A TECTONICALLY ACTIVE TROPICAL SETTING, COSTA RICA

EPISODIC TURNOVER IN LATE PALEOZOIC BENTHIC FAUNAS OF THE NORTHERN MIDCONTINENT: TESTING CLAIMS OF COORDINATED STASIS

Thomas Olszewski
Advisor: Mark Patzkowsky

Recent analysis of marine benthos from Silurian-Devonian rocks of the Appalachian Basin in New York (Brett and Baird 1995) revealed a pattern of faunal turnover termed "coordinated stasis". These workers found that fossil assemblages in the basin showed little change in composition for periods of 3 to 11 Myr (ecological-evolutionary subunits); these times of low turnover were separated by episodes of elevated turnover in multiple, unrelated lineages lasting 100,000's of years. Based on this pattern, a theory of "ecological locking" was put forward suggesting that rates of evolutionary change were suppressed during ecological-evolutionary subunits by the interactions of species within an ecological community (e.g., coadaptation, competition, predation), that evolutionary change occurred primarily when community structure was disrupted, and that the Devonian pattern should be ubiquitous in the fossil record. This mechanism of faunal change has implications for the role of community-level processes in the timing, selectivity, and recovery of extinction events at all scales.

The aim of my study is to test these proposals by exploring the turnover patterns of bivalves and brachiopods over a 17.5 Myr interval of the Pennsylvanian-Permian succession from the North American Midcontinent. In particular, I am interested in identifying episodes of elevated and suppressed rates of turnover to see if they conform to the predictions of coordinated stasis. The highly cyclic nature of the rocks in the study interval allows them to be divided into 32 packages, each about 0.5 Myr long. This level of resolution is much shorter than the average species duration in the basin, allowing turnover events to be distinguished. Occurrences of species and genera in each of these cycles were compiled directly from primary literature reports and museum collections. In order to determine whether changes in faunal composition were due to addition and removal of taxa, turnover is divided into rates of first and last appearance. Intervals of elevated or suppressed rates of turnover are identified by comparing the actual number of first or last appearances in a cycle to the number expected assuming a constant rate, which serves as the null hypothesis.

This approach indicates that episodes of elevated turnover do occur in both brachiopods and bivalves in the study interval. However, these events do not occur at the same time in both groups (i.e., they experience different turnover histories). In addition, intervals with elevated first appearances are not related to intervals with elevated last appearances within either group. Also, very rarely are rates of appearance or disappearance significantly below the expected range of values -- i.e., in this case, if there was any mechanism acting to suppress turnover, it cannot be distinguished from the null hypothesis. Finally, comparison with a lithology-based paleoclimatic history of the basin suggests that the primary mechanism driving extinction in the region involves elimination of certain environments rather than collapse of ecological community structure. This is consistent with the findings of modern ecologists, who find that habitat destruction, natural or artificial, is closely associated with elevated rates of extinction.

THE REMOVAL MECHANISMS OF WASTEWATER-DERIVED NITRATE FROM THE GROUNDWATER OF THE FLORIDA KEYS: KEY COLONY BEACH, FL

Erin Griggs
Advisor: Lee Kump

Eutrophication of nearshore surface waters is a growing issue of concern for the Florida Keys ecosystem. Nutrient-enriched groundwater, thought to be wastewater derived, is reaching the canals and other surface waters surrounding the Keys, creating algal blooms. These blooms hinder the growth of underlying marine life by preventing sunlight penetration. All current methods of wastewater disposal introduce excess phosphate and nitrate into the groundwater system. By determining the processes controlling the nutrient concentrations after introduction into the subsurface, the likelihood of these nutrients reaching nearshore waters and causing eutrophication can be better evaluated.

Key Colony Beach injects tertiary treated wastewater into the porous Key Largo Limestone bedrock creating a large, traceable, low salinity plume of wastewater. Both phosphate and nitrate behave non-conservatively as the wastewater moves away from the point of injection. This study focuses on the mechanisms for nitrate removal from the groundwater system at Key Colony Beach.

The concentration of nitrate in monitoring wells installed around the point of injection exhibits greater depletion than expected from purely dispersion and mixing with seawater. This suggests some removal is occurring, but it is not complete.

Two possible mechanisms for nitrate removal are 1) nitrate reduction to N2 by denitrification, or 2) nitrate reduction to ammonium ion. A number of wells with depleted nitrate and elevated ammonia concentrations and may be experiencing nitrate reduction to ammonium. Others wells with depleted nitrate, low ammonium concentrations, and excess N_2 gas may be undergoing denitrification.

We hypothesize that the amount of removal is dependent on the residence time of the water in the subsurface. The Key Largo Limestone generally has a high hydraulic conductivity of 1400 m/day and is overlain by a layer of mud. The wastewater tends to flow underneath the mud-limestone contact. A seismic refraction survey indicates that this contact is undulating with vertical variations of up to three meters. As a result, the flowpath of the wastewater may be varying greatly through the subsurface and allowing for the build-up of water in the backwater areas.

Although significant amount of removal may occur along the flowpath, we are confident that a portion of the nitrate has the ability to reach canal waters. Current research focuses on determining the mechanism and rate of removal.

MODELING CLIMATE – VEGETATION FEEDBACKS

Persaram Batra
Advisor: Eric Barron

As gauging the potential effects of greenhouse warming on human societies becomes an issue for policymakers, accurately modeling the climate system becomes more and more important. The climate system includes feedbacks between surface vegetation and the atmosphere that can regionally affect temperature by up to 4°C and precipitation by 7.5 mm day^{-1}. Interactively coupled climate-vegetation models are necessary to simulate these feedbacks. If the models are accurate under conditions different from the present day this should increase the probability that they will be accurate under future climate change scenarios. In this study, I will test four coupled climate-vegetation models in four different paleoclimates in order to determine how accurate they are and to determine the nature and extent of the climate-vegetation feedbacks.

SYNTHETIC REFLECTION SEISMOGRAM GENERATION FOR THE J SAND, GREEN CANYON BLOCK 65, GULF OF MEXICO

Joseph Comisky, Kevin Best, Michael Moreland, and Alastair Swanston
Advisor: Peter Flemings

Synthetic seismograms constructed from well data for the J Sand in the Green Canyon Block 65 area of the Gulf of Mexico agree very well with actual seismic data. The J Sand contains 4 main lobes (J1 through J4). Depending on factors such as sand thickness and water saturation, it is possible to resolve the individual J1 and J2 Sands in the seismic data. The J Sand reservoir in the Bullwinkle field is a Pleistocene age turbidite with reserves estimated at 120 million barrels of oil. Synthetic seismograms were constructed for the J Sand at different points in the reservoir. These synthetic seismograms differ depending on their location. We observe that the characteristics of the synthetic and actual seismograms are scaled by the regional heterogenetic rock properties of the J Sand. These rock properties include sand thickness, sand quality, and water saturation.

Wireline logs and a checkshot survey were used to first generate a depth to two-way traveltime tie. Subsurface P-wave velocity and bulk density measurements were used to then generate a reflection coefficient series which describe the high frequency impedance contrasts at the wellbore. Synthetic seismograms were created using this impedance information. Two methods were employed for creating synthetic seismograms. The first method called “runsumming” involves cumulatively summing the reflection coefficient series and then applying a lowpass filter. This lowpass filter was designed in such a way that the synthetic and actual seismograms contain the same range of frequencies. The second method involves convolving a Ricker wavelet which has been phase shifted by 90 degrees with the reflection coefficient series. Both methods produce synthetic seismograms which have the same characteristics as the actual seismic data.

OCEONOGRAPHIC CHANGES IN THE UPPER ORDOVICIAN IN RESPONSE TO THE TACONIC OROGENY

Achim Herrmann
Advisor: Mark Patzkowsky

Earth scientists working in the Ordovician of eastern North American are faced with the problem that despite the fact that Laurentia was situated in tropical to subtropical latitudes during that time, lithological evidence indicates that parts of the Late Ordovician was characterized by deposition under cool water conditions: Turinian deposition was dominated by warm water carbonates, while Early Chatfieldian marks a shift to temperate-type carbonates, an increase in siliciclastic influx and phosphatic sediments. This change in lithofacies was accompanied by a major biotic turnover event. In the Richmondian the pre-Chatfieldian tropical conditions were reestablished and several new taxa occurred in the basin.

It has been proposed by several workers that these linked paleontologic and lithologic changes have been caused by combined effect of the Taconic orogeny. The beginning of the Taconic orogeny in the Chatfieldian brought about a change in ocean circulation patterns which lead to the spreading of turbid, nutrient-rich, and possibly cooler waters across eastern North America. The filling of the foreland basin most likely changed circulation patterns once more, probably eliminating the source of cool and nutrient-rich water. These changes in oceanographic conditions have been invoked as causes for the observed Late Ordovician episodes of biotic turnover.

It is the purpose of this research to use a coupled numerical atmosphere-ocean circulation model to determine the ultimate causes for pulses of extinction and migration in the Late Ordovician epeiric seas of North America. This study has two main components. The first component aims at testing the hypothesis that rapid shifts in environmental conditions linked to biotic turnover during the Late Ordovician of Laurentia were caused by changes in bathymetry, paleogeography, and precipitation associated with Taconic orogenesis. Changes in these variables would have affected circulation patterns and sediment dispersal routes radically changing oceanographic conditions in the epeiric seas. The Modular Ocean Model (MOM, v. 2) will be used to simulate the circulation during four time intervals in order to capture a range of paleobathymetries, paleogeographies, continental positions, and climatic conditions. The corresponding atmospheric conditions which will drive the ocean circulation model will be obtained from the atmospheric model GENESIS 2.0. The time intervals range from pre-orogenic conditions in the Early Late Ordovician, to peak development of the Appalachian foreland basin in the Middle Late Ordovician, to a time of extensive filling of the basin by siliciclastic sediment derived from the Taconic highlands in the Latest Ordovician. The validity of the model results will be tested against the distribution of lithologic indicators of oceanographic conditions and against sediment dispersal patterns inferred from sedimentologic and stratigraphic observations.

The second component will focus on investigating the relative importance of changes in sea level, paleogeography, bathymetry, and precipitation in producing rapid oceanographic shifts in the epeiric seas that may have caused significant biotic turnover. In investigating the ultimate causes of biotic turnover, modeling has the advantage that single variables can be isolated and their effects on the system evaluated. Plausible causes of the bioevents will be identified by determining how well the model results match the spatial and temporal faunal changes.

By gaining insight into the causes of rapid oceanographic changes in these epeiric seas, this study has broad implications for understanding environmental change and biotic turnover during any time when epeiric seas were important components of marine ecosystems.

IRON ISOTOPE FRACTIONATION IN SOILS

Robin Guynn
Advisor: Susan Brantley

Recent advances in the ability to measure iron isotopes have sparked interest in investigating the isotopic fractionation of iron in geologic systems. In soil environments, iron may be present in primary minerals, secondary weathering products, adsorbed to exchange complexes, or dissolved in pore water solutions. Particular attention has been given to the ability of microorganisms to fractionate iron isotopes. Bacteria are ubiquitous in soils, where they may play a significant role in the cycling of iron.

Dissolution experiments with hornblende and an *Arthrobacter* soil isolate have shown that the presence of the bacteria increases iron concentrations in solution. This iron, dissolved in the presence of *Arthrobacter*, is isotopically lighter than the iron in the bulk mineral. It is also isotopically lighter than the iron dissolved in a control experiment containing hornblende, but no bacteria.

Exchangeable iron and iron oxides and oxyhydroxides were extracted from soil samples from the hornblende collection site. The iron present as the exchangeable ions was lighter than that in the hornblende, while the iron in oxide phases was heavier (δFe^{56} values differed from that of the hornblende by -0.6‰ and +0.4‰ respectively). These preliminary results indicate that significant variations may exist among different iron reservoirs in soils. One source of this variation may be the activity of soil microorganisms.

A DEPOSITIONAL MODEL FOR THE BULLWINKLE FIELD “J” SANDS, GREEN CANYON 65

Michael Moreland, Kevin Best, Joseph Comisky, and Alastair Swanston
Advisor: Peter Flemings

We interpret 3D seismic, core data, and well-logs and construct structure and isopach maps to characterize the reservoir architecture of the Bullwinkle Basin, Green Canyon 65, Gulf of Mexico. Bullwinkle is a mature oil field, with 90% of its total production emanating from Pliocene, turbidic "J" sands. To characterize sand heterogeneity, representative wells were selected. These wells were used to infer depositional environments and reservoir evolution. Well-log cross sections were constructed across structural strike and dip to determine sand extent and reservoir geometry. Synthetic seismograms were then used to tie well-log character to seismic response and to map individual J sand units from the Bullwinkle 3D seismic survey in areas where no log data was available. Well log cross sections indicate a transition from ponded amalgamated sand deposition to channelized sediment bypass sedimentation, which fits the typical turbite mini-basin model. Stratigraphically lower sands are uniformly thick across the basin, while upper sands are increasingly incised and infilled with turbidite channel fill. Based on seismic mapping and well log-derived isopach maps, the turbidite flow direction was from the northeast, with a basinal axis trending NE-SW. This region is located in the northwest quarter of Green Canyon 109, high on structure. Based on turbidite facies models, the best Bullwinkle reservoir rocks, in terms of permeability and porosity, lie along this Green Canyon 109 NE-SW trend.

NEURAL NETWORKS AND POLAR CLIMATE: FILLING THE GRID WITHOUT DOING ALL THE WORK

David Reusch
Advisor: Richard Alley

Atmospheric modeling benefits many aspects of ice core interpretation by helping to identify source areas (e.g., for moisture and aerosols), transport paths, circulation patterns, and seasonal effects, and by supplementing the extremely limited weather station records. Existing reanalysis products (e.g., ECMWF, NCEP) provide a means to relate ice core records to larger features of the atmosphere such as the Southern Oscillation. These data sets remain valuable despite known flaws in the Antarctic) and relatively low spatial resolution (e.g., 2.5° x 2.5°) because of the even lower density of available weather station data and the greater length of the reanalysis products. Back trajectory analysis from reanalysis data sets aids identification of moisture source temperature effects in $\delta^{18}O$ and δ D records as well as giving information on sea ice extent.

Recent developments in climate downscaling in temperate latitudes suggest it may be possible to acquire subgrid-scale climate data for the Antarctic without the cost of mesoscale climate modeling. One approach is the application of artificial neural network techniques to relate large-scale features of the atmosphere (e.g., geopotential heights and specific humidity) to precipitation without resorting to physical models. This technique would be particularly beneficial due to the problems existing GCMs have in polar regions. Neural networks also provide a means to identify nonlinear relationships that traditional techniques, such as EOF analysis, are unlikely to find.

PREDICTING OVERPRESSURES IN SANDS AND SHALES IN THE DEEPWATER GULF OF MEXICO: IMPLICATIONS FOR BASINAL FLUID FLOW

Jacek Lupa
Advisor: Peter Flemings

A one-dimensional model is used to predict the pressure in buried shales at the Bullwinkle region of the continental slope of the Gulf of Mexico. The model implies that sediments are overpressured from near the sea floor to a depth of at least 4000 meters, with pressures reaching 80% of the overburden over several thousands of meters. A three-dimensional model is developed to describe the pressure distribution within buried permeable sands that are bounded by these overpressured shales. The model implies a complex three-dimensional flow is ongoing in this basin. To predict pressure in the shales, porosity is assumed to be proportional to vertical effective stress. This relationship is empirically constrained in locations of known effective stress. The one-dimensional model predicts shale and sand pressures are equal at approximately one third of the way down within the bowl-shaped basin. A simple mathematical model is used to show this pressure represents the average pressure the sand is exposed to from its bounding shales. This model suggests a complex three-dimensional flow field where the sands are draining the bounding shale at depth with channelized flow up the margins of the basin.

WEATHERING RINDS AS A CALIBRATED DATING TECHNIQUE IN A TECTONICALLY ACTIVE TROPICAL SETTING, COSTA RICA

Peter Sak
Advisor: Donald Fisher

The rate of weathering rind growth as a function of time on andesitic clasts from fluvial terraces in Costa Rica is evaluated using a radial diffusion mode. The mountainous fore arc of the central Pacific coast of Costa Rica is subdivided into 8 fault-bounded blocks, characterized by differential rates of surface uplift. On the Esterillos Block a flight of four fluvial terraces and one uplifted Holocene abrasion platform have been mapped. The four fluvial terraces are distinguished on the basis of pedogenic characteristics and the mean thicknesses of weathering rinds. These terraces display decreasing pedogenic maturity and mean rind thicknesses with decreasing elevation above base level. From oldest to youngest these terraces are: El Diablo terrace 9>45ka and <330ka) (Qt1) with a red (2.5 YR) matrix and a mean rind thickness of 93mm, (2) Qt2 characterized by a red (2.5 YR) matrix and a mean rind thickness of 44mm, (3) the 26.1ka±330yr (Qt3) terrace with a yellowish red (5 YR) matrix and a mean rind thickness of 29mm, and (4) Qt4 a deposit characterized by a yellowish brown (10YR) matrix and mean rind thickness of 15mm. Solving the diffusion equation for Qt3 yields a diffusion parameter of 1.86×10^{-12} mm^2/s. This diffusion parameter predicts a 125ka age for the regionally extensive Qt1, coincident with the oxygen isotope sub-stage 5e highstand. Furthermore, this diffusion model predicts that all terraces were deposited during sea level highstands. The diffusion parameter calculated in this model is higher than values obtained for similar rock types in temperate climates. Thus, accelerated weather rates in tropical settings allow use of weathering rinds to date Quaternary soils at higher resolution compared to temperate climates.

ORAL PRESENTATION SCHEDULE - THURSDAY MORNING

Time	Presenter	Advisor	Title
9:00	Nikolai Pedentchouk	Katherine Freeman	ORGANIC SULFUR GEOCHEMISTRY OF LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS FROM WEST AFRICAN RIFT BASINS
9:15	Alastair Swanston	Peter Flemings	AMPLITUDE MAPPING AND PRELIMINARY 4-D ANALYSIS OF THE BULLWINKLE J-SAND, GREEN CANYON 65, GULF OF MEXICO
9:30	Jennifer Eigenbrode	Katherine Freeman	BIOGEOCHEMICAL AND ENVIRONMENTAL INFLUENCES ON THE COMPOSITION OF LATE ARCHEAN KEROGENS AND EXTRACTS
9:45	Merri Lisa Formento-Trigilio	Doug Burbank, Rudy Slingerland	RIVER RESPONSE TO AN ACTIVE FOLD-AND-THRUST BELT IN A CONVERGENT MARGIN SETTING, NORTH ISLAND, NEW ZEALAND
10:00	**Break**		
10:15	Laura Leist	Susan Brantley	ROLL OF SOIL BACTERIUM, *AZOTOBACTER VINELANDII*, IN MINERAL DISSOLUTION
10:30	Jennifer Bland	Katherine Freeman	THE USE OF LIPID BIOMARKERS AS INDICATORS FOR MICROORGANISMS IN METHANOTROPHY
10:45	Melinda Foland	Katherine Freeman, Jim Kubicki	INVESTIGATION OF ECOSYSTEM RESPONSE TO ENVIRONMENTAL CHANGES THROUGH BIOMARKER AND STABLE ISOTOPE ANALYSIS

ORGANIC SULFUR GEOCHEMISTRY OF LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS FROM WEST AFRICAN RIFT BASINS

Nikolai Pedentchouk
Advisor: Katherine Freeman

The main focus of this work is the analysis of influence of organic sulfur geochemistry on the distribution of biomarkers in Lower Cretaceous lacustrine source rocks from West African rift basins. Hydrocarbon biomarkers are routinely utilized for determining lacustrine paleoenvironmental conditions and sources of organic matter (OM). Using individual biomarkers is often problematic, because of the interference of several factors such as variations in rock lithology, OM sources, and degree of OM maturity. Another important problem with using biomarkers arises from the fact that biomarkers may undergo reactions with H_2S and/or polysulfides during early diagenesis. Interpretations of the geological record will be strongly biased if sulfur-bound biomarkers are not taken into account.

Few studies incorporate biomarker information obtained from sulfur-bound fractions during paleolacustrine analyses, because of the common perception that sulfurization of OM in lacustrine systems is a minor process. This approach may not be valid in a lacustrine system with high sulfur content. An excellent example is the lacustrine source rocks from West Africa. Preliminary analyses of biomarkers used for redox identification in the Congo Basin showed that these biomarkers are neither consistent with each other nor consistent with inorganic and sedimentological proxies. In addition, biomarkers used to indicate OM maturity and sources produce mixed results. The reasons for these problems remain unclear. Because West African lacustrine rocks are characterized by unusually high total sulfur content (up to 3.5 wt%), it is hypothesized that problems with biomarker interpretation result from OM sulfur enrichment.

In order to test this hypothesis a wide range of samples representing different stratigraphic and geographic positions in the lacustrine West African rift basins will be simultaneously subjected to 3 different analytical procedures that would allow maximize the yield of S-bound biomarkers. These techniques include: a) solvent extraction (does not liberate S-bound compounds), b) desulfurization (liberate lower-molecular S-bound compounds), and hydropyrolysis (liberate S sequestered in the high-molecular fraction). Paleoenvironmental and OM source information obtained from analyses of biomarkers using these techniques will be compared among each other and to other inorganic and sedimentological proxies with the purpose of determining the utility of these organic compounds in paleolacustrine analysis.

AMPLITUDE MAPPING AND PRELIMINARY 4-D ANALYSIS OF THE BULLWINKLE J-SAND, GREEN CANYON 65, GULF OF MEXICO

Alastair Swanston, Kevin Best, Joseph Comisky, Michael Moreland.
Advisor: Peter Flemings

The J-sand is the major hydrocarbon-producing horizon of the Bullwinkle Field, over which a unique collection of 3-D seismic data sets has been acquired. These include two orthogonal pre-production surveys by Shell in 1988, and a Geco-Prakla survey completed after significant production, in 1995. An amplitude extraction was performed on both of the 1988 surveys in order to investigate the original fluid distribution in the reservoir. It was found that hydrocarbon bright spots were clearly visible, the most significant of which correspond to the Bullwinkle and Rocky reservoirs. The lower boundary of the high amplitude region is sub-horizontal and corresponds to the oil-water contact. The J-sand is constrained laterally by pinch-out against salt structures and the amplitude maps show that the southern margin of the Rocky field is fault bounded, whilst the Bullwinkle Reservoir appears to be confined stratigraphically by a degradation in sand quality and permeability. Normalized amplitude maps were produced by dividing the extracted amplitudes by an R.M.S background value so that the two surveys could be compared and insight could be gained into the effect of shooting direction in an area of complex subsurface geology. The results show that, although the two surveys are similar and the repeatability of the acquisition and processing techniques is verified, there are also regions where significant differences exist. A comprehensive 4-D evaluation of the field is planned, and a preliminary amplitude extraction of the J-sand event in the 1995 survey illustrates considerable differences in the location and extent of the hydrocarbon bright spots.

BIOGEOCHEMICAL AND ENVIRONMENTAL INFLUENCES ON THE COMPOSITION OF LATE ARCHEAN KEROGENS AND EXTRACTS

Jennifer Eigenbrode
Advisor: Katherine Freeman

An extraordinary negative shift in the organic carbon isotope is observed in the late Archean (2.7-2.5 Ga) that is unlike any other recognized in Earth's history. Extracted molecular biomarker data suggest that late Archean ecosystems were composed of a diverse group of organisms. Although debated, geological and geochemical evidence suggest the late Archean was anoxic, with the rise of oxygen occurring sometime later. However, some evidence suggests aerobic organisms were present, possibly supported by oxygenated microenvironments within depositional systems. Biomass contributions from methane-oxidizers or chemoautotroph consuming a ^{13}C-depleted carbon substrate, such as methane or respired carbon dioxide, could explain the anomaly. Determining the biological source of the substantially ^{13}C-depleted carbon may have important implications on our understanding of the influence of O_2 on carbon cycling.

It is hypothesized that depositional environments influenced the composition of microbial ecosystems by controlling O_2 availability. In order to evaluate this hypothesis we propose a sedimentological and organic geochemical study of rock successions in the Hamersley Basin, Western Australia. The study will employ both core and outcrop samples representing a range lithofacies of both shallow and deep-water environments.

Specifically, we propose to (1) structurally and isotopically characterize the extractable molecular and non-extractable kerogen records of late Archean microbial ecosystems, (2) evaluate these records for systematic patterns, and (3) use stratigraphic and sedimentological observations to test if these patterns are associated temporal, spatial, and/or environmental variability. Furthermore, analysis of molecular constituents of kerogen, released from their bound form using hydropyrolysis, will allow us to test the influence of contamination (during burial, weathering, and drilling) on the extractable organic component.

Our approach integrates sedimentological and stratigraphic observations with chemical and isotopic data and should provide important new observations about the organic geochemical record of life in the late Archean and insight into biogeochemical and environmental controls on microbial ecosystems on the early Earth.

RIVER RESPONSE TO AN ACTIVE FOLD AND THRUST BELT IN A CONVERGENT MARGIN SETTING, NORTH ISLAND, NEW ZEALAND

Merri Lisa Formento-Trigilio
Advisors: Doug Burbank and Rudy Slingerland

Rivers aggrade or degrade their floodplains in response to up basin controls characterized by sediment/discharge relationships and to down basin controls that drive local and regional base level fluctuations. Typically, the changes in sediment/discharge inputs are ascribed to climate change, whereas, base level fluctuations are attributed to either eustatic changes or tectonic uplift. It is often difficult to separate these two forcing functions in determining landscape evolution because it is unusual to find a sedimentary record that is detailed, well exposed, well dated and can be correlated to a long history of deformation. Such a record exists along the southern portion of New Zealand's Hikurangi margin in the Wairarapa fold-and-thrust belt.

We chose the Huangarua River valley within the southern portion of the Wairarapa fold-and-thrust belt to reconstruct basin response to both climate change and Quaternary uplift. Terrace cover beds consist of a well-defined regional loess and paleosol sequence that reflect environmental changes during glacial and interglacial cycles. We use this regional record and soil stratigraphy from ten 4X4-m trenches excavated in terrace cover beds to interpret climate-induced sediment supply changes within the Huangarua River valley.

Base level fluctuations are recorded in the preservation of faulted and tilted fluvial terraces. High-resolution digital elevation data (10-m horizontal resolution) is used to reconstruct residual surfaces that record late Quaternary river response to differential uplift. Outcrop data of deformed latest Miocene and younger strata are combined with tilted and faulted terraces to unfold the regional geomorphic and structural history. In the Huangarua River valley strath terraces form during periods of regional base level rise and increased sediment supply. This is in contrast to traditional interpretations of terrace genesis, whereby strath terraces are presumed to have formed during periods of stable base level and decreasing sediment supply. The results from the Huangarua River valley will be used to evaluate landscape evolution further inland in the northern portion of the Wairarapa fold-and-thrust belt. Mechanisms of strath terrace formation in the northern Wairarapa reflect greater sediment fluctuations because these basins are proximal to sediment source areas in uplifting axial ranges and are less affected by eustatic sea level change. The relative contribution of either up-basin or down-basin forcing functions in strath terrace formation will be explored by comparing the southern Wairarapa where local and regional base level fall appears to dominate river response and the northern Wairarapa where sediment supply issues are more important.

ROLE OF SOIL BACTERIUM, *AZOTOBACTER VINELANDII*, IN MINERAL DISSOLUTION

Laura Leist
Advisor: Susan Brantley

We are investigating the role of *Azotobacter vinelandii*, a nitrogen-fixing soil bacteria, in dissolution of Mo, Fe, and Ni from minerals. *A. vinelandii* produces five different siderophores to increase the concentration of Fe and Mo in the extracellular environment. Siderophores produced by other bacteria such as *Streptomyces* sp. increase Fe dissolution , and fractionate isotopes in the dissolution process. Initial experiments have not shown an increased dissolution of Fe, Mo, or Ni from minerals in the presence of *A. vinelandii*. We expect that future experiments will show an increase mineral dissolution caused by *A. vinelandii*, and possibly isotope fractionation of Fe, Mo, and Ni.

THE USE OF LIPID BIOMARKERS AS INDICATORS FOR MICROORGANISMS IN METHANOTROPHY

Jennifer Bland
Advisor: Katherine Freeman

Two gases of interest in this study are methane (CH_4) and nitrous oxide (N_2O). Respectively, these two gases are increasing at a rate of ~1 % and 0.25 % annually, and are ~27x and ~250x more effective than CO_2 as greenhouse gases on a per molecule basis.

Nitrification and denitrification via microbial processes are the primary sources of N_2O in soils and in marine and freshwater environments. Methane is formed from a variety of sources including, but not limited to wetlands, rice production, enteric production by animals and landfills. Primary net consumption of methane occurs by a reaction with OH radicals in the troposphere. Microbial communities in soils also consume methane and may serve as an important regulator of methane. Diverse grassland and forest soils, and soils overlying thermogenic methane seeps have widespread methane consumption.

The bacteria responsible for methane consumption (methanotrophs) and nitrous oxide production (autotrophic nitrifiers) appear to be similar evolutionarily, physiologically, and ecologically. Both groups of microbes are able to oxidize CH_4 and NH_4^+. This means that methanotrophs may be important in the nitrification process and nitrifiers may be important for CH_4 consumption.

Bacterial cultures will be analyzed to determine the microbial populations responsible for N_2O formation and CH_4 consumption in this study. This determination can be made by identifying membrane lipid compositions and measuring the $\delta^{13}C$ values for these compounds. This research aims to evaluate $\delta^{13}C$ values of lipids in soils as diagnostic indicators of microbial populations active in methane cycling

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

Melinda Foland
Advisors: Katherine Freeman and Jim Kubicki

Ecosystem response to changes in CO_2 and aridity is unclear. In this study we hope to elucidate these relationships between low latitude mountain ecosystems and environmental factors by using biomarker studies, $\delta^{13}C$ isotope analysis, and TOC data. Because biomarkers can be related directly to specific precursor compounds or classes of precursors they can be used to ascertain the composition of ancient ecosystems. For examples, high molecular weight n-alkane lipids from leaf waxes indicate higher plants. Carbon isotope analysis of both TOC and specific biomarkers can be used to determine carbon sources and processing. Six Mesoamerican lakes have been selected for this study. The lakes have experienced different moisture conditions during the last glacial stage, which should aid in the evaluation of the effect of aridity. I will perform biomarker analysis to determine vegetation change and $\delta^{13}C$ isotope analysis of lipids and TOC to determine carbon sources and responses to changes in CO_2 concentration and aridity levels from two of these six lakes. These tests will illustrate how vegetation changes with changes of environmental factors. Finally this study may help determine factors controlling the balance of C3-C4 plants.

ORAL PRESENTATION SCHEDULE - THURSDAY AFTERNOON

Time	Presenter	Advisor	Title
1:00	Cindy Werner	Susan Brantley, John Wyngaard	THE APPLICATION OF EDDY CORRELATION TO QUANTIFY CO_2 FLUXES IN GEOTHERMAL REGIONS
1:15	Kevin Best	Avrami Grader, Peter Flemings	HISTORY MATCHING OF THE J2-RB RESERVOIR, GREEN CANYON BLOCK 65, GULF OF MEXICO
1:30	Yumiko Watanabe	Hiroshi Ohmoto	CARBON ISOTOPIC COMPOSITIONS OF ORGANISMS THAT LIVED IN A SUBMARINE HYDROTHERMAL POOL 2.7 BILLION-YEARS AGO: EVIDENCE FOR COMPLEX ECOSYSTEMS
1:45	Erin Matlack	Michael Arthur	SPATIAL AND TEMPORAL VARIABILITY IN METHANE FLUX FROM A TEMPERATE SALT MARSH: CHINCOTEAGUE BAY, VA

THE APPLICATION OF EDDY CORRELATION TO QUANTIFY CO_2 FLUXES IN GEOTHERMAL REGIONS

Cindy Werner
Advisors: Susan Brantley and John Wyngaard

Estimation of CO_2 degassing in geothermal regions is often difficult due to the spatial and temporal variability of emissions. Measurements of CO_2 emissions in previous studies have relied on chamber methods for diffuse degassing. Uncertainty is associated with chamber based estimates because the chamber disturbs the surface where the measurement is made, the measurement represents only one point in time, and the method requires spatial extrapolation of individual point measurements (cm^2) to larger regions (m^2 or km^2). Eddy correlation is a micrometeorology technique that offers an alternative to the chamber method. EC offers the advantages over typical chamber techniques in that the measurement is: (1) non-invasive, (2) continuous, which allows for monitoring of temporal variability that is not possible with the chamber method, (3) representative of a spatial average of fluxes over the upwind surface, and (4) can be operated remotely. This study will test the limits of application of EC, and aid in determining the geothermal contribution to global CO_2 VGM estimates.

An EC station including the LI-COR 6262 infrared CO_2/H_2O analyzer and a Campbell CSAT3 anemometer were deployed for a week of preliminary measurements in late August 1999 in the Mud Volcano region of Yellowstone. Data were collected for individual runs for periods of 30 minutes to one hour. Preliminary results suggest that EC fluxes measured in thermal areas of Mud Volcano range between 50 and 2000 $gm^{-2}d^{-1}$, and are typical of fluxes measured using the accumulation chamber technique in the same area during 1997 and 1998. Fluxes measured in background regions of Yellowstone (i.e., grasslands) with no geothermal CO_2 flux indicate fluxes of –7 $gm^{-2}d^{-1}$ related to vegetative uptake. Initial results using the flux footprint function (a weight function that is convolved with surface fluxes) at a low-flux site suggests that EC fluxes are comparable to surface fluxes within 15%.

HISTORY MATCHING OF THE J2 RESERVOIR, GREEN CANYON BLOCK 65, GULF OF MEXICO

Kevin Best, Joseph Comisky, Michael Moreland, and Alastair Swanston
Advisor: Peter Flemings

A 2-D simulation model of the J2-RB reservoir for history matching is constructed to gain insight into deepwater turbidite rock properties and their effect on aquifer strength. Laboratory determined rock properties from whole and sidewall core samples were higher than those typically found in shelf basins; permeability (700 md to 3000 md), porosity (25% to 34%), and bulk rock compressibility (7E-6 psi-1 to 12E-6 psi-1). Actual production history data show that oil production declines linearly with time as the reservoir pressure depletes. These observations are indicative of a strong aquifer influx. A preliminary 2-D model was constructed using the structure map, thickness map, amplitude extraction map for boundary constraints, constant reservoir and aquifer rock properties, PVT data, and the Carter-Tracy method for aquifer influx. The reservoir was modeled using the implicit form of the finite difference equations for the undersaturated state condition. The historical oil production rate was specified. The pressure and water production rate was observed through time for the twelve producing wells. A rough pressure history match was obtained. Differences observed in water cut through time suggest regional heterogeneous rock properties and/or faulting within the reservoir. We believe that the heterogeneous permeability distribution and porosity are responsible for these observed differences.

CARBON ISOTOPIC COMPOSITIONS OF ORGANISMS THAT LIVED IN A SUBMARINE HYDROTHERMAL POOL 2.7 BILLION-YEARS AGO: EVIDENCE FOR COMPLEX ECOSYSTEMS

Yumiko Watanabe
Advisor: Hiroshi Ohmoto

The Kidd Creek Mine in the Abitibi district, Canada, hosts one of the largest massive sulfide deposits in the world. The sulfide ores accumulated in a submarine hydrothermal pool, similar to the modern Red Sea brine pool, about 2.7 Ga ago. We have conducted a systematic geochemical investigation of ~50 shale samples from four drill holes in a 2x3 km area around the mine. Analyses were made for the elemental abundances (about 70 elements, including REE); the elemental ratios of C, H, N, S and $\delta^{13}C$ of the extracted kerogen; and $\delta^{34}S$ values of sulfides. We have recognized the following changes in the geochemical characteristics of shales through the stratigraphic section:

The shales deposited prior to the sulfide mineralization do not exhibit Eu anomaly, or enrichment of heavy metals. They contain 0.8 - 2.0 wt % organic C with $\delta^{13}C$ values about -38 ‰. The shales deposited during the hydrothermal events are characterized by positive Eu anomalies, high and variable contents of heavy metals, sulfide S, and organic C (up to ~12 wt %). The $\delta^{13}C$ values of organic matter in the ore-zone shales are similar to those in the pre-ore shales. However, the shales in the main ore zone have distinctly heavier $\delta^{13}C$ values (~-20 ‰). The post-ore sediments (graywackes) contain very low S (<0.02 %) and organic C (~0.02 %) with uniform $\delta^{13}C$ values of -26 ‰. The organic matter in all the shale samples is highly matured as indicated by the very low (<0.1) H/C atomic ratios. Therefore, the $\delta^{13}C$ values of the original organisms were probably about 3 ‰ heavier than the kerogen values (c.f., Watanabe *et al*., 1997). The above data suggest complex ecosystems existed in the Kidd Creek Basin 2.7 Ga ago. The important organisms during the pre-ore stage probably included cyanobacteria, methanogenic bacteria, methanotrophic bacteria, and sulfate reducing bacteria in a stratified basin. In addition to these organisms, hyperthermophillic chemotrophs appeared to have been active near the vent sites during the period of intense submarine hydrothermal activity. After the ore formation, the basin became entirely oxic and was dominated by cyanobacteria.

SPATIAL AND TEMPORAL VARIABILITY IN METHANE FLUX FROM A TEMPERATE SALT MARCH: CHINCOTEAGUE BAY, VA

Erin Matlack
Advisor: Michael Arthur

The increasing concentration of methane in Earth's atmosphere is of concern because of its behavior as a greenhouse gas. Although the concentration of methane within the atmospheric reservoir is easily measured, the individual sources are poorly constrained. Coastal salt marshes could be a significant source of methane that generally has been overlooked. Salt marshes are one of the most productive ecosystems on Earth. The tremendous supply of organic matter to salt marsh sediments coupled with a high water table, typically drive sediments anoxic below the sediment water interface. Thus making the sediments habitable to a variety of anaerobic bacteria, including methanogens. In this study, chamber flux measurements of methane have been taken from the Palus Crisium Marsh in Chincoteague Bay, VA over four characteristic salt marsh environments: panne, *Spartina alterniflora* (short form), *S. alterniflora* (tall form) and *S. patens*, over the course of seven months in order to observe the spatial and temporal variations in methane flux. There was no obvious correlation between temperature or tidal influence over the fluxes due to the very low observed methane concentrations and limited data set. Generally, the highest fluxes were observed at the panne site; the lowest fluxes were observed at the S. patens site. Positive methane fluxes from the Palus Crisium Marsh were found to be 2-3 orders of magnitude lower than freshwater environments. Poor correlation coefficients (<0.50), and therefore no flux, were calculated for half of the chamber flux measurements. Additionally, negative fluxes as high as 44 μmoles m^{-2} d^{-1} were observed. These negative fluxes are indicative of methanotrophic activity. Within the sediments, methane concentrations are found on the mM scale, and generally increase exponentially with depth. These "concave upward" profiles suggest first order consumption of methane within the upper meter of sediments. The low fluxes and low concentrations of methane within the sediments may be attributed to high sulfate concentrations (>20 mM) within the first meter of sediments. In this salt marsh, sulfate reducers dominate carbon cycling due to a kinetic and thermodynamic advantage over methanogens. Consequently, methanogenesis is not an important mode of carbon cycling until sulfate is depleted and sulfate reduction ceases. The dominance of sulfate reducers, coupled with consumption/oxidation of methane within the anoxic sediments and by aerobic methanotrophic bacteria, allows relatively little methane to escape to the atmosphere from the Palus Crisium Marsh. Therefore, when compared with known sources of methane, this salt marsh is not a significant source of methane to the atmospheric reservoir.

POSTER PRESENTATIONS - FRIDAY MORNING

Presenter	Advisor	Title
Amanda Ault	Doug Burbank	GEOMORPHIC ANALYSIS OF THE SAN LUIS BASIN, RIO GRANDE RIFT, COLORADO
Maggie Benoit	Andrew Nyblade	410 AND 660 DISCONTINUITY STRUCTURE BENEATH WESTERN SAUDI ARABIA
Ian Brewer	Doug Burbank	APPLICATION OF 2D THERMAL FINITE-DIFFERENCE MODELING OF DETRITAL MINERAL COOLING AGE TRAJECTORIES TO CONSTRAIN HIMALAYAN TECTONICS
Amanda Clark	Barry Voight	PUMICE FLOW DEPOSITS AT SOUFRIÉRE HILLS VOLCANO, MONTSERRAT: IMPLICATIONS FOR MODELING THE 1997 VULCANIAN EXPLOSIONS
Shannon Greenan	Donald Fisher	STRAIN HISTORIES RECORDED WITHIN EOCENE SLATES FROM THE EASTERN CENTRAL RANGE OF TAIWAN: A REGIONALLY EXTENSIVE CHANGE IN SHEAR DIRECTION
Chris Guzofski	Kevin Furlong	RELATIONSHIPS BETWEEN CRUSTAL DEFORMATION, VOLCANISM, AND SURFICIAL PROCESSES: RESEARCH ON THE MIGRATION OF THE MENDOCINO TRIPLE JUNCTION
Achim Herrmann	Mark Patzkowsky	EVALUATING GRAPHIC CORRELATION WITH SIMULATED DATA
Dannie Hidayat	Barry Voight	BROADBAND SEISMIC EXPERIMENT AT MERAPI VOLCANO, JAVA INDONESIA: VERY LONG PERIOD PULSES EMBEDDED IN MULTIPHASE EARTHQUAKES
Caroline Loop	William White, Barry Scheetz	ALTERATION OF ACID MINE DRAINAGE WATER AS A RESULT OF THE ADDITION OF FLY AND BOTTOM ASH
Rocco Malekvisi	Kevin Furlong	AUSTRALIAN PLATE FLEXURE AND THE TOPOGRAPHY OF FIORDLAND, NEW ZEALAND
Shuhei Ono	Hiroshi Ohmoto	CONSTRAINTS O THE OXYGEN LEVEL OF THE ARCHEAN ATMOSPHERE BASED ON NEW DATA ON DISSOLUTION RATES OF URANINITE
Heather Hennessey Parizek	Charles Langston	INVERSION OF THE SKS RECEIVER FUNCTION
Kosei Yamaguchi	Hiroshi Ohmoto	RARE EARTH ELEMENTS IN PRECAMBRIAN BANDED IRON FORMATIONS: ARE THE CERIUM ANOMALIES REAL?

GEOMORPHOLOGIC ANALYSIS OF THE SAN LUIS BASIN, RIO GRANDE RIFT, COLORADO

Amanda Ault
Advisor: Doug Burbank

The Rio Grande Rift (RGR) is a major continental rift zone that extends from Leadville, Colorado to Chihuahua, Mexico. The structural manifestation of ongoing rifting includes large (100-scale km), N-S striking half-grabens, including the San Luis Basin, which is a major sedimentary basin in the RGR that is formed by an east-tilted half-graben. This study considers how spatial variations in structure relate to the rift-scale geomorphology of the San Luis Basin and provides new insights into landscape evolution by looking at fluvial system development in a semi-arid environment. Preliminary topographic analysis performed in ARC/INFO, such as drainage basin size, shape, relief, and slope, suggests that footwall-derived drainage basins are topographically different than drainage basins derived from the hanging wall; for example, footwall-derived drainage basins are relatively small in area (i.e., 35 km^2) compared to drainage basins present in the hanging wall (up to 2,000 km^2).

410 AND 660 DISCONTINUITY STRUCTURE BENEATH WESTERN SAUDI ARABIA

Margaret Benoit
Advisor: Andrew Nyblade

Recent seismic studies of lithospheric structure beneath the Saudi Arabian shield indicate the presence of anomalously low seismic velocities in the upper mantle extending to depths of at least 100-130 km. The origin of the anomalous structure is unknown. However, because of the Cenozoic volcanism in the region, a plume origin has been previously proposed. In this study, we examine the structure of the 410 and 660 km discontinuities beneath western Saudi Arabia to place constraints of the depth extent of the anomalous upper mantle structure and to investigate further its origin. Structure on the 410 and 660 km discontinuities is imaged by applying a receiver function stacking method to broadband data from the Saudi Arabia PASSCAL experiment. The stacking method enhances P-to-S wave converted phases in the coda of teleseismic P and PP phases, letting us identify lateral variations in the depth of the 410 and 660 km discontinuities. In our analysis, we extracted 170s time windows around teleseismic P-waves between 30 and 95 degrees distance and teleseismic PP-waves between 60 and 180 degrees distance. This provided 293 station-event pairs for stacking. Receiver functions were calculated using frequency domain deconvolution with waterlevel stabilization and a 0.2 Hz low pass gaussian filter. Within the area of good data coverage (20-27 Latitude and 42-49 Longitude), Ps conversions from the 410 and 660 km discontinuities are clearly seen. Little relief is seen on either discontinuity and the average depths are in good agreement with the average depths for these discontinuities. Thus, we conclude that the anomalous structure in the upper mantle beneath western Saudi Arabia does not extend into the transition zone.

APPLICATION OF 2D THERMAL FINITE-DIFFERENCE MODELING OF DETRITAL MINERAL COOLING AGE TRAJECTORIES TO CONSTRAINING HIMALAYAN TECTONICS

Ian Brewer
Advisor: Doug Burbank

Detrital mineral cooling ages from modern river sediments provide an integration of bedrock cooling ages from the contributing area. In the Himalayas this provides an easy method to sample the range of cooling ages found within basins that rise to over 8000m and contain significant glacial cover – areas in which bedrock thermochronology is clearly impractical. The Marsyandi River transects the main topographic axis of the Himalayas, cutting through all climato-tectonic zones (Whitehouse, 1990) from the Tibetan Plateau to the Gangetic foreland basin. We present the results of $^{40}Ar/^{39}Ar$ analysis on detrital muscovite from 12 sites sampled within the Marsyandi basin during fieldwork in 1997. These cooling ages provide a measure of the spatial variation in erosion rates across the area.

Bedrock cooling ages are commonly interpreted in one dimension - erosion rates are calculated assuming that the rock column is moving vertically towards the surface. However, the importance of lateral advection of rock mass through continental collision zones is increasingly recognized. We have developed a numerical model to investigate the parameters controlling the thermal structure of the Himalayas and examine the influence of lateral advection and topography upon the pattern of bedrock, and therefore detrital, cooling ages.

With a simplified ramp-flat geometry we use a 2D finite difference model to investigate the effects of conduction and advection on the steady-state thermal structure of the Himalayas. Using the geometric architecture (Henry *et al.*, 1997), the trajectories of particles are traced laterally through the orogen. The distance traveled by a particle between passing through the argon closure temperature (~350°C) and reaching the surface (0°C) is converted into a cooling age using the specified rates of plate convergence.

The cooling age for every point in the landscape can be determined by combining 90m digital elevation data with the thermal model. GIS software uses individual drainage basin templates to extract bedrock cooling ages. The summation of cooling ages, from each point in the basin, provides a representation of the cooling age signal derived from sediment at the catchment mouth.

Comparison between model results and the real detrital cooling age data provides constraints on our tectonic interpretation. We can determine the sensitivity of the detrital cooling age signal to the underlying ramp position, ramp angle, and convergence rate. In addition, erosion rates may be calculated as a function of ramp-flat geometry and this has important geomorphic implications for steady state landscapes.

PUMICE FLOW DEPOSITS AT SOUFRIÉRE HILLS VOLCANO, MONTSERRAT: IMPLICATIONS FOR MODELING THE 1997 VULCANIAN EXPLOSIONS

Amanda Clarke
Advisor: Barry Voigt

A total of 88 short-duration explosions, nearly all accompanied by radial fountain collapse, occurred in August (13) and September through October, 1997 (75) at the Soufrière Hills Volcano, Montserrat. Radial pyroclastic currents reached distances of about 2 km, with channeled pumice flows reaching 3 – 6 km. Although the pumice flow deposits from individual eruptions cannot be recognized, due to the large number of very similar vulcanian eruptions which occurred in a period of a few months, the deposits and exposures are adequate to characterize the general properties of the eruption products. Deposit morphology is lobate with well-defined levees and with steep and thickened noses. The levees are fines-depleted and contain clasts up to 100 cm in diameter, but most large clasts have diameters ~20-30 cm. Proximal deposits (< 1.5 km from source) have not been studied due to eruption hazards. In the medial region (~1.5 – 3 km from source, deposits are as much as 2 m thick, with the pumiceous clasts inversely graded and the lithic clasts normally graded. In distal regions (> 3 km), few lithic clasts remain and some locations exhibit coarse-tail grading (i.e. only the largest pumice clasts are inversely graded). Some medial and distal deposits exhibit a clearly defined fines-depleted basal layer which generally thickens in local depressions. The pumice flow deposits were sampled along three radial transects and sieved in the field (with manual sieve-class measurements of coarse clasts) in order to account for large grain sizes, with samples taken from top, middle and basal sections of deposits. Samples of fallout tephra from the 1997 events have also been collected at several locations. Dissolved water content in the pumiceous glass was measured and has been used to make estimates of minimum pre-eruptive pressure and its variability. Corresponding densities were also measured, allowing, with some assumptions, estimates of maximum pre-eruptive pressure and its variability and of pre-eruptive solid to volatile volume ratio. The deposit sampling has led to useful constraints on multi-phase explosion model input parameters and initial conditions.

STRAIN HISTORIES RECORDED WITHIN EOCENE SLATES FROM THE EASTERN CENTRAL RANGE OF TAIWAN: A REGIONALLY EXTENSIVE CHANGE IN SHEAR DIRECTION

Shannon Greenan
Advisor: Donald Fisher

Characterization of the structural history along the eastern portion of the Taiwan orogenic belt provides further insight into arc-continent collision processes and the kinematics within the ductile interior of an oblique collision. Incremental and finite strain analyses in Eocene slates of the Eastern Central Range from 22°56" N to 22°40" N suggest a regional zone of three-dimensional noncoaxial strain consistent with a progressive counterclockwise rotation of the shear direction. Structural characteristics in this area include an E-SE dipping cleavage and an associated penetrative sub-horizontal stretching lineation trending NE-SW. Cleavage is axial planar to mesoscopic isoclinal folds.

Strain indicators, such as chlorite-mica aggregates and pyrite pressure shadows, are useful in estimating finite strain magnitudes and orientations, shear sense, and kinematics. Chlorite-mica aggregates are observed throughout the slates and are ellipsoidal in shape, with the minor aggregate axis perpendicular to cleavage, the major axis parallel to the lineation, and the intermediate axis parallel to cleavage and perpendicular to the stretching lineation. The chlorite porphyroclasts are prolate as a result of growth in the x-direction, and record a stretch of more than 190%. Pyrite pressure shadows record a finite stretch varying from 270% to 880%, and analyses of finite strain from the pressure shadows indicate a maximum finite extension approximately parallel to the NE-SW shallowly plunging stretching lineation. Pressure shadow fibers display gradual curvature in both the XY (cleavage parallel) and the XZ (cleavage perpendicular and lineation parallel) planes, a 3-D pattern that is best explained by systematic variation in the shear direction.

Overall, these results are in sharp contrast to observations of down-dip extension during top-to-the-west shearing in the Western Central Range. Together, these data depict a triclinic shear zone in the eastern part of the Taiwan mountain belt, with a west-to-east transition from thrusting to lateral extrusion and/or strike slip. The progressive changes in shear direction during cleavage formation may reflect advection of deeply buried Eocene rocks through a complex 3-D strain field due to the rapid unroofing along the backside of the Taiwan mountain belt.

RELATIONSHPS BETWEEN CRUSTAL DEFORMATION, VOLCANISM, AND SURFICIAL PROCESSES: RESEARCH ON THE MIGRATION OF THE MENDOCINO TRIPLE JUNCTION

Chris Guzofski, Jane Lock, Jaime Whitlock
Advisor: Kevin Furlong

The transition of the plate boundary in northern California from subduction to strike slip at the Mendocino triple junction has been modeled to dynamically effect the crustal structure and thermal state of the North American plate. These perturbations in the thermal and crustal structure are caused by the northward migration of the triple junction and the asthenospheric upwelling in the space ("slab window") that is created as the Gorda plate is removed from beneath the North American crust. Northward younging volcanism observed in northern California is believed to be genetically related to the upwelling within this slab window, although this relationship has never been tested through petrologic studies of the volcanic bodies. In addition, the crustal deformation driven by these processes should have a demonstrable effect on the surface topography and the river drainage pattern throughout northern California. As the crust is first ephemerally thickened in advance of the triple junction and then thinned in its wake, the surface topography should evolve due to the crustal deformation in a pattern that migrates through time with the triple junction.

We are conducting a multi-pronged research project to look at the effects of the triple junction migration and the upwelling in the slab window. These include, first modeling the thermal state of the crust as this deformation signal (thickening/thinning, and upwelling) migrates to the north with the triple junction. Secondly, analyzing the magmatic signal of the melting of the edge of the Gorda slab and the asthenospheric upwelling in the slab window. These results will provide constraints on the properties of the asthenosphere in the slab window and the crustal melting due to magma emplacement. Lastly, studying the landscape evolution as driven by the crustal thickening and thinning to help us better quantify the rates and patterns of uplift and erosion in northern California. These results will provide us with a better understanding of the interplay between surficial processes and lithospheric dynamics.

We hope that this interdisciplinary study of the deformation in northern California will provide better insights into the effects of crustal deformation, volcanism, and surface processes, and can demonstrate how they are intricately linked in plate tectonic models.

EVALUATING GRAPHIC CORRELATION WITH SIMULATED DATA

Achim Herrmann
Advisor: Mark Patzkowsky

Mathematical simulations of the fossil record based on realistic models of sediment accumulation and species distributions in space and time permit evaluation of biostratigraphic methods because the true order of events and the correlation among sections are known. In this study, we simulate the fossil record by combining a basin fill model (STRATA) with a biostratigraphic model (BIOSTRAT). We then use the simulated data to evaluate the performance of graphic correlation based on constrained optimization (Sadler, 1999). Constrained optimization finds the best solution to stratigraphic correlation by using all observations in all sections simultaneously and thereby avoids many of the subjective decisions that go into constructing a composite section in traditional graphic correlation. Our preliminary results are based on a simulated species file that contains a large proportion of abundant and eurytopic species, which should bias our results in favor of accurate correlation. We find that constrained optimization generally performs well, even when a small number of sections are used. The greatest problem occurs in resolving the true solution around sequence boundaries. This problem increases as facies differences between sections increases and the stratigraphic density of samples decreases. However, as more and more sections are added to the final solution the problem of resolving sequence boundaries is minimized. Additional work will explore in more detail the effects of sampling and facies differences on correlation and on the ability of graphic correlation to resolve the true order of events.

BROADBAND SEISMIC EXPERIMENT AT MERAPI VOLCANO, JAVEA, INDONESIA: VERY LONG PERIOD PULSES EMBEDDED IN MULTIPHASE EARTHQUAKES

Dannie Hidayat
Advisor: Barry Voight

Multiphase (MP) and low frequency (LF) earthquakes with spectral peak amplitudes at 3 to 4 Hz and 1 Hz, respectively, are two common types of shallow volcanic earthquakes previously recognized at Merapi volcano. Their mechanisms are poorly understood but MPs have been temporally associated with lava dome growth. We conducted a seismic experiment in January - February 1998, using 4 broadband seismographs to investigate the nature of seismic activity associated with dome growth. During our experiment, Merapi experienced mild dome growth with low-level seismic activity. We compare our data to that recorded on a local short-period (SP) network, with the following preliminary results.

MP and LF events as recorded and classified on the short-period network instruments were recognized on the broadband network. Frequency spectrograms revealed similar patterns in the near summit region at widely separated broadband stations. Higher frequency spectra than previously recognized were identified for both MP and LF events, and were strongly attenuated as a function of radial distance from the source. Thus the spectral characteristics of these events as recorded on far-field stations are not fully indicative of the source processes. In particular, many events classified as LF-type appear to have much high frequency energy near the source. This aspect of these so-called LF earthquakes, and their association with very-long-period (VLP) pulses, suggests that many events identified in the far-field as LF events are in actuality a variety of the MP event and involve similar source processes. Broadband records indicated that simple large-amplitude VLP pulses were embedded in MP and LF wavetrains. From event to event these pulses were similar in their waveforms and had periods of 4 sec. VLP events embedded in LF and MP earthquakes were located using particle motions. The epicenters were clustered in a central region of the dome complex, and preliminary source depths were within about 100 m of the dome surface, suggesting a source region deep within the dome or the uppermost conduit. A similar source location was established by study of MP high-frequency onsets. Our broadband data suggests that we have recorded both elastic seismic waves and a simple embedded pulse that is interpreted to represent a surface tilt at the seismometer site. The inferred tilt indicates an inflation and subsequent deflation, possibly caused by a gas pressure pulse or episodic shallow magma transport with stick-slip movement of the conduit wall.

ALTERATION OF ACID MINE DRAINAGE WATER AS A RESULT OF THE ADDITION OF FLY AND BOTTOM ASH

Caroline Loop
Advisor: William White

As of November 1999, over 500,000 tons of fly and bottom ash have been placed in a former acid mine pool in the Eastern Middle anthracite field of Pennsylvania. A fluidized bed combustor, used at the plant to reduce SO_2 emissions, is a significant source of CaO and $CaSO_4$ to the ash. Within 2 1/2 years, the CaO in the ash has changed the pH value of the 135 million gallon acid mine pool from 3.6 to 11.6. In fact, the top two feet of the mine pool have been precipitating a rim of $CaCO_3$ on the surrounding highwalls. This is the first full-scale attempt to study the impact of ash placement below the water table in a surface mine pool. The focus of this study is the prediction of long-term chemical speciation in the basin.

There is only one outlet for the Silverbrook Basin, and it drains both the mine pool, known locally as the "Big Gorilla" and the underlying deep mines. During low flow conditions, this outlet forms the headwaters of the Little Schuykill River. The deep mines account for approximately 3/4 of the water in the basin. Based on a comparison of many mineral saturation indices, calculated by PHREEQC for the Big Gorilla and the outflow, the two waters were equivalent before ash was placed in the mine pool. Ash deposition has significantly upset this equivalence, and there has been no evidence that mine pool water has altered the chemistry of the outflow. The mine pool water has become increasingly buffered with continued ash placement. During the first winter, when ash placement was suspended, the pH value of the mine pool declined 3 units; last winter it decreased less than one unit. Although there has been an increase in SO_4, there has also been a clear decrease in Al, Fe, Mn, and Zn. As Fe, Mn, and Al oxides precipitate within the mine pool, they act as a sink for trace metals as well. Thus, the alkaline surface mine water not only serves to buffer the water entering the highly acidic deep mines, but it also aids in co-precipitating oxides and trace metals.

AUSTRALIAN PLATE FLEXURE AND THE TOPOGRAPY OF FIORDLAND, NEW ZEALAND

Rocco Malservisi
Advisor: Kevin Furlong

The southwestern region of the Southern Island of New Zealand, Fiordland, is characterized by the subduction of a corner of Australian plate below the Pacific plate. In spite of a similar transpressional regime along the plate boundary in the Southern Island, a regionally different gravitational signature shows that the compressive component of the plate motion has been accommodated in different ways. In the central region, the high topography of the Southern Alps is associated with a negative Bouguer gravity anomaly showing that isostatic forces sustain the high elevation. In the southwest, a very high positive Bouguer gravity anomaly (>200 mgal) associated with the high elevation of Fiordland, indicates that isostatic compensation is not supporting the topography. We suggest that the deformation of the corner of Australian plate, shown by a highly distorted Benioff plane, can provide the dynamic support for the Fiordland topography. To prove this assumption we use a Finite Element Model to analyze the behavior of an elastic slab (Australian plate) which has been deformed to a shape suggested by the local seismicity. The comparison of the slab displacement with the observed topography and the gravity signature allows us to understand how different plate geometries and plate interactions can affect the local dynamic. In particular we find that to mimic the observed topography we need to apply a pressure on the northern side of the slab, representing the interaction with the Southern Alps region (crustal thickening), and to introduce a tear in the Australian plate (propagation of the Alpine fault).

CONSTRAINTS ON THE OXYGEN LEVEL OF THEARCHEAN ATMOSPHERE BASED ON NEW DATA ON DISSOLUTION RATES OF URANINITE

Shuhei Ono
Advisor: Hiroshi Ohmoto

Uraninite (UO_2) is thermodynamically unstable under an oxygenated environment. Therefore, the presence of detrital uraninite in some quartz-pebble conglomerates of ~2.9 to ~2.2 Ga has been used by many geochemists as important evidence for an anoxic atmosphere prior to ~2.2 Ga (e.g., Holland, 1994). Based on the results of series of experiments, Grandstaff (1976) suggests that the rate of uraninite dissolution is first order with respect to [H^+], [O_2] and [total CO_2]; the rate also depends on the impurity of uraninite. Using the Grandstaff's rate equation, Holland (1984) estimates the pO_2 level of the Archean atmosphere was less than 0.1 % of the present atmospheric level (PAL) for the survival of a uraninite. Additional assumptions used in the computation were that the atmospheric pCO_2 was 100 – 1000 PAL (Kasting, 1993), and that the duration for exposure of the uraninite to the aerated water during weathering, transportation, and deposition was between 1,000 and 10,000 years.

Recently several investigators have conducted new experiments on the kinetics of dissolution of uraninite (e.g. Bruno *et al.*, 1991; Gray and Wilson, 1995; Torrero *et al*., 1996; de Pablo *et al*., 1999). They showed that the initial dissolution rate was much faster than true value for most experiments, and it took about a month to obtain true steady state dissolution rate. However, the duration of some experiments, including those of Grandstaff, was too short to obtain the true rates. The well-controlled experiments give the dissolution rates of –11.5 to –9.5 (log(rate) in mol /m^2/s) at the present atmospheric condition. These rates are 1 to 2 orders of magnitude slower than those obtained by Grandstaff. The dependence of the dissolution rate on [H^+] and [total CO_2] obtained by the recent investigators are also much less than that suggested by Gandstaff.

Using the rate equation of Torrero *et al*. (1996), we calculate that 0.1 mm size uraninite grains survives under the present atmospheric condition if the total duration of weathering, transportation and deposition is less than ~10,000 years. This explains the occurrence of detrital uraninites in modern aluvial sediments in the Upper Indus River. The detrital uraninites in the pre-2.2 Ga conglomerates would have survived even if the pO_2 was 1 PAL and pCO_2 100 PAL as long as the exposure time to the aerated water was less than ~5,000 years. Such a short duration is consistent with the nature of host sediments. The abundance of pre-2.2 Ga placer uraninite deposits may only reflect the abundance of uraninite-rich source rocks rather than the atmospheric evolution.

INVERSION OF THE SKS RECEIVER FUNCTION

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A source equalization technique similar to that used for teleseismic P wave receiver functions is applied to SKS waves which display possible effects of shear wave splitting. Deconvolution of the radial component
SKS wave from the tangential component yields the SKS receiver function which is independent of the effective source function for incident SKS waves. Source normalization thus allows use of stacking methods for removing noise from the data and building up the signal from shear wave splitting or near- receiver scattering effects. Tests using synthetic seismograms calculated from an accurate wave propagation algorithm for plane wave propagation in arbitrary anisotropic layers and with the simple model of split orthogonal shear waves shows that the method produces a time series displaying the relative times and amplitudes between split shear waves on the tangential components. Complicated waveforms sometimes arise for some aniotropic models when the radial component shows distinct split arrivals. A grid search procedure is successfully employed to invert for the split time and fast direction using the standard simple model of orthogonal split shear waves. Azimuthal suites of SKS receiver functions will be the focus of waveform inversion for layer elastic coefficients incorporating accurate synthetic seismogram computations. SKS receiver functions for SAO (San Andreas Observatory) are investigated to evaluate the effect of multilayered anisotropic models.

RARE EARTH ELEMENTS IN PRECAMBRIAN BANDED IRON FORMATIONS: ARE THE CERIUM ANOMALIES REAL?

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Rare earth elements (REEs) in Precambrian Banded Iron Formations (BIFs) have been used to estimate the chemical characteristics of ancient oceans, because the REE patterns of detritus-free BIFs, i.e., pure chemical sediments, are expected to reflect the REE characteristics of the contemporaneous seawater. Previous researchers have recognized the existence of prominent positive Eu anomalies and negative Ce anomalies in BIFs, and suggested the contributions of high temperature hydrothermal fluids and oxic seawater in the BIF-forming environments, respectively. They developed a mixing model of hydrothermal fluids and anoxic deep water for BIF formation under a globally reducing ocean and atmosphere with locally oxygenated surface seawater. However, there are serious flaws in their BIF model. First, modern oxic deep water is used as a mixing endmember of the model. Such deep water with negative Ce anomaly formed under modern oxic atmosphere and cannot be used for the model. Second, there are various problems in the analyses of REE in BIFs. Only a minor 'contamination' of clastic materials in a BIF may obscure the REE characteristics of the chemical component of BIF. INAA (instrumental neutron activation analysis) has been used to produce REE data of BIF, however, it is less precise analytical method than ID-TIMS (isotope dilution - thermal ionization mass spectrometry) and ICP-MS (inductively coupled plasma - mass spectrometry), especially for Ce in Fe-rich samples such as BIF . Third, anomalous behaviors of La in seawater, typically showing positive La anomaly, may produce "false" negative Ce anomalies. Serious question has remained as to whether or not the observed REE anomalies, especially the negative Ce anomalies, are real. Therefore we have carefully and critically examined many REE data of Precambrian BIFs reported in published literatures, using a new method of defining Ce and La anomalies.

By applying this method to only REE data of chemically pure BIF samples obtained by precise ID-TIMS and ICP-MS methods, we realized that many of the previously observed negative Ce anomalies disappear and that they are largely due to positive La anomalies. However, there are negative and also positive Ce anomalies in some BIFs. In general, BIFs with enhanced positive Eu anomalies show no Ce anomaly, while those with slight positive, no, or negative Eu anomalies show a wide range of Ce anomalies. These REE characteristics are consistent with the model that BIFs formed by hydrothermal fluids that locally discharged in stratified basins with an oxic upper zone and an anoxic lower zone; the global ocean was oxygenated. The degree of interaction of fluid and rocks in the hydrothermal plumbing system has probably determined the patters of Eu anomaly. The redox state of local seawater and the degree of mixing with hydrothermal fluid appear to have determined the patterns of Ce anomaly.