34th Annual Graduate Student Colloquium
Department of Geosciences

April 17th –19th , 2002

244 Deike Building
The Pennsylvania State University

2002 Graduate Student Colloquium Committee:
Dave Reusch, Amy Ehmann, Pushker Kharecha, Jennifer Nemitz, Matt Spencer,
Dorothy Vesper, Xialoi Liu, and Caroline Loop

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 undergraduates and graduates involved in geoscience research. The format stimulates research discussion, allows students to practice for national meetings, 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, cash awards are rewarded for 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 Peter Deines for departmental support and prize money. Great thanks areextended to this year's judges for their time and assistance.

2002 Graduate Student Colloquium Program Schedule
April 17th-19th, 2002

All sessions will be held in 244 Deike Building
Talks are a maximum of 12 minutes with an additional 3 minutes for questions
Refreshments will be provided during each session

Session	Date	Time
Posters	Wednesday	9 am - 5 pm
Geomorphology and Geochemistry I	Thursday	9:45 - 11:15 am
Geophysics	Thursday	1:45 - 3:45 pm
Paleoclimate, Paleontology, Structure, and Seismology	Friday	9:45 - 11:45 am
Geochemistry II	Friday	1:30 - 2:45 pm

Wednesday
Posters

Matt Bachmann
Achim Herrmann
Chris Junium
Minoo Kosarian
Jane Lock
Monica Maceira
Rocco Malservisi
Kristen Meyers
Kristine Nielson
Mike O'Driscoll
Erica Schneider
Winchelle Sevilla
Beth Strickland
Jamie Whitlock
Aubrey Zerkle

Time	Thursday Oral	Friday Oral
9:45	Katya Bazilevskaya	Achim Herrmann
10:00	Katherine Bulinski	David Reusch
10:15	Jane Lock	Zach Krug
10:30	Break	Break
10:45	Karla Panchuck	En-Chao Yeh
11:00	Nicolai Pedentchouk	Juliette Florentin
11:15		Paul Winberry
11:30		Margaret Benoit
1:30		Heather Buss
1:45	Xiaoli Liu	James Moran
2:00	Kyle Straub	Christina Lopano
2:15	Break	Kelly Knight
2:30	Break	
2:45	Aaron Janssen	
3:00	Eric Kuhl	
3:15	Christine Lee	
3:30	Ben Seldon	

POSTER PRESENTATIONS

Presenter	Advisor	Poster Title
Matt Bachmann	Lee Kump	POTENTIAL IMPACTS OF CHEMOLITHOTROPHIC SULFUR BACTERIA ON GROUNDWATER QUALITY IN THE FLORIDA KEYS
Achmin Herrmann	Mark Patzkowsky	BIOMODULE: A JAVA PROGRAM TO HELP MODEL AND INTERPRET THE STRATIGRAPHIC RECORD
Chris Junium		EARLY CRETACEOUS HIGH LATITUDE PALEOCLIMATE: A POSSIBLE COOL PERIOD IN A GREENHOUSE WORLD
Minoo Kosarian	Charles Ammon	CRUSTAL STRUCTURE BENEATH MIDDLE-EAST AND NORTH AFRICA
Jane Lock	Kevin Furlong	COMPLEX DRAINAGE RESPONSE TO MIGRATING TECTONIC UPLIFT: EXAMPLE FROM THE NORTHERN CALIFORNIA COAST RANGES
Monica Maceira	Charles Ammon	BROADBAND RUPTURE PROCESSES OF THE 1999 IZMIT (M_w=7.4) AND THE DUZCE (M_w=7.2) TURKEY EARTHQUAKES
Rocco Malswervisi, Christine Gans	Kevin Furlong	CREEPING FAULTS AND SEISMICITY: LESSONS FROM THE HAYWARD FAULT, CALIFORNIA
Kristen Meyers	Barry Voight	EVOLUTION OF THE BEZYMIANNY VOLCANO MAGMA CHAMBER, 1956-1997, KAMCHATKA, RUSSIA
Kristine Neilson	Charles Fisher, Chris House	AN INVESTIGATION OF THE RELATIONSHIP BETWEEN VESTIMENTIFERAN TUBEWORMS AND BACTERIA IN SEDIMENTS SURROUNDING THEIR ROOTS
Mike O'Driscoll	David DeWalle, Richard Parizek	CHARACTERIZATION OF STREAM-AQUIFER INTERACTIONS IN A CARBONATE WATERSHED
Erica Schneider	Kevin Furlong	ANALYSIS OF STRESS FIELDS AROUND FAULT ZONES IN WELLINGTON, NEW ZEALAND

Presenter	Advisor	Poster Title
Winchelle Ian Sevilla	Charles Ammon	DEPTH DEPENDENCY OF RUPTURE PROCESSES ALONG THE PHILIPPINE TRENCH: IMPLICATIONS FOR UNDERSTANDING THE ROLE OF SEDIMENTS IN RUPTURE PROPAGATION AND THE OCCURRENCE OF TSUNAMI EARTHQUAKES
Beth Strickland	Peter Flemmings	STRUCTURAL OVERVIEW OF POPEYE FIELD, GREEN CANYON BLOCK 116, AND THE INFLUENCE OF ALLOCHTHONOUS SALT ON BASIN DEVELOPMENT
Jame Whitlock	Kevin Furlong	THE JUAN DE FUCA SLAB-WINDOW AND COAST RANGE VOLCANICS, CALIFORNIA: CORRELATION BETWEEN SUBDUCTED SLAB AGE AND MANTLE WEDGE GEOCHEMISTRY
Aubrey Zerkle	Chris House	FLOURESCENT IN SITU HYBRIDIZATION STUDY OF MICROBIAL ABUNDANCE AND DIVERSITY WITHIN MEROMICTIC FAYETTEVILLE GREEN LAKE, NY

POTENTIAL IMPACTS OF CHEMOLITHOTROPHIC SULFUR BACTERIA ON GROUNDWATER QUALITY IN THE FLORIDA KEY

Matt Bachmann
Advisor: Lee Kump

Recent analyses of nitrogen cycles in the Florida Keys have identified depleted nitrogen levels at a subsurface mud-rock interface between NO_3^- rich upwelling groundwaters and overlying HS^- rich anoxic confining sediments (Griggs, 2000). Nitrate reducing, sulfur oxidizing bacteria may be responsible for the observed nitrogen imbalance, linking the sulfur and nitrogen cycles in subsurface environments in order to remove excess nitrate contamination.

Several species of large, vacuolated bacteria, *Thioploca* and *Beggiota*, are known to thrive in marine sediments overlain by nutrient rich waters. These bacteria use long (up to 15cm) filamentous sheaths to migrate between nitrate rich seawater and sulfide rich anoxic ocean sediments (Jorgenson and Gallardo, 1998). Nitrate storage within the cells is achieved by means of large liquid vacuoles containing nitrate concentrations of up to 500 mM (Maier et al, 1990). With the ability to link the sulfur and nitrogen cycles in marine sediments, these and similar organisms may also have the potential to remove excess nitrate from polluted aquifers in the Florida Keys.

To effectively model the migration of nitrate-contaminated groundwater, high resolution spatial data from the mud-rock interface must be obtained, and correlated with the chemical uptake rates of local microbial communities. By measuring the nitrate and sulfide concentrations across the boundary, and culturing and characterizing the microbes found there, predictive groundwater models can be made to more accurately reflect the biogeochemical processes occurring in the aquifer.

BIOMODULE: A JAVA PROGRAM TO HELP MODEL AND INTERPRET THE STRATIGRAPHIC RECORD

Achim D. Herrmann
Advisor: Mark Patzkowsky

A combination of a stratigraphic simulation package (STRATA) and an evolutionary-ecological model (BIOSTRAT) can be used to simulate the distribution of species within a sequence stratigraphic framework. BIOMODULE is an extension of this model approach in that it facilitates the visualization and interpretation of those simulations and their input data. Environmental factors (e.g., sea-level changes or sedimentation rates) and ecological factors (different preferred water depth, depth tolerances, abundance) that determine the spatial and temporal distribution of species are easily and quickly investigated. In addition, BIOMODULE can be used to compile the stratigraphic first and last appearances of those species and export them into available graphic correlation software packages (Conop9 and GraphCor). This can be used to test the graphic correlation technique and investigate its accuracy and precision under a range of different conditions (different stratigraphic architectures, sampling densities, etc) since the true correlation of the different sections is already known.

EARLY CRETACEOUS HIGH LATITUDE PALEOCLIMATE: A POSSIBLE COOL PERIOD IN A GREENHOUSE WORLD

Chris Junium

Recent work in the Early Cretaceous indicates paleotemperatures which are cool and accompanied by a high latitudinal temperature gradient. This contradicts the traditional notions of the greenhouse climate with high latitude warmth. The so-called warm equable climate has been the standard set for nearly all of the Cretaceous. However, the Early Cretaceous, especially the Valanginian-Hauterivian has been proposed as a period of apparently cooler temperatures and a steep latitudinal temperature gradient. This is supported by oxygen isotopic data, faunal assemblages, modeling evidence and distributions of glendonites (a pseudomorph of calcite stable at -1 to 5°C). The same period also shows a distinct positive N413Ccarbonate excursion, in Tethyan and North Atlantic samples. Bulk carbonate N413C data acquired from ODP Leg 198 show similar high values, extending the record to the Pacific Ocean. I plan to test the possibility of cold polar temperatures in the Valanginian-Hauterivian. I will evaluate this possibility by obtaining high latitude belemnite and Buchiid bivalves samples for N413C and N418O stable isotopic analysis from Early Cretaceous strata of Svalbard, Norway. Svalbard is an appropriate field area because of its high paleolatitude (>70° N) and reasonably well documented Early Cretaceous strata. The goal of this study is to better understand the thermal state of the early Cretaceous. In addition the study will expand the geochemical characterization of a period of time that is very much in need of more quantitative paleotemperature data. These data can then be used to test hypotheses regarding carbon cycling, pCO_2, and its relation to the robustness of numerical climate models, and the possibility of Early Cretaceous glaciation.

CRUSTAL STRUCTURE BENEATH MIDDLE-EAST AND NORTH AFRICA

Minoo Kosarian
Advisor: Dr. C. J. Ammon

Seismograms contain important information on the earthquake faulting geometry, the earth structure in the vicinity of both the source and the receiver and propagation effects through the mantle. Source, near-source structure, and mantle propagation effects can be removed from the seismograms using a deconvolution that sacrifices P-wave information for the isolation of near receiver effects. The result is a receiver function. Receiver functions are time series, computed from three-component body-wave seismograms, which show the relative response of earth structure near the receiver.

In the Middle East and North Africa, a number of refraction studies provided estimates of basement and crustal thickness, although there is sparse coverage of three-component broadband seismic stations needed for receiver function analysis. As part of my research, in order to improve knowledge of the lithospheric structure, I will systematically apply the receiver function method to seismic stations throughout the Middle East and North Africa. The result will allow a comparison of crustal structure and the character of the crust mantle transition.

Specifically, we propose to (1) apply this method for a collection of seismic stations throughout the research area to estimate crustal structure of the region, where few geophysical measurements have been made, (2) use joint inversion of receiver functions and surface wave dispersion to minimize the non-uniqueness problem that results from velocity-depth trade off, and (3) compare results with other geophysical observations and recently research works of this area.

We have used observations recorded by one of the seismic station KIV located on the northern flank of the Caucasus Mountains in Kislovodsk, southern Russia. Using P-waveforms recorded at KIV from 650 events with Mw > 5.5 from 1990 to 1999, we computed 298 receiver functions corresponding to various epicenter distances and back-azimuths. I will illustrate the approach using observations from station KIV.

COMPLEX DRAINAGE RESPONSE TO MIGRATING TECTONIC UPLIFT: EXAMPLE FROM THE NORTHERN CALIFORNIA COAST RANGES

Jane Lock
Advisor: Kevin Furlong

Migration of the Mendocino triple junction in northern California produces rapid and dramatic changes in the processes and patterns of crustal deformation. In response to this tectonism, the river systems of the northern California Coast Ranges have developed a complex drainage history and pattern. The tectonic response to this migrating triple junction is described by the Mendocino Crustal Conveyor model (MCC), which predicts a spatially and temporally varying pattern of crustal deformation and uplift. We use a combination of geomorphic and geophysical observations, coupled with landscape evolution modeling to develop the links between the geomorphic observations in the Coast Ranges and the uplift/subsidence pattern predicted by the MCC. In contrast to many previous landscape evolution studies that find that streams typically cut through or are diverted around growing structures, in the northern California Coast Ranges drainage reversal and stream capture appear to be the response to tectonism. Our landscape evolution modeling shows that the uplift predicted by the MCC produces: (1) a topographic gradient that switches from trending northwest to southeast, causing streams that at first flow to the northwest to reverse and drain to the southeast, (2) drainage divides that migrate in concert with the triple junction, and (3) river evolution that will result in fish hooked drainage patterns, all characteristics similar to those observed in the Northern California Coast Ranges. The uplift/subsidence pattern in the northern Coast Ranges is further complicated by the interaction of a second tectonic driver – the Pioneer fragment. The Pioneer fragment migrates with the Pacific (south of the triple junction) and creates a mini-slab window, adjacent to the coast, to produce a superimposed secondary uplift/subsidence pattern. The effects of this Pioneer related uplift are recorded by the Eel River. Key to the complex evolution of river systems in northern California is the interaction of a migrating, spatially complex pattern of uplift/subsidence, producing drainage patterns that differ from those often observed in more stationary orogens.

BROADBAND RUPTURE PROCESSES OF THE 1999 IZMIT (M_W=7.4) AND THE DÜZCE (M_W=7.2) TURKEY EARTHQUAKES

Monica Maceira
Advisor: C. J. Ammon

A large, devastating earthquake struck western Turkey on August 17, 1999, causing significant loss of life and damage in the region of Izmit Bay. The earthquake occurred on the east-west trending North Anatolian fault, and was followed by another large earthquake on November 12, 1999 near the town of Düzce, highlighting the unique characteristics of earthquake sequences along the North Anatolian fault. It has been shown that during the period between 1939-1944 four westward migrating earthquakes occurred along the North Anatolian fault, and we will investigate the source process of the two 1999 events. The Izmit earthquake occurred near the eastern end of Izmit Bay (40.75° N, 29.86° E), while the Düzce earthquake occurred farther east (40.76° N, 31.16° E). We characterize the spatio-temporal rupture history of both events. We utilize an empirical Green function analysis of body and surface waves to obtain the rupture directivity information and map the moment rate along the fault. The Izmit earthquake ruptured bilaterally, with slightly more energy being released to the west of the hypocenter. The extent of rupture is approximately 120 km, closely matching surface observations. Preliminary results for the Düzce earthquake show a bilateral rupture extending 90 km, with slightly more energy released to the west of the hypocenter. In this case, the 40 km surface rupture only extends west of the epicenter, suggesting a unique rupture process for this event. We will further validate these results and compare them with other studies of several large strike-slip events.

CREEPING FAULTS AND SEISMICITY: LESSONS FROM THE HAYWARD FAULT, CALIFORNIA

Rocco Malservisi, C. Gans
Advisor: K. Furlong

While faults remain mostly locked between large strain releasing events, they can dissipate some of the accumulating elastic strain through creep. One such fault that releases a significant fraction of accumulating strain by creep is the Hayward fault in the San Francisco Bay region of California. The seismic risk associated with creeping faults such as the Hayward fault will depend in part on the net rate of moment accumulation (slip deficit) on the fault. Using a visco-elastic finite-element model driven by far field plate motions, we have investigated how the specific geometry of locked and free portions of the fault, and the interactions between the fault zone and the surrounding lithosphere influence creep on the fault plane and thus the seismic risk. In contrast to previous studies of the effects of the geometry of locked patches on the surface creep rate that specified rates on those patches, we specify only "creepable" regions and allow the system to adjust the creep rate. With our approach, we can infer fault zone geometries and physical properties that can produce the observed surface creep on the Hayward fault letting the rheology, geometry, and mechanics of system determine patterns of creep on the fault plane. Our results show that the creep rate decreases smoothly moving toward the locked patches. This leads to "creepable" (low friction) areas that accumulate a high slip deficit as compared to other low friction segments of the fault. A comparison of the creep pattern from our results with Hayward fault micro-seismicity indicates that events cluster in the "creepable" regions with a creeping-velocity gradient that leads to a significant strain accumulation rate in the elastic material surrounding the creeping fault. This correlation provides an additional tool to map deformation patterns and strain accumulation on the fault. Micro-seismicity, surface deformation, and geodynamic modeling combine to allow us to refine our estimation of net strain accumulation on the fault.

EVOLUTION OF THE BEZYMIANNY VOLCANO MAGMA CHAMBER, 1956-1997, KAMCHATKA, RUSSIA

Kristen Meyers
Advisor: Barry Voight

In 1956, after ~1000 years of dormancy, Bezymainny erupted in a massive directed blast explosion, blowing out the eastern side of the cone. Since the 1956 eruption, the volcano has been continuously active, forming lava domes, and erupting ash and pyroclastic flows. The volcanic deposits of 1956 are very different from deposits of 1993 and 1997, indicating a change in magma chamber conditions. Using the varying petrology of 7 samples, 2 from 1956, and 5 from the 90's, the pressure and temperature changes and rates of ascent can be discovered.

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN VESTIMENTIFERAN TUBEWORMS AND BACTERIA IN SEDIMENTS SURROUNDING THEIR ROOTS

Kristine Nielson
Advisors: Charles R. Fisher, Chris House

Vestimentiferan tubeworms, such as *Lamellabrachia* cf. *lumymesi*, a species associated with cold seeps in the Gulf of Mexico, are unusual among animals in structure and metabolism. They lack a mouth and anus, receive the bulk of their nutrition from symbiotic bacteria that grow in their tissues, and acquire sulfide to support these symbionts through a root structure that grows a meter or more in length into the anoxic sediments of the gulf. Sulfide may be produced by anaerobic oxidation of seawater sulfate (though this process is limited to the top 10 cm of sediment), by bacterial reduction of Castille gypsum that is often associated with limestone caprock, and by decomposition of buried detritus. It has been reported that in respiration experiments individual tubeworms absorb sulfide at an average rate of 4.1 μmol/g/hr. While this rate cannot directly be extrapolated to tubeworm bushes in their undisturbed state, it is reasonable to assume that a typical aggregation of 500-2,000 individuals would require a significant input of sulfide from the environment. Given the requirements of a tubeworm bush and the rate of sulfide production from other processes, estimated to be between 0.27 to 2.51 μmol/cm^3/day, the possibility has also been proposed that vestimentiferan worms may pump sulfate into the sediments to stimulate the necessary production of sulfide from sulfate.

I plan to investigate the possibility of a syntrophy between tubeworms and bacteria using the following techniques: 1) Florescence In-Situ Hybridization (FISH) and 16S RNA to characterize the community and look at small scale spatial distribution of bacteria; 2) lipid analysis to see larger scale changes in composition of community; and 3) isotopic analysis of sulfur to trace sulfide through the system.

CHARACTERIZATION OF STREAM-AQUIFER INTERACTIONS IN A CARBONATE WATERSHED

Mike O'Driscoll
Advisors: David R. DeWalle and Richard R. Parizek

The interactions between surface water and groundwater are important because they have a major effect on the physical and chemical hydrology of streams and shallow groundwater. To characterize either system it is necessary to understand how both systems interact. Carbonate (karst) watersheds often possess streams that leak water through their channel sediments (influent streams) and may have significant surface water –groundwater interactions. I hypothesize that stormwater runoff from urbanized and agricultural land amplifies stream-groundwater interactions and alters groundwater quality and flow paths in alluvial aquifers in karst watersheds. My study goal is to quantify the physical effects of urban and agricultural runoff on surface water–groundwater interactions in stream channels located in carbonate watersheds. I am using an integrated approach to monitor stream-groundwater systems during baseflow and runoff events and to determine the major controls on surface water and groundwater mixing. Surface water and groundwater temperature, chemistry and hydraulics are being examined in stream channels receiving urban and agricultural runoff. Runoff-induced changes in surface water-groundwater interactions are being investigated with chemical and isotopic tracers. Water quality samples and hydraulic data are being collected from multi-level channel piezometers, (screened wells used to measure subsurface water pressure) equipped with pressure recorders. Numerical models, calibrated with site-specific data, will be used to predict the effects of increased urbanization on surface water-groundwater interactions. Conclusions can provide information that will help characterize surface water-groundwater interactions during runoff events and evaluate groundwater supplies located near streams.

ANALYSIS OF STRESS FIELDS AROUND FAULT ZONES IN WELLINGTON, NEW ZEALAND

Erica J. Schneider
Advisor: Kevin Furlong

Wellington is the second largest city in New Zealand, as well as being the capitol of the country. The proximity of the city to several fault zones creates a high level of seismic risk to its inhabitants. A large magnitude event would be devastating in terms of loss of life and property but also to the overall stability of the national economy and government. In order to prevent damage and the loss of life, it is important to understand the fault systems surrounding Wellington. By studying the stress fields around the fault zones adjacent to Wellington, it is possible to gain an interpretation of how an event on one fault will affect the stress regime on another nearby fault. When stress increases on a nearby fault, that may increase the likelihood of a seismic event. Conversely, a decrease in stress will reduce the chances of an earthquake on an adjacent fault. Stress changes were calculated using a Coulomb stress program, which incorporates the dimensions and orientation of the faults, basic lithologic characteristics and the character of the seismic event.

DEPTH DEPENDENCY OF RUPTURE PROCESSES ALONG THE PHILIPPINE TRENCH; IMPLICATIONS FOR UNDERSTANDING THE ROLE OF SEDIMENTS IN RUPTURE PROPAGATION AND THE OCCURRENCE OF TSUNAMI EARTHQUAKES

Winchelle Ian Sevilla
Advisor: Charles Ammon

Subduction zones are the primary plate boundaries that release seismic energy. Earthquakes along these zones exhibit spatial variations in rupture processes. Plate boundary interface frictional properties are complex and there is no general consensus on what controls the details of faulting. Recent studies demonstrated a systematic decrease in the duration with increasing depth along the plate interface. One interpretation of these results is an increasing rigidity of the materials with depth in the seismogenic zone. Variations in physical properties are critical in light of the occurrence of tsunami earthquakes, which are class of earthquakes that produces anomalously large tsunamis relative to their magnitudes. An emerging consensus suggests that tsunami earthquakes tend to occur at very shallow depth, with unusually slow rupture propagation, and low rigidity sediments are present.

The Philippine trench offers a venue to explore the variations of rigidity along the plate interface. The trench has numerous interplate earthquakes with hints of statistically significant geographic distributions in the data. The distribution of earthquakes can help us address variations with depth and the lateral variations along the strike of the trench. The uneven distribution of the sediments will help us to explore their role in governing the variations of frictional properties at the plate interface.

As part of my Master's Degree research, I (1) perform a study on rupture behavior along the plate interface of the Philippine trench using multi-station deconvolution method, (2) asses the depth and along strike variations in rupture duration of the plate interface (3) investigate the role of sediments, either subducting with the slab or accreting at the accretionary prism (4) correlate the results with other subduction zones (5) evaluate the strengths and weaknesses of the models adapted for this study .

STRUCTURAL OVERVIEW OF POPEYE FIELD, GREEN CANYON BLOCK 116, AND THE INFLUENCE OF ALLOCHTHONOUS SALT ON BASIN DEVELOPMENT

Beth Strickland
Advisor: Peter Flemings

A simple, vertical model of basin evolution is developed for the Popeye field minibasin. This model demonstrates that as sediment load increases on the downthrown side of the major growth fault in the northern part of the field, differential loading pushes allochthonous, Jurassic Louann salt outwards to create the basin. The movement of salt from the area produces subsidence and creates accommodation space. The Popeye minibasin is in a region between two different allochthonous salt systems; this transition zone contributes to the structural complexity of the basin. The late Pliocene field is bounded to the north by an E-W trending growth fault that dips south. Smaller antithetic and synthetic normal faults run parallel to the main fault, along with normal faults that dip down to the southwest in a direction oblique to the main growth fault.

THE JUAN DE FUCA SLAB-WINDOW AND COAST RANGE VOLCANICS, CALIFORNIA: CORRELATION BETWEEN SUBDUCTED SLAB AGE AND MANTLE WEDGE GEOCHEMISTRY

Jamie Whitlock and C.E. Lesher
Advisor: Kevin Furlong

In the Coast Ranges of central and northern California, a suite of northward-younging volcanic centers erupts within the Juan de Fuca slab window. The slab window forms as the Mendocino triple junction migrates to the northwest, removing the subducting slab from beneath North America. This study looks at the most recent, post Mid-Miocene (< 12 Ma) set of volcanics that lie ~ 50 km onshore of and parallel to the California coastline. In an attempt to characterize the nature of their magma source and create a complete, consistent and representative geochemical dataset, we have analyzed 37 samples from 8 localities throughout this region. Major elements were determined via XRF (UMass lab) and trace and rare earth analyses were determined by ICP-MS at UC Davis. Using our data, supplemented by published datasets, we focus mainly on basalts with greater than 6-8% MgO. By studying these, the least differentiated and least contaminated samples, we can use the geochemistry of the basalts as a probe to the characteristics of the source.

The source of the mantle material that fills the slab window has, in the past, seemed uncertain. Our preliminary analyses indicate that the relic mantle wedge to the east is a viable candidate. If the Coast Range volcanics source from the mantle wedge, they provide a probe of the wedge during the latter stages of subduction, just prior to Mendocino triple junction passage. This “tap” into the geochemistry of the mantle wedge over the time span of the Mendocino triple junction migration is made more interesting because the age of the subducting Gorda/Juan de Fuca plate has decreased from ~ 14 Ma to the present, young age of ~ 5-6 Ma. Previous studies of the geochemical response within the mantle wedge to variations in the subducting slab age have, by necessity, compared arc volcanic products erupted from different plate boundaries. The Coast Range volcanic series provides an alternative means of sampling mantle wedge geochemistry, avoiding some of the potential problems inherent in sampling and comparing the geochemistry from different arcs. Our analyses of the primitive magmas erupted into the Coast Ranges allow us to test both the source location and whether mantle wedge chemistry has varied in response to changes in age (and hence thermal structure) of the subducted slab north of the triple junction.

FLUORESCENT *IN SITU* HYBRIDIZATION STUDY OF MICROBIAL ABUNDANCE AND DIVERSITY WITHIN MEROMICTIC FAYETTEVILLE GREEN LAKE, NY

Aubrey Zerkle
Advisor: Chris House

Geochemical stratification of a meromictic lake has produced significant variations in the composition and distribution of microbial populations living in the water column. Fayetteville Green Lake (FGL), NY, is a permanently stratified lake with a well-oxygenated surface water mass (mixolimnion) overlying a relatively stagnant, anoxic deep water mass (monimolimnion). A strong chemocline occurs in the lake around 20m depth, where oxygen concentrations decrease along with increasing sulfate and methane concentrations. The chemical and physical stratification of FGL along with the presence of a dense bacterial plate at the chemocline suggest a high degree of microbial abundance and diversity. In addition, the presence of low levels of methane in the water column, along with a decrease in sulfate concentrations at the chemocline suggests that methane produced in the anoxic sediments by methanogens may be removed from the water column by anaerobic methane oxidation coupled with sulfate reduction. However, classification of microorganisms present in FGL has been limited to optical identification of bacteria within the upper layer and chemocline of the lake. In this study, water samples taken from depths of up to 40m in the FGL water column are being analyzed using fluorescent *in situ* hybridization (FISH) and 16S rRNA PCR cloning techniques. Initial results of FISH studies reveal diverse communities of bacteria and archaea that vary both in structure and abundance throughout the water column. Results of cloning studies will be used to create specifically labeled oligonucleotide probes for further analysis and enumeration of microbes within FGL.

ORAL PRESENTATION SCHEDULE - GEOMORPHOLOGY AND GEOCHEMISTRY I

Time	Presenter	Advisor	Poster Title
9:45	Katya Bazilevskaya	Hiroshi Ohmoto	MICROSCALE GEOCHEMICAL STUDY OF BANDED IRON FORMATIONS: ANALYTICAL AND EXPERIMENTAL APPROACH
10:00	Katherine Bulinski	Sharon Miller	THE USE OF THERMOGRAVIMETRIC ANALYSIS FOR THE CHARACTERIZATION IF INDUSTRIAL LIMESTONE AND SCRUBBER SOLIDS
10:15	Jane Lock	Kevin Furlong	COMPLEX DRAINAGE RESPONSE TO MIGRATING TECTONIC UPLIFT: EXAMPLE FROM THE NORTHERN CALIFORNIA COAST RANGES
10:30	Break		
10:45	Karla Panchuk	Lee Kump	CARBON CYCLING IN EPEIRIC SEAS AND ITS RELEVANCE TO THE HISTORY OF THE OCEAN CARBON CYCLE
11:00	Nikolai Pedentchoulk	Katherine Freeman	SOURCES OF 1,2,3,4-TETRAMETHYLBENZENE IN LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS, WEST AFRICAN BASINS AS REVEALED BY COMPOUND-SPECIFIC CARBON ISOTOPIC ANALYSIS

MICROSCALE GEOCHEMICAL STUDY OF BANDED IRON FORMATIONS: ANALYTICAL AND EXPERIMENTAL APPROACH

Ekaterina Bazilevskaya
Advisor: Hiroshi Ohmoto

Although much work has been done on banded iron formations (BIF), many questions are still unclear, including the mechanism of precipitation of interbedded silica-iron layers. If the precipitation from the water column is confirmed, these structures can give important information about paleoocean environment.

The working hypothesis for the oxide facies of Algoma-type BIF implies that ferric oxyhydroxides and silica colloids in seawater coagulated actively due to their opposite surface charge and precipitated as iron-silica mixture. The iron to silica ratio was determined by the activity of a particular hydrothermal vent. At higher activity of hydrothermal system, more ferrous iron is discharged to the seawater, with subsequent precipitation as ferric hydroxide and reduction by ferrous rich fluids during diagenesis to form magnetite. At lower temperatures, aqueous silica is dominant. Examination of the thin section is conducted to check this hypothesis.

My current research is focused on the 2.7-2.9 Ga Algoma-type BIFs in Ontario, Canada, which we visited during summer 2001. Preliminary bulk analysis of a set of samples from the 2.7Ga Temagami iron formation, located in the Proterozoic greenstone belt in Ontario, shows that distribution and correlation of trace and major elements, especially rare earths (REE), varies significantly within several centimeters. For this reason, we decided to make analyses of REE and other elements using the laser ablation ICP-MS method, which allows measurements on solid sample surface within each individual microband (~µm to ~cm scale). Regularities in the paragenetic relationships and isotopes (O, S, Fe, Sr, Nd) of the iron oxides also provide very significant information on the mechanism of formation of the Algoma-type BIFs.

Along with geochemical analyses, experiments will be conducted to study the precipitation of Fe hydroxides and partition of REEs between solution and solid phase depending on pH, pO_2, and T.

THE USE OF THERMOGRAVIMETRIC ANALYSIS FOR THE CHARACTERIZATION OF INDUSTRIAL LIMESTONE AND SCRUBBER SOLIDS

Katherine V. Bulinski
Advisor: Sharon Miller

The objective of this research project is to evaluate the accuracy of thermogravimetric analysis (TGA) for determining the efficiency of sulfur removal by limestone in a wet flue gas desulfurization (WFGD) system.

The process of TGA identifies mineralogical phases according to their decomposition temperature. TGA has been identified as a useful technique for measuring the weight percent of numerous compounds including $CaSO_4 \cdot 2H_2O$, $CaSO_3 \cdot 0.5H_2O$, $CaCO_3$, $MgCO_3$ and dolomitic $MgCO_3$ (Buecker, 1996). In the case of end product scrubber solid characterization, the molar ratio of Ca to S as measured by TGA can indicate the efficiency of sulfur removal from a scrubbing system.

The accuracy of TGA for the purpose of limestone and scrubber solid analysis has been called into question based upon literature regarding TGA. The paper "*Thermogravimetry Simplifies Scrubber Solid Analysis"* claimed that the thermogravimetric analyzer is an effective tool for accurately and efficiently determining the chemistry of industrial limestone scrubber reagents and solids (Buecker, 1996). Buecker's studies performed using TGA were not representative of intended applications of TGA in industry. The experiment used a limited range of high purity limestones. Additionally, the scrubber solid analyses from Buecker's study were not effectively verified by comparison with additional chemical analysis. This thesis report will either support or discount the claims presented in Buecker's report.

The accuracy of TGA will be evaluated by comparing TGA data with X-ray diffraction (XRD), CO_2 coulometry, and Direct Plasma Spectroscopy (DCP). The TGA, XRD, CO_2 Coulometry, and DCP analysis will be conducted on a selection of ten limestone samples and of varying chemical, petrographic and mineralogical character and their corresponding scrubber solids. The scrubber solids were generated in a pilot-scale WFGD system at The Energy Institute.

COMPLEX DRAINAGE RESPONSE TO MIGRATING TECTONIC UPLIFT: EXAMPLE FROM THE NORTHERN CALIFORNIA COAST RANGES

Jane Lock
Advisor: Kevin Furlong

Migration of the Mendocino triple junction in northern California produces rapid and dramatic changes in the processes and patterns of crustal deformation. In response to this tectonism, the river systems of the northern California Coast Ranges have developed a complex drainage history and pattern. The tectonic response to this migrating triple junction is described by the Mendocino Crustal Conveyor model (MCC), which predicts a spatially and temporally varying pattern of crustal deformation and uplift. We use a combination of geomorphic and geophysical observations, coupled with landscape evolution modeling to develop the links between the geomorphic observations in the Coast Ranges and the uplift/subsidence pattern predicted by the MCC. In contrast to many previous landscape evolution studies that find that streams typically cut through or are diverted around growing structures, in the northern California Coast Ranges drainage reversal and stream capture appear to be the response to tectonism. Our landscape evolution modeling shows that the uplift predicted by the MCC produces: (1) a topographic gradient that switches from trending northwest to southeast, causing streams that at first flow to the northwest to reverse and drain to the southeast, (2) drainage divides that migrate in concert with the triple junction, and (3) river evolution that will result in fish hooked drainage patterns, all characteristics similar to those observed in the Northern California Coast Ranges. The uplift/subsidence pattern in the northern Coast Ranges is further complicated by the interaction of a second tectonic driver – the Pioneer fragment. The Pioneer fragment migrates with the Pacific (south of the triple junction) and creates a mini-slab window, adjacent to the coast, to produce a superimposed secondary uplift/subsidence pattern. The effects of this Pioneer related uplift are recorded by the Eel River. Key to the complex evolution of river systems in northern California is the interaction of a migrating, spatially complex pattern of uplift/subsidence, producing drainage patterns that differ from those often observed in more stationary orogens.

CARBON CYCLING IN EPEIRIC SEAS AND ITS RELEVANCE TO THE HISTORY OF THE OCEAN CARBON CYCLE

Karla Panchuk
Advisor: Lee Kump

Epeiric seas were the sites of deposition for thick sequences of carbonate rocks that make up the greater part of the ancient marine rock record. Because epeiric sea limestones have Cisotope compositions ($d_{13}C$) that reflect the $d_{13}C$ of dissolved inorganic carbon (DIC) in the waters in which they formed, epeiric sea limestones are also a valuable record of C-cycing in ancient marine environments. As such, epeiric sea C-isotope data have been used to reconstruct the C-isotope history of ocean water. However, new C-isotope measurements from a well-constrained time-slice at 454 Ma, representing the Ordovician Mohawkian Sea of Eastern Laurentia, suggest that the relationship between epeiric sea C-cycling and ocean C-cycling is not a straightforward one. Rather than displaying a relatively uniform distribution of d-values, suggestive of a strong link between the ocean and epeiric sea C-cycles, the $d_{13}C$ of whole rock carbonates and organic C vary by ~4.5‰ and ~7.5‰ respectively across the time slice in patterns that reflect lithology, biofacies, and other geochemical data.

An implication of the relative decoupling of epeiric sea and ocean C-cycles is that Cisotope profiles measured in epeiric sea sediments cannot be assumed to record globally-relevant C-isotope signals. This means that the Paleozoic portion of the C-isotope secular curve, constructed from analyses of fossils from epeiric sea environments, may, in fact, provide little information about the $d_{13}C$ of ocean DIC through time.

SOURCES OF 1,2,3,4-TETRAMETHYLBENZENE IN LOWER CRETACEOUS LACUSTRINE SOURCE ROCKS, WEST AFRICAN BASINS AS REVEALED BY COMPOUND-SPECIFIC CARBON ISOTOPIC ANALYSIS

Nikolai Pedentchouk
Advisor: Katherine Freeman

Understanding whether high primary productivity or enhanced preservation in anoxic conditions is the main control on the accumulation of sedimentary organic matter is crucial for petroleum exploration in paleolacustrine basins. Previous work indicates that changes in primary productivity controlled organic matter preservation in the Lower Cretaceous lacustrine source rocks in the Congo basin, West Africa. However, the initial investigation of organic matter accumulation in the Kwanza basin of Angola and the Atlantic basin of Gabon showed that anoxia could have played the dominant role. The purpose of the present study is to provide a better understanding of this factor in Angola and Gabon by determining the sources of 1,2,3,4- tetramethylbenzene (1,2,3,4-TMB). Specifically, we are interested in the occurrence of isorenieratane: a more direct indicator, when compared with other biomarker proxies, of photic zone anoxia.

We analyzed (using py-GC/MS) 41 samples from several stratigraphic intervals in these basins. Analysis of these data revealed that pyrolyzates contain various amounts of 1,2,3,4-TMB in almost all samples. Compound-specific carbon isotope analysis of off-line pyrolyzates as well as saturate and aromatic fractions from 11 samples indicate that there were at least two potential sources for 1,2,3,4-TMB: primarily isorenieratene in Angola and b-carotene in Gabon. Enriched ($d_{13}C$ = from -24.1 to -20.1‰) 1,2,3,4-TMB values from the Angolan samples are consistent with increased amounts of isotopically enriched ($d_{13}C$ = -14.3 and -14.5‰) isorenieratane. Isotopically depleted ($d_{13}C$ = from -28.3 to -26.1‰) 1,2,3,4-TMB is present in the samples from Gabon. These samples are characterized by an elevated b-carotane content ($d_{13}C$ = from -31.3 to -28.5‰) and an absence of isorenieratane.

The presence of isotopically enriched isorenieratane indicates anoxic conditions during the deposition of sediment represented by the Angolan samples. However, the extent of anoxia in Gabon remains questionable, since b-carotane may have accumulated under a variety of environmental conditions.

STRESS-LIMITED GAS COLUMN HEIGHT IN THE GAS HYDRATE SYSTEM OF BLAKE RIDGE

Xiaoli Liu
Advisor: Peter Flemings

Gas phase pressure at the base of the gas hydrate zone (GHZ) exceeds overburden stress at ODP Site 997 of the Blake Ridge, offshore South Carolina. Pressures predicted from porosity range from hydrostatic in the shallow sediments to significantly overpressured beneath the GHZ. The GHZ traps a free gas column of ~100 m at Site 997. A two-phase, steady-state flow model with pressure-dependent fracture permeability describes the relation between flux, pressure, stress and gas column height. In the model, both water and gas pressures are predicted to follow the lithostatic gradient. As water flux increases, water pressure converges on overburden stress, fractures dilate and the amount of free gas that can be trapped below the GHZ declines. The model is insensitive to changes in gas flux. The geochemically-estimated fluid fluxes (q_w = 0.2 m^3/m_2/ky and q_g = 6.8´10^{-4} m_3/m_2/ky) and the porosity-predicted pressure predict that a closely spaced fracture network (S = 0.3 mm) traps the gas column observed at Blake Ridge.

OVERPRESSURE WITHIN THE NANKAI ACCRETIONARY PRISM FROM OCEAN DRILLING PROGRAM LEGS 131, 190, AND 196

Kyle M. Straub
Advisor: Peter Flemings

Pressures above the Nankai accretionary prism decollement are inferred to be higher than pressures interpreted from the consolidation state of the sediments. This suggests that the overlying strata have been unloaded. Pressures inferred from consolidation state increase abruptly across the decollement at ODP Sites 1174 (1.1 MPa) and 808 (2.0 MPa) suggesting a pressure discontinuity. Predicted pressures below the decollement are consistent with those predicted by Screaton *et al.* (2002). To maintain the pressure discontinuity for 0.3 m.y., a one-dimensional diffusion model requires a vertical permeability of at least 10^{-21} m^2. Vertical permeability of these strata, however, is significantly higher (10^{-19} m^2; Karig, 1993). Two models may account for the apparent pressure discontinuity: (1) the decollement has a permeability less than 10^{-21} m_2 and (2) pressure above the decollement is higher than predicted by the porosity-stress relation. In the latter case, late stage pressurization results from fluid migration from the highly overpressured footwall to the less overpressured hanging wall. The increase in pressure causes a decrease in effective stress. This is not reflected in the porosity because porosity records the maximum effective stress to which a sample has been subjected. The one-dimensional flow simulation predicts unloading of up to 2.0 MPa above the decollement. The simulation suggests that pressures are continuous across the decollement whereas the porosity-based prediction suggest discontinous pressures. This unloading model predicts that the decollement exists at the unloading boundary with continuous pressures across the decollement; however, rock properties differ across the decollement.

THE IMPACT OF ACQUSITON GEOMETRY ON THE ATTENUATION OF MULTIPLE REFLECTIONS IN THREE-DIMENSIONAL REFLECTION SEISMIC SURVEYS

Aaron Janssen
Chris Barret (Conoco)
Advisor: Peter Flemings

One principle goal of reflection seismology is to produce an image of the normal incidence reflectivity structure of the subsurface. Because geologic interfaces reflect both upcoming and down-going seismic waves, recorded surface seismic data contains multiple reflection events that must be removed before an accurate reflectivity image can be constructed.

While many multiple attenuation techniques are available, a large class of them operate on the principle that, for a particular two-way traveltime, multiple reflection events have a different traveltime vs. offset (moveout) behavior than primary reflections. Various transforms are available to map the recorded data to a domain where the multiple reflection events separate from primary reflections and can be removed. We show that the success of this class of multiple attenuation procedures depends on the acquisition geometry used to record the survey. Different acquisition geometries cause the multiple attenuation procedures to leave differing levels of residual multiple energy in the data after application of the procedure. Because some aspects of acquisition geometry vary in a regular spatial pattern within a 3D survey, we expect lateral dependence of residual multiple energy in the image.

We then model an inter-bed multiple reflection of particular interest in a South Texas 3D survey to test the effect of acquisition geometry on multiple attenuation. We compare the multiple attenuation characteristics of a survey with a narrow range of source-receiver azimuths to a survey with full azimuthal coverage and demonstrate that the full azimuth survey can significantly improve multiple attenuation. Both of these acquisition geometries impart a lateral pattern in residual multiple energy that could not be removed by the multiple attenuation procedure.

FAMILIARIZATION OF RELATIVE PERMEABILITY IN A GAS CONDENSATE RESERVOIR: POPEYE, GREEN CANYON BLOCK 116, GULF OF MEXICO

Eric Kuhl
Advisors: Turgay Ertekin, Peter Flemings

A model is presented that describes the changes in relative permeability for both the oil and gas phases of a gas condensate reservoir. In the 116-A2-BP well of the Popeye field the hydrocarbons initially are in a single gas phase. Once production begins the pressure in the reservoir declines, and due to the gas condensate nature of the hydrocarbon fluid, liquids begin to condense out of the gas phase and block the pore space. As the saturation of the oil phase increases, the relative permeability of the gas phase is reduced, resulting in declined production from the reservoir and higher residual oil saturations.

SYNTHETIC SEISMOGRAMS IN THE POPEYE FIELD, GREEN CANYON BLOCK 116, GULF OF MEXICO

Tin Wai Lee
Advisor: Peter Flemings

The comparison of the synthetic seismograms created for two wells in the Popeye field with the available 3-D seismic dataset indicates that there is a static time mismatch at both wells and the mismatch is related to the checkshot survey. In addition, sonic log filtering dramatically influenced the quality of synthetic seismograms. The creation of synthetic seismograms derived from the density and sonic logs allows the prediction of the expected seismic response of the GSand and other horizons of interest. Two types of synthetic seismograms were created at two representative, non-deviated wells on opposite sides of the Popeye field. Convolving a Ricker wavelet with the reflection coefficient log and phase shifting the result 90° created one type of synthetic seismogram. Performing a running summation of the reflection coefficient log and detrending and band-pass filtering the result created the other type. Not only did the two types of synthetic seismograms differ from the real data, they differed from each other as well. The process involved in the second type of synthetic seismogram resulted in a loss of high frequency energy.

RESERVOIR CHARACTERIZATION OF THE POPEYE FIELD, GREEN CANYON, DEEPWATER GULF OF MEXICO

Ben Seldon
Advisor: Peter Flemings

Gas volumes in the G-Sand reservoir, Popeye Field, were delineated from the amplitude extraction of the seismic horizon. Distribution of these volumes is controlled by sand structure and fault compartmentalization. Well and 3-D seismic data has allowed interpretation of reservoir geometry and fluid content.

The Popeye Field is located in a salt withdrawl minibasin in late Pliocene strata on the Gulf of Mexico slope, 140 miles South of New Orleans. The G-Sand reservoir interval is composed of a massive turbidite sand overlain by a laminated sand and shale facies. A distinct log signature is correlatable across the field and displays a shift in facies dominance. Hydrocarbon volumes are present on both sides of a synclinal subsurface geometry. These are confined up-dip on structure by regional salt related faulting. An amplitude extraction of the reservoir horizon delineates fluid volumes and contacts, some of which are intra-reservoir contacts.

Future research will center on analysis of the amplitude extraction phenomena and a detailed characterization of the reservoir facies. The culmination of this analysis will result in the production of a working reservoir model. The model will be used to elucidate structural and pressure communication issues between the individual reservoir compartments.

ORAL PRESENTATION SCHEDULE - PALEOCLIMATE, PALEONTOLOGY, STRUCTURE, AND SEISMOLOGY

Time	Presenter	Advisor	Poster Title
9:45	Achim Herrmann	Mark Patzkowsky	CHANGES IN POLEWARD OCEAN HEAT TRANSPORT IN RESPONSE TO CHANGES IN SEA LEVEL, CONTINENTAL DRIFT, AND ATMOSPHERIC PCO_2 DURING THE LATE ORDOVICIAN
10:00	David Reusch	Richard Alley	A NEW MULTISITE AWS TEMPERATURE AND PRESSURE RECORD FOR WEST ANTARCTICA
10:15	Zach Krug	Mark Patzkowsky	THE LATE ORDOVICIAN MASS EXTINCTION AND EARLY SILURIAN RECOVERY: COMPARISON BETWEEN LAURENTIAN AND GLOBAL DIVERSITY
10:30	Break		
10:45	En-Chao Yeh	Donal Fisher	STRUCTURAL EVOLUTION OF EASTERN CENTRAL RANGE, TAIWAN
11:00	Juliette Florentin	Andrew Nyblade	UPPER MANTLE SEISMIC VELOCITY STRUCTURE BENEATH THE TANZANIAN CRATON, EAST AFRICA
11:15	Paul Winberry	Sridhar Anandakrishnan	RESULTS OF A SEISMIC DEPLOYMENT IN WEST ANTARCTICA: ICE SHEET EFFECTS ON HIGH RESOLUTION IMAGING
11:30	Margaret Benoit	Andrew Nyblade	UPPER MANTLE AND TRANSITION ZONE STRUCTURE BENEATH SAUDI ARABIA

CHANGES IN POLEWARD OCEAN HEAT TRANSPORT IN RESPONSE TO CHANGES IN SEA LEVEL, CONTINENTAL DRIFT, AND ATMOSPHERIC PCO_2 DURING THE LATE ORDOVICIAN

Achim D. Herrmann
Advisor: Mark Patzkowsky

We performed sensitivity experiments with the global ocean general circulation model MOM on two stages of the Late Ordovician (Caradocian, ~454 Ma; Ashgillian, ~446 Ma) under a range of atmospheric pCO_2 values (8-18x PAL; pre-industrial atmospheric level) and high and low sea level in order to determine the importance of these variables on poleward ocean heat transport. In all simulations, a drop in sea level led to a reduction in poleward ocean heat transport. This indicates a possible positive feedback that could have led to enhanced global cooling in response to pre-glaciation sea level drop during the Late Ordovician. While a decrease in atmospheric pCO_2 leads to an increase in poleward ocean heat transport in the Caradocian, there is no change in poleward ocean heat transport between 15x and 8x PAL in the Ashgillian. A decrease in atmospheric pCO_2 levels would therefore not have led to a positive feedback favoring glaciation in the Latest Ordovician. For all simulations with pCO_2 values above 10x PAL and with a high sea level (the pre-glaciation condition), the Ashgillian paleogeography yields higher poleward ocean heat transport. Therefore, at pCO_2 values above 10x PAL paleogeographic evolution alone would probably not have favored breaching a threshold for glaciation in the Late Ordovician. However, at atmospheric pCO_2 levels of 8x PAL the Ashgillian paleogeography leads to a lower poleward ocean heat transport than in the Caradocian. Continental drift could explain the observed global cooling trend in the Late Ordovician through a combined poleward ocean heat transport feedback and increased ice-albedo effect if atmospheric pCO_2 was low during the entire Late Ordovician.

A NEW MULTISITE AWS TEMPERATURE AND PRESSURE RECORD FOR WEST ANTARCTICA

David B. Reusch
Advisor: Richard Alley

Improved interpretation of the ever growing body of ice-core-based paleoclimate records from Antarctica requires a deeper understanding of Antarctic meteorology. New field campaigns and improved numerical forecasting models will ultimately provide long-term benefits but neither addresses the existing observational archive. In contrast, our work with automatic weather station (AWS) data addresses this issue directly. AWS currently provide the only year-round, continuous 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 and/or incomplete due to the vagaries of the harsh environment and station relocations. This reduces their usefulness for climatological studies. Building on climate downscaling results in temperate latitudes we have used GCM-scale meteorological data sets (e.g., ECMWF reanalysis products) to both fill the gaps in AWS records and extend them back in time to create a uniform and complete database of West Antarctic surface meteorology at selected AWS. Such records are highly relevant to the improved interpretation of the expanding library of snow-pit and ice-core data sets.

Our solution uses artificial neural network (ANN) techniques to predict the near-surface meteorology recorded by AWS instruments (e.g., temperature) using large-scale features of the atmosphere (e.g., 500 mb geopotential height) from a region around the AWS. ANNs are trained to predict observed AWS data from the corresponding GCM-scale data. Intrayear prediction (of observations in the training year) has been very successful (e.g., RMS errors < 2 mbar). Interyear prediction (of observations not in the training year) are acceptable but open to improvement from further refinements in methodology.

Our methodology has thus far been applied to five AWS on a transect spanning West Antarctica from the Ross Island area (Ferrell) to the Bellingshausen Sea region (Siple Station) for the period 1979-1993. Empirical orthogonal function (EOF) analysis of the 15-year temperature records suggests significant (though as yet uninterpreted) differences between the easterly/ice-sheet (Siple Station and Byrd) and westerly/ice-shelf (Lettau, Marilyn, Ferrell) stations. Short-term trends in annual high and low temperatures are also present.

These results support high confidence in the ANN-based predictions from ECMWF data for periods where AWS data are unavailable, e.g., before installation. ANNs thus provide a means to expand our surface meteorological records significantly in West Antarctica.

THE LATE ORDOVICIAN MASS EXTINCTION AND EARLY SILURIAN RECOVERY: COMPARISON BETWEEN LAURENTIAN AND GLOBAL DIVERSITY

A.Z. Krug
Advisor: Mark Patzkowsky

The evolution of complex life on Earth or any habitable planet may be closely tied to the number and severity of mass extinction events. In order to understand better the relationship between mass extinction and evolution, we began an analysis of the Late Ordovician mass extinction and early Silurian recovery. Because regional studies of extinction, survival, and recovery are vital in understanding diversity dynamics during mass extinctions, we examined diversity in Laurentia and compared it to global diversity. Our data consist of macrofaunal community lists compiled from the literature spanning the Late Ordovician and Early Silurian (Caradoc through Wenlock). Genera from 5 classes (articulate and inarticulate brachiopods, trilobites, anthozoa, and bivalves) were considered in this analysis.

Overall, raw diversity patterns in Laurentia are remarkably similar to the global patterns. Diversity is high in the Caradoc and reaches a peak in the Ashgill before dropping precipitously in the Early Llandovery (Rhuddanian). Diversity then slowly rises to reach pre-extinction levels in the Wenlock. However, the proportional drop in diversity in Laurentia is lower than the global pattern. In Laurentia, although 60% of genera to go extinct, total diversity is only reduced by about 25%. Globally, a 70% generic extinction results in a 50% reduction in diversity, far larger than in Laurentia. Importantly, all major groups considered here rebounded after the extinction, a pattern which stands in contrast to other mass extinction events. Rarefaction analysis of genus occurrences per time interval in Laurentia produced a different diversity curve than the raw data. The standardized diversity curve is flat from the Late Ordovician into the Early Silurian, drops slightly in the Middle Llandovery (Aeronian), and then rebounds to earlier levels. This analysis suggests that the rebound in diversity from the Late Ordovician mass extinction may have occurred as early as the Rhuddanian, around ten million years earlier than suggested by the raw data.

STRUCTURAL EVOLUTION OF EASTERN CENTRAL RANGE, TAIWAN

En-Chao Yeh
Advisor: Donald Fisher

Analyses of structure, and incremental strain histories in the eastern Central Range of Taiwan provide insights into the kinematics within the metamorphic core of the Taiwan arc-continent collision. The results of these analyses are consistent with a three-dimensional displacement field that is fixed relative to the geometry of a thin-skinned double-sided wedge. The obliquity between the Luzon arc and the Asian passive margin results in a collision that propagates southward through time, and this time-space equivalence allows north to south variations in structural history to be evaluated in the context of mountain belt evolution. There are three general structural events in the eastern Central Range of Taiwan. D1 involves west-vergent folding and development of a slaty cleavage/schistosity with growth of fibrous overgrowths and ellipsoidal chlorite-mica aggregates. D2 is represented by east-vergent folds that deform the earlier fabrics. D3 is composed of subhorizontal crenulation cleavages associated with meter-scale recumbent folds and normal faults that crosscut all the earlier fabrics. The regional stretching lineation (L1) is consistently orogen-parallel and is also parallel to the F1and F2 fold axes.

Strain analyses indicate 270 to 880 % of extension parallel to the mountain belt during D1. D1 strain histories, after restoring the rotations associated with D2 east-vergent folding, depict west-vergent thrusting followed by left-lateral shearing. Examples of right lateral shear are due to complete overturning of earlier foliations during D2 east-vergent folding. This temporal variation in extension direction and shear direction from down-dip to along-strike is similar to the observed west-to-east variation in the orientation of the D1 stretching lineation across the Central Range. This observation, coupled with the reversal in vergence of structures from west-vergent during D1 to east-vergent during D2, indicates that the rocks of the Asian passive margin have advected from west to east relative to a displacement field that is fixed relative to the mountain belt topography. Strain histories for the D1 event are consistent along the eastern Central Range indicating that all the rock has moved through this same displacement field. The left lateral shear is consistent with strain partitioning, with the margin-parallel component of the relative plate motion vector accommodated in the eastern portion of the ductile core of the mountain belt.

UPPER MANTLE SEISMIC VELOCITY STRUCTURE BENEATH THE TANZANIAN CRATON, EAST AFRICA

Juliette Florentin
Advisor : Andrew Nyblade

The Lake Tanganyika earthquake of October 2nd, 2000, was recorded by a network of seismic stations in Ethiopia, which provided new data for the study of the Archean Tanzanian Craton, East Africa. The possible existence of a low velocity zone beneath the Craton, starting at a depth of 150 km, is investigated using synthetic seismograms computed through a wavenumber integration code. Matching them to the ones recorded in Ethiopia on October 2nd, 2000, helps in imaging the velocity structure of the area. A low velocity zone would be a key factor in explaining the uplift of the East African Plateau.

RESULTS OF A SEISMIC DEPLOYMENT IN WEST ANTARCTICA: ICE SHEET EFFECTS ON HIGH RESOLUTION IMAGING

Paul Winberry
Advisor: Sridhar Anandakrishnan

We report on the results of a broadband seismic deployment in West Antarctica. The velocity structure of the cryosphere imposes special difficulties in analysis of the data. The large acoustic impedance contrast at the base of the ice and the near-surface velocity gradient due to firn densification both contribute significant ice-sheet generated signals that can mask information about crustal properties. We have developed techniques for deconvolving the ice sheet effects; techniques that are aided by ice-thickness measurements obtained separately (e.g., ice penetrating radar or active seismic measurements). From these data we can determine some of the properties of the subglacial environment at relatively high resolution; we report on the variation in subglacial sedimentary basins across the West Antarctic. These structures have been hypothesized as key controls on the flow of the ice sheet.

UPPER MANTLE AND TRANSITION ZONE STRUCTURE BENEATH SAUDI ARABIA

Margaret Benoit
Advisor: Andrew Nyblade

In this study we investigate upper mantle structure under western Saudi Arabia using broadband teleseismic data recorded by the Saudi Arabia PASSCAL experiment. From previous studies, there is evidence for anomalously slow seismic velocities in the upper mantle beneath regions of Cenozoic volcanism and uplift in western Saudi Arabia along the Red Sea. However, the shape of the low velocity structure in the upper mantle is uncertain, thus making it difficult to evaluate models for the origin of the volcanism and uplift.

Using 170 teleseismic events, we present new images of upper mantle structure obtained by inverting P wave travel time residuals using Vandecar's body wave tomography code and by stacking receiver functions to reveal topography on the 410 and 660 km discontinuities. Preliminary tomography results suggest a northeast to southwest velocity gradient of about 2% with lower than average wave speeds under the volcanic regions and higher than average wave speeds under the rest of the Arabian shield. P wave travel time residuals support these findings, revealing slower than average arrivals near the volcanic areas, and faster than average arrival times on the Arabian shield. The receiver function study shows a thicker than average transition zone beneath the whole of the research area, showing that the low velocity structure probably does not extend through the transition zone. These findings, if supported by further analyses of the data, would imply that the upper mantle thermal anomaly might not extend regionally throughout the uplifted portion of the western Saudi Arabian shield.

ORAL PRESENTATION SCHEDULE - GEOCHEMISTRY II

Time	Presenter	Advisor	Poster Title
1:30	Heather Buss	Susan Brantley	BIOGEOCHEMICAL PROCESSES OF COPPER ISOTOPE FRACTIONATION: PRELIMINARY WORK AND FUTURE RESEARCH DIRECTIONS
1:45	James Moran	Katherine Freeman, Chris House	A STABLE ISOTOPE TEST FOR ANAEROBIC METHANE OXIDATION IN PURE ARCHAEAL CULTURES
2:00	Christina Lopano	Peter Heaney	TIME-RESOLVED STRUCTURAL ANALYSIS OF HEAVY METAL CATION EXCHANGE REACTION IN MANGANESE OXIDES
2:15	Kelly Knight	Tanya Furman	TERTIARY CHEMICAL STRUCTURE OF THE AFAR PLUM: EVIDENCE FROM PRIMITIVE MAFIC LAVAS FROM TURKANA, N. KENYA

BIOGEOCHEMICAL PROCESSES OF COPPER ISOTOPE FRACTIONATION: PRELIMINARY WORK AND FUTURE RESEARCH DIRECTIONS

Heather Buss
Advisor: Susan Brantley

Trace metal isotopic ratios in earth materials are affected by microbial biogeochemical cycling and these isotopic signatures may be documented in natural systems. Isotopic fractionation of metals by bacteria is of interest for studying biological activity in ancient sediments (biosignatures) and in analysis of biogeochemical cycles. Copper is of particular interest because it is both essential for life and highly toxic and Cu enzymes play major roles in both photosynthesis and respiration. Relationships between Cu and biology are also of geologic and economic importance (e.g., bioleaching of Cu from low-grade ores). Very little is known about the natural isotopic variability of Cu although recent studies indicate that isotopic fractionation results from secondary processes (e.g., supergene enrichment of ore minerals, chemical weathering, biomineralization) rather than source heterogeneities.

Two experiments have also suggested fractionation of Cu isotopes by bacteria. Ruiz *et al*. (2001) analyzed Cu-rich solutions eluted from columns containing Cu-porphyry ores inoculated with *Thiobacillus ferrooxidans* and *Leptospirrilum ferrooxidans*. The $d_{65}Cu$ of the eluted solutions changed from 5.0 to 0.9 ‰ over 60 days, an effect not observed in un-inoculated columns. Preliminary experiments in our laboratory revealed isotopically heavier Cu ($d_{65}Cu$ = 0.22, 0.21, 0.17 ‰) in cell pellets of *Bacillus* sp. after incubation with an Fe-silicate glass than in abiotic solutions incubated with the glass ($d_{65}Cu$ = 0.03, -0.25 ‰). Our current research involves investigating matrix interferences and purification of Cu from samples for Cu isotope measurement by multicollector inductively-coupled plasma mass-spectrometry (MC-ICP-MS). We also plan to conduct an interlaboratory calibration of MC-ICP-MS Cu isotope measurements by analyzing identical samples at laboratories in Tuscon, AZ and Lyons, France.

Future research directions include further laboratory experimentation as well as field investigations to help elucidate the biogeochemical mechanisms of Cu fractionation processes in natural systems. A thorough understanding of these mechanisms is necessary to enable the use of metal isotope systems as biosignatures or (bio)geochemical tracers.

A STABLE ISOTOPE TEST FOR ANAEROBIC METHANE OXIDATION IN PURE ARCHAEAL CULTURES

James Moran
Advisors: Katherine Freeman Chris House

Understanding the major sources and sinks controlling atmospheric methane levels is important for estimating past and future concentrations of this potent greenhouse gas. Stable isotope and lipid-based studies propose a net anaerobic methane oxidation pathway. Stable isotope and molecular evidence indicate an Archaean with close phylogenetic relationship to modern methanogens is the catalyst for this pathway.

While there is significant evidence of its existence, the Archaean catalyzing anaerobic methane oxidation has not been isolated. Here we are examining Archaeal species closely related to the proposed anaerobic methane oxidizer. We seek to determine whether any of these organisms can, to even a small extent, reverse their biochemical machinery to anaerobically consume methane like their closely related, but thus far not isolated, counterpart. Until this organism is isolated, analyzing Archaean species capable of even trace amounts of methane oxidation may aid in understanding the chemical reactions and enzymology used for the anaerobic oxidation pathway.

We are using $_{13}C$ labeled methane to test for methane oxidation in anaerobic, pure Archaeal cultures. Analysis of the $d_{13}C$ of CO_2 in the bottles before and after incubation with the labeled methane will indicate the extent of methane to carbon dioxide conversion in each culture. Initial results show that a number of species oxidize minimal or no methane. One species (*Methanosarcina acetivorans*), however, produces a strong oxidation signal, suggesting it can actively oxidize small amounts of methane.

TIME-RESOLVED STRUCTURAL ANALYSIS OF HEAVY METAL CATION EXCHANGE REACTIONS IN MANGANESE OXIDES

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Manganese oxides offer some of our most promising resources for the natural andartificial removal of metal toxins in polluted waters. Fine grain sizes provide enhanced access to cation exchange sites, and isomorphic substitutions promise greater longevity than sorption for cation storage. Mn oxides swap cations in and out of their interlayer and intertunnel regions rather than their octahedral sites. The rates of exchange are rapid and are strongly dependent on the hydration state of the mineral. As part of my masters research, I will focus on the correlation between hydration and cation exchange. Specifically, I am investigating the process by which dissolved cationic metals substitute into layers and channels of minerals using high-resolution synchrotron X-ray structural analysis in real time. I am trying to resolve the following questions:

1. How do the mechanisms of cation exchange vary with the hydration state of Mn oxides?
2. Does cation exchange in Mn oxides occur over ordered or disordered sites within the interlayer?
3. What is the structural path by which Mg-birnessite (a layered Mn oxide) transforms to todorokite, which has a tunnel-like structure?

Recently I took advantage of the very rapid data collection capabilities of beamline X7B at the Brookhaven National Lab in order to monitor cation-exchange reactions for birnessite, using a simple flow-through cell that allowed me to gauge cation exchange in real time. A series of synthetic Na-birnessite samples were saturated with solutions containing dissolved K^+, Mg^{2+}, and Ba^{2+}, and changes in the buserite/birnessite structures as the reactions proceed were monitored by Synchrotron X-ray diffraction. Lab experiments indicate that the exchange reactions are extremely rapid and generally achieve completion in less than two hours. These experiments will determine whether cations exchange over the same sites that are occupied by the Na^+ cations and whether Na replacement is random or follows a pattern that generates metastable intermediate compositions. The experiments reveal that significant structural changes occur with cation exchange. Further Rietveld refinement of the data will reveal the full extent of cation exchange.

TERTIARY CHEMICAL STRUCTURE OF THE AFAR PLUME: EVIDENCE FROM PRIMITIVE MAFIC LAVAS FROM TURKANA, N. KENYA

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The East African Rift System is an ideal location for investigating the link between tectonism and magmatism during rift evolution. Geochemical studies in this region provide insight into plume-driven rift processes, including documenting the chemical structure of the sublithospheric mantle. The structure and chemistry of the Oligocene Afar plume were categorized by Pik *et a*l. (1999) and Marty *et al*. (1996) in Ethiopian flood basalts of the northern rift. Plume influences have also been noted in Quaternary samples of the Afar/Red Sea region (Barrat *et al*. 1993) as well as at Turkana, N. Kenya (Furman *et al*., 2001).

We use new data on primitive (6-28 wt. % MgO) mafic lavas of Tertiary age from Turkana to investigate possible temporal and spatial evolution of the sub-lithospheric source region(s) beneath the East African Rift. Preliminary data suggest a plume influence in the source region for Tertiary Turkana mafic lavas. For example, most primitive lavas have La/Nb greater than 0.6 and Ba/Nb values between 3 and 20. Furthermore, Zr/Nb ratios from the Turkana suite demonstrate that incompatible trace element signatures in this area are spatially controlled; Zr/Nb values in central Turkana mafic lavas (about 5.5) are significantly higher than those observed 40 km to the south (around 2.5). La/Nb ratios also show spatial control, with values in the north ranging from 0.75-0.85 and those in the south ranging 0.45-0.7. These data imply consistent, latitudinal spatial heterogeneity in the Turkana source area.

U/Th ratios of the Turkana Tertiary suite overlap mafic Turkana Quaternary samples, suggesting a common, sub-lithospheric source component. Geochemical differences between Turkana and Ethiopian HT2 flood basalts (Pik *et al*. 1999) in the Tertiary may reflect the chemical structure of the Afar plume, or may imply a more complex scenario of melt segregation and transport within the lithosphere. The geochemical and isotopic data from Turkana basalts are thus an important part of a comprehensive interpretation of the dynamic East African Rift System and will enable us to constrain temporal and spatial chemical structures of the Afar plume.