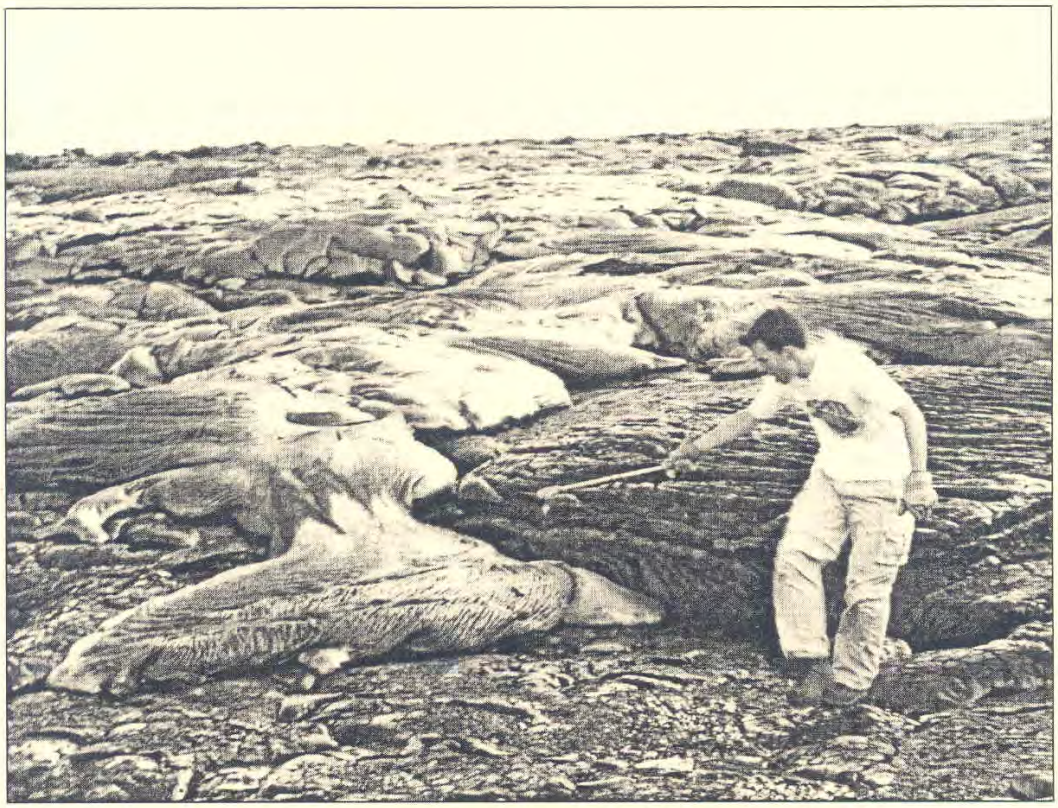
36th Annual Graduate Student Colloquium



sponsored by the
Department of Geosciences
19-23 April 2004

Photo Contest Winners:

Front cover photo submitted by Roeland Doust
“Collecting fresh lava samples for geochemical analysis from the Pu’u’O’o crater on Hawaii”

Back cover photo submitted by Tyrone Rooney
“Roeland trying to hammer in Butijera”

36th Annual Graduate Student Colloquium

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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 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 meeting for high quality talks and posters with visual appeal.

Talks are a maximum of 12 minutes with an additional 3 minutes for questions. Talks will begin Wednesday afternoon and continue all-day Thursday in the fifth floor conference room. Posters will be hung in the 3rd and 4th floor hallways of Deike building.

The Committee wishes to thank the students for sharing their work and their faculty advisors for giving constructive advice.

The Committee also wishes to thank the Shell People Services division of Shell Oil Company and the Department of Geosciences for their generous financial support. The Shell Corporation has generously donated prize money to establish the following awards this year:

1) Best paper on a petroleum related topic
2) Best paper for a post-comps student on a geosciences related topic
3) Best paper for a pre-comps student on a geosciences related topic
4) Best paper for a masters student on a geosciences related topic

Colloquium Schedule

Oral Sessions

All oral session will be held in Deike 541.

Oral Session I 1:00-3:00 pm Wednesday, April 21

Oral Session II 9:00-11:00 am Thursday, April 22

Oral Session III 1:00-3:15 pm Thursday, April 22

Poster Session

Judging 12:30-1:30 pm Friday, April 23

Posters will be on display on the third floor of Deike Building during colloquium week.

Oral Presentation Schedule -- Wednesday Afternoon, April 21

Time	Presenter	Advisor	Title
1:00	Chekwube Enunwa	Peter Flemings	Seismic Interpretation of a Ponded Turbidite System in the Deepwater Gulf of Mexico
1:15	Gavin Hayes	Kevin Furlong	The Development of Shear Zones in the Crust of the Northern California Coast Ranges as Determined by Regional Strain Models
1:30	James Bonelli	Mark Patzkowsky	Testing for Faunal Stability Among Recurring Biofacies: Quantifying Stasis Across a Regional Biotic Transition in the Middle Devonian Appalachian Basin
1:45	Leo Peters	Sridhar Anandakrishnan	Subglacial Sediments Beneath a West Antarctic Ice Stream and Their Influence on Streaming Ice Flow
2:00	Kideok Kwon	James Kubicki	Searching for the Origin of Life Using Molecular Modeling: Why Left-Handed Amino Acids and Not Right-Handed Amino Acids?
2:15	Lev Horodyskyj	Lee Kump	Horseshoe Crab and Eurypterid Dietary Analysis Using Stable Carbon Isotopes
2:30	Satyakee Sen	Sridhar Anandakrishnan	Wave Equation Tomography Beyond the Born Approximation
2:45	Amy Whitaker	Terry Engelder	Using Joint Population Distributions to Indicate Stress Field Stability During Fracturing

SEISMIC INTERPRETATION OF A PONDED TURBIDITE SYSTEM IN THE DEEPWATER GULF OF MEXICO

Chekwube Enunwa
Advisor: Peter Flemings
MS Student

High frequency 2-D seismic data across East Breaks, northwestern Gulf of Mexico are used to image a submarine fan deposited within a ponded turbidite system. This intraslope basin is located at approximately 1450m water depth with a maximum width and sediment thickness of about 25km and 285km respectively. Sediment infill into the basin is composed of two distinct packages, separated by a zone of transparency. This region of very low reflectivity is a result of lack of internal impedance contrast and suggests highly uniform lithology. In the upper package, the fan is thickest to the north (~270m) and it thins to the south. To the north, the seismic signature is chaotic, whereas to the south parallel reflectors are present. This chaotic facies is wedge shaped and initially progrades over the parallel facies to the south, and then retrogrades in the north direction.

I interpret the chaotic facies to be deposited close to the source of the fan were perhaps sand content is greater or there are multiple channels. The parallel laminated facies is deposited toward the distal part of the fan where sand is not as abundant or there is no channeling. The zone of thickening supports the fact that the source of sediment inflow to this basin is from the north. The chaotic seismic character of the facies might indicate the presence of sand bodies with discontinuous geometries that is characteristic of infilling of submarine channel cut into paleoslopes. It may also suggest high velocity of deposition in this region due to its proximity to the sediment source.

THE DEVELOPMENT OF SHEAR ZONES IN THE CRUST OF THE NORTHERN CALIFORNIA COAST RANGES AS DETERMINED BY REGIONAL STRAIN MODELS

Gavin Hayes
Advisor: Kevin Furlong
PhD Student, Pre-Comps

The Coast Ranges of California have formed with the passage of the Mendocino triple junction through Northern California over the past 20 million years. Understanding the crustal structure in terms of thickness and seismic velocity structure is key in determining the way in which processes driven by the passage of this triple junction have influenced crustal evolution of this area. We have combined crustal structure models from the seismological receiver functions generated at a suite of broadband stations in the region with 3D tomography to develop a model of the crustal architecture over the entire Coast Ranges. The resulting crustal model is used to construct shear strain models of the North American crust.

Analyzing these results in combination with predictions from the Mendocino Crustal Conveyor model has allowed us to develop a 3D model of present-day crustal strain in the Coast Ranges. Results identify a crust with three main interfaces: a shallow layer of approximately 12km thickness that does not vary significantly across the model, and mid- and deep-crustal layers that accommodate the thickening and thinning associated with the passage of the triple junction. The models can also be used to produce differential strain rates and velocity maps that delineate where shear zones develop within the crust. Initial results identify vertical shear zones in the same locations as the Rodgers Creek and Ma'acama Faults, as well as several horizontal shear zones interpreted as mid-crustal detachments. In the west, these detachments may link the San Andreas Fault system to the Hayward Fault system, while in the east this decoupling separates the shallow crust from the deeper crust, explaining the lack of thickness variation in the upper-crustal layer.

TESTING FOR FAUNAL STABILITY AMONG RECURRING BIOFACIES: QUANTIFYING STASIS ACROSS A REGIONAL BIOTIC TRANSITION IN THE MIDDLE DEVONIAN APPALACHIAN BASIN

James Bonelli Jr.
Advisor: Mark Patzkowsky
PhD Studnent, Pre-Comps

One of the major questions addressed by evolutional paleoecologists remains unresolved: Do regional assemblages of species tend to persist temporally as cohesive, tightly-knit units, or are they more loosely-structured, varying continually with habitat fluctuation? A decade ago, qualitative observations suggested that recurring coral-rich biofacies remained ecologically unchanged through the seven million year duration of the middle Devonian Hamilton Group in the Appalachian Basin. These findings led some researchers to propose that species association were rigid and maintained by strong biotic interactions. However, because the spatio-temporal consistency of the Hamilton coral-rich faunas has not been examined quantitatively, the extent to which they remain stable, and the mechanism(s) responsible for their alleged persistence remain contentious.

In this study, a recurring coral-rich fauna was sampled from two beds within the Hamilton Group and overlying Tully Formation of the Appalachian Basin. Species abundance data were collected and compared quantitatively to examine variability at multiple spatial scales within each bed. These data prove a baseline against which to evaluate variation seen through time. If the faunal variation exhibited among beds were no greater than that shown within each time horizon, than the hypothesis of strong biotic interactions would not be rejected.

Despite being separated by an intervening period of biotic transition, species membership changed little among the recurring biofacies. Importantly however, statistically significant variability was detected in community structure; the rank ordering of numerically dominant species changed drastically through time. These findings suggest that recurring assemblages are not composted of highly interdependent species that track habitats as coherent entities. Rather, they appear to consist of species that tolerate the specific physical conditions of the moment and respond individually to environmental fluctuation by altering both their abundance and geographic distributions through time.

SUBGLACIAL SEDIMENTS BENEATH A WEST ANTARCTIC ICE STREAM AND THEIR INFLUENCE ON STREAMING ICE FLOW

Leo Peters
Advisor: Sridhar Anandakrishnan
MS Student

A series of seismic reflection and refraction experiments were performed along Kamb and Bindschadler Ice Streams during the 2002-2003 Antarctic field season to image the subglacial geology beneath these ice streams and interpret its significance in the dynamics of the West Antarctic Ice Sheet. Subglacial sediments are hypothesized to play an important role in initiating and maintaining streaming ice flow in West Antarctic, but the properties and extent of this sediment cover are not well known. I present the results of two seismic reflection and refraction experiments performed along the upstream reaches of Bindschadler Ice Stream and interpret the role of subglacial geology in maintaining streaming ice flow along the Siple Coast of West Antarctica.

Seismic imaging of Bindschadler Ice Stream has revealed a thick, layered sedimentary basin extending across the width of the ice stream. These sediments form four distinct layers with compression wave seismic velocities increasing from V_p=1580m/s to V_p=4870m/s, as the sediments become more consolidated with depth in the basin. The uppermost layer consists of a meters-thick unit with V_p=1580±50m/s, that is consistent with a highly porous till-water system. Such a till has been interpreted to act as a lubricant in enhancing ice flow. These results suggest that subglacial sediment cover and the presence of a deformable till are important factors in ice drainage along the Siple Coast of West Antarctica.

SEARCHING THE ORIGIN OF LIFE USING MOLECULAR MODELING: WHY LEFT-HANDED AMINO ACIDS AND NOT RIGHT-HANDED AMINO ACIDS?

Kideok Kwan
Advisor: James Kubicki
PhD Student, Pre-Comps

Biological systems are composed of excessive homochiral molecules such as L-amino acids in proteins. The homochirality has been studied because the origin of homochirality can fill a gap missing in the evolution of life. We know that a simple combination of gases can synthesize organic molecules under UV radiation, and Life has experienced evolution so far. However, the connection from simple organic molecules to the appearance of living organisms is not certain. That is, we don't know how prebiotic compounds assembled into the first living organisms. One key to the origin of life can be elucidated by determining the origin of homochirality.

Recently, a geochemically plausible scenario on the origin of homochirality was proposed (Hazen *et al*., 2001 P NATL ACAS SCI USA) based on adsorption experiments. The scenario proposed that calcite generated homochirality of amino acids by selective adsorption billions of years ago because D- and L-aspartic aids adsorb selectively on calcite surfaces ((21-31) and (3-1-21)). However, the selective adsorption is still a phenomenological observation lacking a theoretical basis.

In this study, molecular modeling was applied to the answer the question "why do D- and L-aspartic acids selectively adsorb to calcite surfaces?" The adsorption was simulated using molecular dynamics (MD) and quantum chemical computation with the hypothesis that the selective adsorption occurs because of differences in adsorption energies and their structures. MD simulations predicted similar results to the adsorption experiments in terms of adsorption energy differences. Detailed structure differences causing the energy differences are currently studied using quantum chemical computations. This research will provide the theoretical basis on the selective adsorption of amino aids, thus contribute to understanding the origin of life.

HORSESHOE CRAB AND EURYPTERID DIETARY ANALYSIS USING STABLE CARBON ISOTOPES

Lev Horodyskyj
Advisor: Lee Kump
PhD Student, Pre-Comps

The horseshoe crab *Limulus polyphemus*, found along the eastern coast of North America from Maine down to the Yucatan, is a chelicerate that is closely related to the extinct sea scorpion know as the eurypterid, which thrived from the Ordovician until the terminal Permian. Horseshoe crabs and eurypterids both inhabited marine environments, and some species of eurypterids shared similar feeding behaviors with horseshoe crabs (predation on epifaunal and infaunal invertebrates). A study of the stable carbon isotopes present in fragments of dead horseshoe crabs found on the coasts of Delaware and Maryland was conducted in order to determine if horseshoe crabs can serve as a modern analog for the extinct eurypterid. Horseshoe crab carapace $\delta^{13}C$ vales were -17.45±0.55‰, which falls within the range for most marine arthropods. Eurypterid cuticle fragments were typically between -25‰ to 27‰. The ~10‰ difference between modern horseshoe crabs and extinct eurypterids is unlikely to have been caused by diagenesis. A more likely explanation is that the source of horseshoe crab and eurypterid dietary carbon is significantly different, perhaps as a result of differences in dietary preferences or primary productivity. This study provides an additional method to comparative morphology for studying organism paleoecology.

WAVE EQUATION TOMOGRAPHY BEYOND THE BORN APPROXIMATION

Satyakee Sen
Advisor: Sridhar Anandakrishnan
MS Student

The key parameter that the exploration geophysicist needs to form an accurate image of the subsurface is the medium velocity, On an active oil field seismic imaging helps target oil wells, monitor fluid flow (Lumley, 1995), provides the rock physicist with reservoir properties and aids reservoir engineers to constrain their simulations (Mao, 1999). Without an accurate velocity model of the subsurface exploration and production activities are hindered at every stage. In this paper I formulate a method based on using the entire seismic coda or the full wavefield for accurate estimation of the subsurface velocity. Since this tomography method is not limited by the high frequency approximations involved in ray theory, it is much more robust in estimating the singularities or the anomalies in the velocity model especially in region of complex geology (overthrusting geology, edges of salt bodies, fault interfaces).

I first show how Prestack Cascaded Stolt migration (PrCSM) is fromuatled in the *f-k* (frequency-wavenumber) domain as a function of a non-dimensional parameter (γ), which is the ratio of the incorrect velocity and the true medium velocity. PrCSM can then be used to improve the focusing of images obtained with an initial incorrect velocity model by applying a series of fast transformations to the initial incorrect image. This sequence of transformations ultimately converge to the correct image as long as the product of the γ values used at each stage equals the ratio of the initial migration velocity and the true medium velocity. I then show how wave equation tomography (WEMVA) can be formulated to estimate large slowness anomalies by using the concept of cascaded image perturbations without violating the Born approximation. WEMVA is based on linearization of the wavefield using the Born approximation which allows image perturbations to be related to the corresponding slowness perturbations. The Born approximation is essentially a “small phase perturbation” restriction imposed during this linearization procedure about a background velocity mode. The consequence of the Born limitation is that if the image perturbation is large, the inversion scheme diverges an becomes unstable. As a result we can estimate only a small amount of the actual slowness anomaly. I overcome this restriction by approaching the improved image, which is not within the Born limit of the initial image, via intermediate images which are all within the Born limit of each other. Since we approach the improved image in small steps we can ensure that the image perturbation at each cascade never violates the Born approximation. I show how two linear systems need to be solved at each cascade to estimate arbitrarily large slowness anomalies. However the improved performance of this method comes at the expense of a substantial increase in the computation cost. But even if we can afford to do only two cascades this method can still estimate much larger slowness anomalies than all other existing WEMVA methods.

USING JOINT POPULATION DISTRIBUTIONS TO INDICATE STRESS FIELD STABILITY DURING FRACTURING

Amy Whitaker
Advisor: Terry Engelder
PhD Student, Post-Comps

The poles to joints in a set formed in a homogeneous stress field, hosted by an isotropic material and measured with a perfectly precise compass would plot as a single point on a stereographic projection. For any real joint set, however, the poled to fractures plot in a region, with point concentration decreasing away form a mean orientation. The tightness, shape and orientation of the pole concentration area are a result of the interaction between stress field complexity and host rock properties at the time of jointing, as well as the compass's precision and accuracy. By comparing joint distribution from various tectonic settings using the eigenvalue ratio method of Woodcock (1977), this study determines the relative stability of the horizontal tectonic and vertical gravitational stress trajectories during the fracturing time interval.

The ratio between the eignevalues of the orientation tensor for joint sets, and therefore the population strength (ζ) and shape (γ), vary predictably be degrees of rock isotropy and stress homogeneity. The distribution shape factors for joint sets range from 1.75 to more than 20 and the strengths are consistently between 5 and 6.5. Joints that form in isotropic rocks under homogeneous stress have the highest distribution strengths, and relatively high shape factors. Joints sets that develop in heterogeneous stress conditions during folding have the highest distribution shape factors, but lower strength factors than can contribute to joint dip dispersion, also leading to a high γ, low ζ distribution. A low γ for the joint distribution indicates rotation of the horizontal stress during fracturing. The strength of rotation joint sets denote the relative frequency of fracturing during each increment of stress rotation. This is to say, high ζ indicates that jointing rate remained constant throughout the rotation while low ζ indicates a discontinuous jointing rate during stress rotation.

Joint distributions in horizontal beds, and especially in isotropic rocks, indicate that the vertical dimension of the fracture is better constrained than the strike dimension in both passive and active tectonic settings. This indicates that the stress trajectory due to overburden is more stable that the horizontal stress trajectories in both active and passive margins during periods of jointing. Additional bed rotation with respect to the vertical stress during folding or irregular mechanical boundaries is necessary to effect joint sets with dip dispersion comparable to strike dispersion.

Woodcock, N. H., 1977, Specification of fabric shapes using an eigenvalue method. *Geological Society of America Bulletin*, **v. 88**, p. 1231-1236.

Oral Presentation Schedule -- Thursday Morning, April 22

Time	Presenter	Advisor	Title
9:00	Shawn Goldman	James Kasting	H_2 Consumers and the Redox State of the Archean Ocean
9:15	Jocelyn Sessa	Mark Patzkowsky	Dynamics of Rapid, Asynchronous Biotic Turnover During the Middle Devonian Appalachian Basin of New York State
9:30	A. Zachary Krug	Mark Patzkowsky	Geographic Variability During the Late Ordovician Mass Extinction and Early Silurian Recovery
9:45	Margaret Benoit	Andrew Nyblade	Upper Mantle Seismic Velocity Structure Beneath Ethiopia
10:00	Jennifer Anthony	Chris Marone	Influence of Particle Characteristics and Surface Roughness on Friction in Granular Fault Gouge
10:15	Winchelle Sevilla	Charles Ammon	Earthquake Rupture Processes Along the Philippine Trench
10:30	Heather Savage	Chris Marone	The Effects of Dynamic Stress on Fault Strength and Stability
10:45	Redescal Uzcatequi	Terry Engelder	Tectonics at the Allegheny Front as Manifested by Jointing in Devonian Rocks

H_2 CONSUMERS AND THE REDOX STATE OF THE ARCHEAN OCEAN

Shawn Goldman
Advisor: James Kasting
PhD Student, Pre-Comps

The recent discovery of hematite in unweathered, 3.5 b.y.-old Archean sediments by H. Ohmoto and his NAI-sponsored drilling crew (2004) in Australia suggest to some that oxygenic photosynthesis evolved very early. The presence of this oxidized iron stands in apparent contrast to constraints on atmospheric O_2 prior to 2.3 Ga imposed by the presence of mass-independent sulfur isotope fractionation, which requires $pO_2<10^{-5}$ times present (Farquhar *et al.*, 2000; Pavlov & Kasting 2002). pO_2 might have been higher than this in the water column if cyanobacteria were present; however, we are led to look for alternative solutions.

We suggest that Fe-oxide stability was driven by consumption of reduced species instead of by production of O_2. Zinder (1993) has shown that some hydrogen consumers can draw pH_2 down to 10^{-8}atm. If bacteria were able to deep dissolved H_2 and O_2 in thermodynamic equilibrium, pH_2 values this low could have allowed hematite to be stable without any free O_2 being present. The ferric iron cold have been precipitated either by direct photo-oxidation of Fe^{++} or by phototrophic Fe-oxidizing bacteria. Hydrogen concentrations in the water column could have been suppressed by a combination of methanogens and Fe-reducing bacteria that used H_2 as the reductant. This could have lead to deep-water oxic condition in some localized basins. This type of oxygen profile would be consistent with the upside-down Archean biosphere proposed originally by Walker (1987).

This conceptual model has the potential to explain the oxidized Fe mineralogy that existed prior to the development of an oxygenated atmosphere, including the banded iron formations that are found throughout the Archean. In this talk we will present our conceptual model, we will show some geological evidence that supports it, and we will detail the future work we plan to do to evaluate it.

References

Ohmoto, H., Nedachi M., Kato Y., Bevaqua D., and Watanabe Y.. INTERANTIONAL JOURNAL OF ASTROBIOLOGY. **3**(S1): p13 MARCH 2004.

Farquhar, J., Bao, H. M., Thiemens, M. SCIENCE. **289** (5480): p756-758 AUG 4 2000.

Pavlov, A. A., Kasting, J. F. ASTROBIOLOGY. **2** (1): p27-41 SPR 2002.

Walker, J. C. G. NATURE. **329** (6141): p710-712 OCT 22 1987.

Zinder, S. H. Physiological ecology of methanogens. In Ferry, J. G. (ed.) Methanogenesis: Ecology, Physiology, Biochemistry, and Genetics. Chapman and Hall, New York (1993).

DYNAMICS OF RAPID, ASYNCHRONOUS BIOTIC TURNOVER DURING THE MIDDLE DEVONIAN APPALACHIAN BASIN OF NEW YORK STATE

Jocelyn Sessa
Advisor: Mark Patzkowsky
PhD Student, Pre-Comps

High resolution stratigraphic and paleoecologic analyses of faunal turnover can reveal much about the evolutionary and ecological processes that control species distributions. For example, several paleoecologic studies of the Appalachian Basin have documented a bimodal pattern of community stability and change, and this pattern has been interpreted to indicate the importance of ecological processes over environmental ones. Groups of species were found to persist as communities for millions of years, with little purported change in taxonomic composition and dominance. Blocks of stability are bounded by intervals of rapid faunal turnover, where preexisting assemblages disassociate and previously unseen taxa appear. These turnover intervals are generally assumed to occur synchronously; however this assumption has rarely been tested. Whether taxa respond to change as a cohesive unit or individually will provide a test for the degree of interconnectedness among communities, and thus evaluate the importance of ecological processes. This in turn will lead to increased awareness of how ecosystems function.

To better understand the nature and variation of regional biotic turnover, a detailed analysis was conducted on the faunal transition that occurs at the boundary of the Moscow and Tully formation in the Middle Devonian Appalachian Basin of New York State. This boundary is associated with basinwide changes in sedimentation and tectonics. A variety of environments from the upper MoscoW and lower Tully were sampled, and taxa were counted from closely spaced stratigraphic horizons. Taxonomic composition was found to be controlled by sedimentologic/environmental variables, as specific faunas are found in particular lithofacies. This is not to imply that specific taxa were restricted to one facies; rather, most of the studied taxa occurred in a surprisingly high number of samples and environments, but their abundance varied significantly. This variation points to low ecological interconnectedness within communities, and instead highlights the importance of environmental controls. Additionally, multivariate statistical analyses indicate an asynchronous, depth mediated replacement of Moscow biofacies by faunas common to the overlying Tully. Taxa are seen to appear and disappear from the rock record in accord with their preferred habitat, not in concert with one another.

A formerly unidentified, multifaceted turnover event is recognized at the Moscow –Tully boundary. These results suggest that detailed dissections of turnover boundaries may reveal subtle environmental controls and previously unrecognized paleoenvironmental gradients. Perhaps most striking is the complexity of faunas and habitats co-occurring in a stratigraphically brief interval of time. The faunal intricacy found at this boundary was unexpected at the outset of this project, and could have gone unnoticed if not for detailed sampling of stratigraphically complete outcrops. Perhaps turnovers in general are more complex than previously assumed.

GEOGRAPHIC VARIABILITY DURING THE LATE ORDOVICIAN MASS EXTINCTION AND EARLY SILURIAN RECOVERY

A. Zachary Krug
Advisor: Mark Patzkowsky
PhD Student, Pre-Comps

Mass extinction events have played am important role in the history of life on Earth. By removing a high proportion of taxa in a short period of time, they have the potential to redirect long-term evolutionary trends and create ecospace for previously minor groups to exploit. Recent works have shown that regional studies of extinction, survival, and recovery are vital in understanding both diversity dynamics during mass extinctions and their ecological and evolutionary consequences. Here, we compare diversity dynamics between the paleocontinents of Laurentia and Baltica spanning the Late Ordovician mass extinction and Early Silurian recovery (Caradoc through Wenlock). Our data consist of macrofaunal community lists compiled from the literature. Genera from five classes (articulate and inarticulate brachiopods, trilobites, anthozoa, and bivalves) were considered in this analysis. Standardization techniques were utilized to remove biases inherent in the compilation of diversity curves.

The standardized diversity curves for the two paleocontinents show marked differences. The Laurentian curve reaches a peak in diversity in the Upper Caradoc, remains high in the Ashgill, and then drops by around 14% in the Rhuddanian. Overall, 53% of genera go extinct in the Ashgill, and pre-extinction levels of diversity are not achieved until the Telychian. In Baltica, diversity increases rapidly through the Caradoc to a peak in the Ashgill, followed by a dramatic diversity drop into the Rhuddanian. Diversity is reduced by 63% in Baltica, and 71% of Baltic genera existing in the Ashgill go extinct. Diversity remains static in the Rhuddanian and Aeronian, begins increasing again in the Telychian, and achieves pre-extinction levels in the Wenlock.

When sample standardization is performed, the two curves diverge even further. In Laurentia, diversity remains flat or rises throughout the time period. The Baltic curve changes far less, with diversity still dropping 41% in the Rhuddanian, and remaining low through the Early Silurian.

These results indicate that both extinction and recovery dynamics vary regionally during the Late Ordovician mass extinction event and further illustrate the global complexity of mass extinction events and their recoveries.

UPPER MANTLE SEISMIC VELOCITY STRUCTURE BENEATH ETHIOPIA

Margaret Benoit
Advisor: Andrew Nyblade
PhD Student, Post-Comps

The origin of Cenozoic tectonism in East Africa remains enigmatic. Previous studies suggest that slow seismic velocities may extend through the upper mantle beneath this region, consistent with a lower mantle origin for the Cenozoic tectonism. To further understand the origin of the tectonism in East Africa, we analyze data collected from the 2000-2002 Ethiopia Broadband Seismic Experiment. We employ body wave tomography and receiver function analysis to examine the upper mantle seismic velocity structure to determine the depth and lateral extent of the thermal anomaly.

Results from our tomography study in Ethiopia reveal a shallow (<300 km) low velocity zone beneath the Main Ethiopian Rift and a deep low velocity region (>410 km) beneath the Afar triple junction. Our receiver function results suggest that the 410 km upper mantle olivine phase transformation is deeper beneath the Afar than beneath the rest of Ethiopia, thereby implying a hotter than average mantle at this depth. Hence, the findings from these two studies suggest evidence for a mantle plume beneath the Afar triple junction.

INFLUENCE OF PARTICLE CHARACTERISTICS AND SURFACE ROUGHNESS ON FRICTION IN GRANULAR FAULT GOUGE

Jennifer Anthony
Advisor: Chris Marone
MS Student

Particle characteristics (shape, size, and roughness) and surface roughness affect friction and the amount of shear localization that occurs within granular shear zones. In order to improve our understanding of grain-scale deformation mechanisms within fault gouge, we performed laboratory experiments using a double-direct-shear testing apparatus. This assembly includes three rigid forcing blocks with two gouge layers sandwiched between rough or smooth surfaces. Roughened surfaces had triangular grooved 0.8 mm deep and 1 mm wavelength machined perpendicular to the sliding direction. Grooves promote shear throughout the layer during cataclastic deformation. Smooth surfaces were mirror-finished hardened steel and were used to promote and isolate grain boundary sliding. Our experiments were conducted by controlling the displacement rate at which the center block was driven between the two side blocks to create frictional shear. We studied gouge layers 2 to 8 mm thick, consisting of smooth glass beads mixed with varying amounts of rough sand particles. We report on particle diameters that range from 0.050-0.590 mm. The experiments are run at room temperature, controlled relative humidity ranging from 5 to 60%, and shear displacement rates from 0.1 to 3000 microns per second. Experiments are carried out under a normal stress of 5 MPa or 10 MPa, a non-fracture loading regime where sliding friction for smooth spherical particles is measurably lower than for rough angular particles.

We compare results from shear between smooth boundaries, where we hypothesize that grain boundary sliding is the mechanism influencing granular friction, to rough sample experiments where shear undergoes a transition from distributed, pervasive shear to progressively localized shear as a function of increasing net strain. For both the rough and smooth surfaces, we find that the frictional strength increases as the fraction of angular grains within a layer increases.

For shear within rough surfaces, stick-slip instability occurs in layers that consists of less than 20% angular grains and begins once the coefficient of friction reaches a value of 0.35-0.40. Peak friction during stick-slip cycles is 0.40-0.45. Each stick-slip event involves a small amount of quasi-static creep prior to failure, which we refer to a pre-seismic slip. For unstable sliding regimes, we measure the amount of pre-seismic slip and the magnitude of dynamic stress drop. These parameters vary systematically with sliding velocity, particle characteristics, and bounding roughness. For shear within smooth surfaces, friction is very low (0.15-0.16 for spherical particles) and sliding is stable, without stick-slip instability.

EARTHQUAKE RUPTURE PROCESSES ALONG THE PHILIPPINE TRENCH

Winchelle Ian Sevilla
Advisor: Charles Ammon
MS Student

Subduction zones are the primary plate boundaries that release seismic energy. Earthquakes along these zones exhibit spatial and temporal variation in rupture processes. Variations in physical properties along the plate interface are critical in light of the occurrence of tsunami earthquakes, which are a 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.

In this work, I apply inverse-modeling to a classic deconvolution analysis in an effort to map the rupture processes of earthquakes in the Philippine Trench and to investigate the tsunami-earthquake potential of the trench. My analysis is a continuation of the studies of previous workers who estimated the depth-dependent rupture properties of earthquakes in several Circum-Pacific subduction zones. The most interesting conclusion of their work is that the moment-scaled duration of earthquakes seems to change for the shallowest sources, consistent with the idea that low-strength sediments present at the shallowest depths slow the rupture process. To determine if the earthquakes at the shallowest region of the Philippine Trench exhibit anomalously long rupture duration, plate interface earthquakes were selected from the Harvard CMT catalogue for the years 1990 to 2003. I gathered teleseismic broadband records of vertical component waveforms from IRIS data center and apply multi-station deconvolution technique to extract the source time function and depth of each event.

Results from the deconvolution method showed significant scatter on the plots of source rupture duration with depth, which reflect heterogeneity of the materials at the plate interface. Interplate earthquakes at the trench do not exhibit anomalously long rupture durations that are comparable with those of large tsunami earthquakes. The scale of low rigidity materials at the shallow region of the trench was probably not enough to render the rupture durations to be anomalously slow. This study was able to demonstrate that sediment-starved trenches like the Philippine Trench may not exhibit any systematic trend in the variations of rupture propagation. Although myriad factors affect the frictional properties of the plate interface, it seemed that the volume of sediments primarily dictate on how fast the rupture should propagate. As far as the available data are concerned, the Philippine Trench is least likely to experiences the occurrence of tsunami earthquakes.

THE EFFECTS OF DYNAMIC STRESS ON FAULT STRENGTH AND STABILITY

Heather Savage
Advisor: Chris Marone
PhD Student, Pre-Comps

Fault interaction can increase seismicity through the transfer of both static and transient stresses. Static stress transfer changes the fault boundary conditions, whereas transient stresses, such as seismic waves or earth tides, can change material response of the fault zone but do not permanently alter the stress state. Dynamic triggering in natural earthquake settings does not seem to depend on the magnitude of the trigger nor distance from the event, but rather might be a function of the oscillating stress. Understanding the subtleties of transient stress effects would enhance our knowledge of fault systems.

We analyze shear stress response of a laboratory fault to transient, periodic loading rate oscillations. Experiments were conducted using a servo-controlled, biaxial apparatus with a double direct shear configuration. The samples were loaded with shear displacement consisting of a linear function with a sinusoid superimposed to simulate an oscillating transient stress. Amplitude and frequency of the oscillation were varied, along with background shear displacement rate, to determine the dependency of the material response. The effects on stability are measured as systematic variations in stick-slip properties such as size of stress drop, recurrence interval and phase angle of failure with respect to the sinusoid. Preliminary results indicate that the correlation between the phase of the velocity oscillation the stick-slips depends on both amplitude and frequency. Higher amplitudes are needed to force events at low frequencies, however for frequencies higher than the inverse of pre-slip time, a constant amplitude threshold is required for stick-slip to correlate with oscillations. Forward models of the laboratory experiment using rate and state friction laws support the result that two modes of correlation exist, one with a velocity threshold and one with an acceleration threshold.

TECTONICS AT THE ALLEGHENY FRONT AS MANIFESTED BY JOINTING IN DEVONIAN ROCKS

Redescal Uzcátegui
Advisor: Terry Engelder
PhD Student, Post-Comps

In central Pennsylvania, the Allegheny front appears as an arcuate trend of folds convex to the west known as the Pennsylvania salient. This salient is composed by a succession of rectilinear folds that change trend with a kink-like geometry to give the front its particular bowed shape. The deformation style in the Valley and Ridge province is dominated by a succession of stacked horses above a basal detachment with a general westward transport direction. In this research, I test the hypothesis that the kinematics of the individual thrust sheets develops local stress fields in which cross-fold joints propagated.

I tested this hypothesis comparing the azimuth of cross fold joints measured in Devonian rocks exposed along the Allegheny front with the trend of straight fold axes defined along the Bald Eagle Mountain. This mountain forms the last important ridge between the Valley and Ridge province and the Appalachian plateau and constitutes the north limb of the Nittany anticlinorium. The term cross-fold joint (CFJ) is used to describe joints orientated at a high angle or perpendicular to fold axes. This kind of fracture are ubiquitous in the area and very well exposed westward the of the Allegheny front in the Devonian Trimmers, Brallier, Harrell, and Lock Haven formations.

Unfolding around bedding strike suggests, but does not require, that in many cases CFJ are pre-folding in age. Furthermore, they show a clockwise rotation from the transport direction in the northeast part of the front and an anticlockwise rotation in the southwest part. These observations indicate that the kinematics of the individual thrust sheets did not develop a local stress field in which cross-fold joints propagated. Some other process was responsible the development of CFJ. To propose an explanation for these observations I follow Wise (2004) model for the origin the Pennsylvania salient.

Wise proposes a two stage model of the origin of the salient based on data compiled in the Piedmont. First, the Reading Prong stage, tectonic transport is at 325° and drag rotation occur in the western edge of the salient. Later, during the Blue Ridge stage, tectonic compression is at 290° and drag rotation occurs in the east side. Finally overprinting in the central region develops the salient. Based on this model, pre-fold cross-fold joints propagated during the first tectonic compression in a NNE direction. The drag rotation proposed by Wise is responsible for the fanning displayed by CFJ along the front, from 300° in the SE to 0° azimuth in the NE. During the second stage, motion in a 290° direction causes tectonic transport to be in an anticlockwise direction from previously formed CFJ in the northeast side of the salient, and in a clockwise direction in the southwest side. During this stage sin- or post-fold CFJ propagated.

Oral Presentation Schedule -- Thursday Afternoon, April 22

Time	Presenter	Advisor	Title
1:00	Matthew Bachmann	Lee Kump	Tidal Pumping and the Fate of Wastewater Nutrients in the Florida Keys
1:15	Heather Buss	Susan Brantley	Mineral Dissolution at the Granite-Saprolite Interface
1:30	Geoff Moret	Andrew Nyblade	Investigating the Hydrostratigraphy of an Unconsolidated Aquifer Using Crosswell Seismic Traveltime Tomography
1:45	Derek Sawyer	Peter Flemings	Shallow Stratigraphy and Pore Pressure in the Ursa Region
2:00	Louanne Christopher	Peter Flemings	Analytical Permeability Prediction of the Ursa Basin Based on the Gibson Model of Constant Sedimentation Rate
2:15	Alexis Navarre	Susan Brantley	Relationship Between Field-Calculated Silicate Dissolution Rates and Carbon Dioxide Partial Pressure
2:30	J. Paul Winberry	Sridhar Anandakrishnan	Crustal Structure of the West Antarctic Rift and Marie Byrd Land Hotspot
2:45	Joel Moore	Susan Brantley	Effects of Giant Sequoia on Soil Chemistry
3:00	Christopher Junium	Michael Arthur	Organic Matter Diagenesis and Nitrogen Isotopes in Cenomanian-Turonian Black Shales

TIDAL PUMPING AND THE FATE OF WASTEWATER NUTRIENTS IN THE FLORIDA KEYS

Matthew Bachmann
Advisor: Lee Kump
PhD Student, Pre-Comps

Significant eutrophication of coastal waterways and the economically important Florida Keys coral reef ecosystem has prompted renewed interest in the subsurface transport and degradation of injected wastewater plumes. Centralized wastewater treatment facilities in the Keys pump up to thousands of m^3/day of low salinity effluent into shallow injection wells in the saline aquifer, creating density-driven flow accompanied by lateral transport along a stratigraphic contact. The saltwater aquifers of the Florida Keys experience differential hydraulic heads that create a reversing groundwater flow system (tidal pumping) which influences the growth and migration of wastewater plumes.

This hydrologic system has been modeled using three dimensional finite element computer model to verify that the natural conditions present in the Florida Keys can produce a reversing flow system, and to determine the effect of such a system on contaminant plume growth and migration. The model predicts that a tidally pumped aquifer exhibits modified plume dimensions when compared to a qualitatively similar static flow field, as well as increased average flowpath lengths and residence times of injected wastewater.

Previous work has shown that nutrient removal rates in the Florida Keys aquifer system are proportional to resident time (for nitrate, due to microbiological denitrification) and flowpath length (for phosphate, due to adsorption/precipitation reactions). By coupling previously determined nutrient removal rates with GIS-rectified site geometries and injection rates permitted by the Florida State Department of Environmental Protection, the finite element model can predict total nutrient loading rates to the coastal environment. The primary results of these model predictions is that injected wastewater is a likely source of near-shore eutrophication in the Florida Keys, but is probably incapable of creating sufficiently large plumes to significantly influence the distal coral reef ecosystem.

MINERAL DISSOLUTION AT THE GRANITE-SAPROLITE INTERFACE

Heather Buss
Advisor: Susan Brantley
PhD Student, Pre-Comps

The Rio Icacos watershed in Puerto Rico's Luquillo Experimental Forest is located on the Tertiary Rio Blanco quartz diorite bedrock mantled by 200-800 cm of saprolite. Previous workers have documented large differences in mineralology and chemistry between the bedrock and the overlying saprolite. Those studies have predominantly focused on wholesale changes between the bedrock and the saprolite. We present a detailed examination of the weathering across the bedrock-saprolite interface. This zone is important because the movement of the rock-regolith boundary into the bedrock facilitates formation of soil.

At the study site, the bedrock weathers spheroidally, forming corestones surrounded by 20-60 cm of approximately concentric layers of weathering rock. We are exploring the geochemistry and mineralogy of this complex interface between the corestones and saprolite at the microscale using inductively coupled plasma-mass spectrometry (ICP-MS), optical microscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), electron probe microanalysis (EPMA), and X-ray diffraction (XRD) to characterize the chemical and physical processes and propagate the weathering front. Preliminary results from EPMA and SEM indicate that weathering is localized in cracks and along the edges of the weathering rock layers. At the outer edge of the corestone and along cracks within the first spheroidal layer, both plagioclase and hornblende release Al in the presence of water and a hydrous alumino-silicate phase precipitates in the void space. ICP-MS results are used to calculate the open-system mass transport (loss or gain) of the sampled section. These calculations show that most of the spheroidal layers have a bulk chemistry similar to the corestone buy slightly depleted in most elements, with the largest chemical differences in the layer adjacent to the saprolite.

The spheroidal weathering may be caused by geochemical reactions at the bedrock interface. We hypothesize that ΔV of these reactions is positive (molar volume of products, V_p, is greater than that of reactants, V_r). Preliminary petrographic evidence suggests that geochemical reactions with one or more Fe-containing minerals likely cause fracturing of the granitic bedrock. Information on spheroidal fracture spacing together with geochemical data are being combined to develop a quantitative model of spheroidal cracking at the site.

INVESTIGATING THE HYDROSTRATIGRAPHY OF AN UNCONSOLIDATED AQUIFER USING CROSSWELL SEISMIC TRAVELTIME TOMOGRAPHY

Geoff Moret
Advisor: Andrew Nyblade
PhD Student, Pre-Comps

In this study, we investigate the use of crosswell tomography to obtain spatially extensive information about subsurface structure and heterogeneity in alluvial aquifers. Our field site was a research wellfield in an unconfined aquifer near Boise, Idaho. The aquifer consists of alluvial sand-and-cobble deposits, and five vertically stratified units have been identified. We collected crosswell and borehole-to-surface seismic data in wells 17.1 m apart. Our inverse routine has a curved-ray forward model and used different grids for forward modeling and inversion. An analysis of the model covariance matrices and model resolution matrices showed that the inversion results were insensitive to traveltime and constraint equation error, and had a vertical resolution of ~1 m and a horizontal resolution of ~5m. The velocity in the saturated zone varies between 2100 m/s and 2700 m/s. Including the borehole-surface data eliminated the X-shaped pattern that is a common artifact in crosswell tomography and improved the accuracy of the model near the top of the tomogram by improving the angular coverage. The final velocity model is consistent with previous stratigraphic analyses of the site, although the boundaries between units disagree with previously determined boundary locations by as much as 2 m. The results of this study demonstrate that seismic tomography can be used to image the stratigraphy of unconsolidated alluvial aquifers, even when the lithologic contrasts between units are subtle.

SHALLOW STRATIGRAPHY AND PORE PRESSURE IN THE URSA REGION

Derek Sawyer
Advisor: Peter Flemings
MS Student

Permeable sand being rapidly buried by low-permeable shale is a hydrodynamic process that exerts a strong influence in geologically young continental margin basins. This process is fundamental to the generation of submarine canyons, landslides, and mud volcanoes. It has caused costly and dangerous deep-water drilling problems including abandonment of wells due to uncontrolled venting of fluidized sediment.

The Ursa Region is located 150 miles south of New Orleans, LA on the northern Gulf of Mexico continental slope in ~4000 ft. of water. This is a fascinating setting where large underwater landslides, shallow slumps, and notorious industry drilling problems have occurred.

Direct pressure measurements made in sands and shales, wireline log data, and core-derived rock and fluid properties data are used in this study to characterize the state of pressure and stress in the shallow sedimentary section at Ursa. The results are then used to explain the drilling difficulties and presence of slumps and landslides in the region. This study is a fine example of straightforward and effective hazard mapping for drilling applications on the continental margins that can lead to safer and more economical drilling procedures.

ANALYTICAL PERMEABILITY PREDICTION OF THE URSA BASIN BASED ON THE GIBSON MODEL OF CONSTANT SEDIMENTATION RATE

Louanne Christopher
Advisor: Peter Flemings
MS Student

Pore pressures in a shaley horizon are observed to be higher than hydrostatic pressure at shallow depths of the Ursa well, located 150-miles south-east of New Orleans in the Gulf of Mexico Basin. The pore pressures follow a near lithostatic gradient and are approximately half of the values of hydrostatic and lithostatic pressure. Core and log data also show that porosity declines rapidly at the shallow depths but is constant at increased depths. An average sedimentation rate of 1.4mm/yr is used to model the consolidation behavior of the basin. This study uses a 1-dimensional approach to produce an analytical sedimentation and flow model based on the Gibson equation of constant consolidation of clay and to predict the permeability value required to produce the observed pressures.

RELATIONSHIP BETWEEN FIELD-CALCULATED SILICATE DISSOLUTION RATES AND CARBON DIOXIDE PARTIAL PRESSURE

Alexis Navarre
Advisor: Susan Brantley
PhD Student, Pre-Comps

Weathering rates for plagioclase, alkali feldspar, biotite, and hornblende were calculated from field data collected in a series of canyons near Indian Wells Valley, CA. Flow in these canyons is intermittent and most of the discharge is through alluvium that fills the bottoms of the canyons. Alluvium is derived from the weathering of granite and granodiorite plutons. Each of the canyons has similar topography, climate, and biological activity. Calculated carbon dioxide partial pressures in stream waters vary over a range from $10^{-1.3}$ to $10^{-2.65}$ atmospheres. Preliminary geochemical models of the system show a strong positive correlation between total dissolved solids (TDS) in the stream water and partial pressure of carbon dioxide (PCO_2). Slope and vegetation type do not change dramatically between these canyons. We hypothesize that higher TDS correlates to higher weathering rates and is a result of elevated CO_2.

A modification of Paces (1983) approach to calculating weathering rates was employed for data from the study area. Variation in lithology and water residence times between canyons has bee accounted for in the calculations. Calculated plagioclase dissolution rates are proportional to $PCO_2^{0.58}$. This relationship was compared to a previously published laboratory derived relationship between weathering rates and partial pressures of CO_2 for high temperature and CO_2 partial pressures much higher than field conditions. This relationship calculated plagioclase weathering rates proportional to $PCO_2^{0.3}$. Numerical models of carbon dioxide sequestration currently used the laboratory developed relationship. Our results indicate that this relationship may not be applicable at field temperatures and CO_2 partial pressures.

CRUSTAL STRUCTURE OF THE WEST ANTARCTIC RIFT AND MARIE BYRD LAND HOTSPOT

J. Paul Winberry
Advisor: Sridhar Anandakrishnan
PhD Student, Pre-Comps

The West Antarctic Rift system is one of the largest regions of extended continental crust on Earth, comparable in size to the Basin and Range province of the western U. S. However, our understanding of the rift dynamics is restricted due to the sparsity of constraints on crustal thickness. We report on crustal thickness values determined from data obtained during the ANUBIS broadband seismic experiment. We measured a mean crustal thickness of 27 km in West Antarctica, excluding the Bentley Subglacial Trench, in accord with previous regional estimates based on gravity and seismic surface wave dispersion measurements. However, our data reveal complexities in the rift system that were not imaged by the prior methods, which smoothed the crustal thickness values over large (~100-200 km) spatial scales. One intriguing result of our study is a 21 km thick crust observed beneath the Bentley Subglacial Trench. The thin crust and extreme topography of the Bentley Subglacial Trench (and possibly the Byrd Subglacial Basin to the north) suggest a distinct extensional regime different than the thicker crust and more subdued topography found father to the west. The other key result is the relatively thin crust (25 km) observed beneath the high topography of the Marie Byrd Land dome. The crust elevation of the dome is 1 km in excess of that predicted by a simple Airy isostasy model of the lithosphere, suggesting support of the topography by a combination of low-density upper mantle and Pratt-type compensation. Future seismic experiments are needed to better constrain the structure of the rift, in particular the Bentley Trench/Byrd Basin system and the Marie Byrd Land dome.

EFFECTS OF GIANT SEQUOIA ON SOIL CHEMISTRY

Joel Moore
Advisor: Susan Brantley
PhD Student, Pre-Comps

The role of plants in governing rates of soil mineral weathering remains unknown. Studies of soil mineral weathering rates conducted in aggrading (young, developing) ecosystems have shown increased weathering in the presence of plants. Here we report preliminary observations from a developmentally steady state ecosystem dominated by giant sequoia (*Sequoiadendron giganteum*). Significant differences were found in the variation and distribution of bulk oxide composition in soils from giant sequoia root zone soils compared to soil from a control site outside a sequoia root zone. Sequoia root zone soils exhibited CaO and P_2O_5 depletion, which may be the result of the loss of apatite and plagioclase feldspar in the soil.

ORGANIC MATTER DIAGENESIS AND NITROGEN ISOTOPES IN CENOMANIAN-TURONIAN BLACK SHALES

Christpher Junium
Advisor: Michael Arthur
MS Student

The nitrogen biochemical record of black shales deposited during the Cretaceous Cenomanian-Turonian Oceanic Anoxic Events is distinctly different from many other well-studied contemporary and ancient organic matter rich deposits (e.g. Peru Margin, Black Sea and Mediterranean Sapropels). Very high C/N ratios (25-40), characteristic of terrestrially sourced organic matter are typical of black shales despite data that suggest a marine (algal or bacterial) source for black shale organic matter. Nitrogen isotopic ratios are significantly depleted (-0.5 to -4.0‰) which is not typical of contemporary marine organic matter but may be more typical of Cretaceous black shales. Data from Ocean Drilling Program (ODP) Leg 207 Demarara Rise (southern North Atlantic), Deep Sea Drilling Program site 603B (equatorial West Atlantic) and Bahloul, Tunisia (ancient Tethys Ocean) show similar trends of higher C/N ratios coupled with more depleted $\delta^{15}N$. The depleted nitrogen isotopic values could suggest that the Cretaceous North Atlantic and Tethys Oceans were N-limited and allowed for primary production that was dominated by N-fixing bacteria (~0 to -2‰) and possible inputs by anaerobic photautotrophs utilizing ammonia as an N substrate. The very high C/N ratios are more likely the result of pervasive diagenesis of nitrate bearing organic compounds, by microbes in the water column and sediment. Data from DSDP site 603B show that more enriched $\delta^{15}N$ values correspond with less well preserved OM (based on Rock-Eval hydrogen index). These data suggest a model where diagenetic reactions favor the lighter isotope, leaving the residual OM isotopically enriched.

Poster Presentations

#	Presenter	Advisor	Title
1	Mulugeta Dugda	Andrew Nyblade	Crustal Structure in Ethiopia and Kenya from Receiver Function Analysis
2	Ellen Herman	William White	Variation in the Timing of Karst Spring Response to Storm Flow in Terms of Suspended Sediment and Chemistry
3	Minoo Kosarian	Charles Ammon	Lithospheric Structure of North Africa
4	Christina Lopano	Peter Heaney	K-, Ba-, and Cs-Exchange in Synthetic Birnessite Using Synchrotron X-Ray Diffraction
5	Katja Meyer	Lee Kump, Katherine Freeman	Microbiology and Geochemistry of Acidic Cave Biofilms in the Frasassi Caves, Italy
6	Vicki Miller	Barry Voight	GPS Strategies for Detecting Signs of a New Eruption Site Within the Auckland Volcanic Field
7	Laure Montandon	Shelton Alexander	Setting of Using Remote Sensing and Geographical Information System to Study the Hydrological Characteristics of the Hierakonpolis Archaeologic Site in Egypt
8	Alexis Navarre	Susan Brantley	Processes Controlling Saprolite Development Evaluated Using Weathering Rind Development on Basalt Clasts as a Small Scale Proxy
9	Jennifer Nemitz	Richard Parizek	Detection, Occurrence, Transport, and Fate of Pharmaceuticals at Penn State's Living Filter Project
10	Yongcheol Park	Andrew Nyblade	Earthquake Focal Depths and the Strength of the Continental Lithosphere
11	Winchelle Sevilla	Charles Ammon	Assessing the Risk of Tsunami Earthquake Occurrences in the Philippine Trench
12	Courtney Turich	Katherine Freeman	Wetland Crenarchaeota Lipid Biomarkers: Implication for Crenarchaeota Distribution and a Novel Paleotemperature Proxy
13	Timothy Watson	Andrew Nyblade	A Broadband Seismological Investigation of the Upper Mantle Structure Beneath the Trans Antarctic Mountains and East Antarctic Craton

CRUSTAL STRUCTURE IN ETHIOPIA AND KENYA FROM RECEIVER FUNCTION ANALYSIS

Mulugeta Dugda
Advisor: Andrew Nyblade

Crustal structure within and surrounding the Eastern Branch of the East African Rift System in Ethiopia and Kenya has been investigated using receiver functions. Data for this study comes from broadband seismic experiments conducted in Ethiopia between 2000 and 2002 and in Kenya between 2001 and 2002. Two methods have been used to analyze the receiver functions, the H-κ (Moho depth (H) and Vp/Vs ratio (κ)) method, and direct stacks of the waveforms. The two approaches yield consistent results.

Moho depths vary from 25 to 31 km within the Main Ethiopian Rift and Afar Depression, and the crust is characterized by high Poisson's ratios of 0.30 to 0.36. Beneath the western and eastern plateaus on either side of the Main Ethiopian Rift, crustal thickness ranges from 33 to 44 km, and Poisson's ratio varies from 0.23 to 0.28, typical for Precambrian crust. These results suggest that Precambrian crustal structure beneath the Ethiopian Plateau has not been significantly modified by the Cenozoic rifting and volcanism, whereas the Precambrian curst beneath the rifted regions has been dramatically thinned in some places and compositionally altered by the addition of mafic rocks. The high Poisson's ratio for the MER and Afar crust suggest that partial melts are also present in the crust.

Crustal thickness to the east of Kenya rift varies between 39 to 42 km and Poisson's ratio varies between 0.24 and 0.27. To the west of the Kenya rift, Moho depths of 37 km and 38 km were found and Poisson's ratio varies between 0.24 and 0.27. These findings support previous studies showing that crustal structure away from the rift proper in Kenya has not been extensively modified by the Cenozoic rifting and volcanism.

VARIATIONS IN THE TIMING OF KARST SPRING RESPONSE TO STORM FLOW IN TERMS OF SUSPENDED SEDIMENT AND CHEMISTRY

Ellen Herman
Advisor: William White

Karst springs respond to storm flows with changes in several characteristic quantities, including discharge, specific conductance, and suspended sediment. These changes provide information on flow pathways and travel times of water, solutes, and sediment through spring systems, and quantification of spring behavior is essential for accurate prediction of contaminant behavior and risk assessment. We are collecting discharge, conductivity, and sediment data at three springs in Pennsylvania to determine how spring size, storm size, and antecedent conditions affect the storm response of the spring system and provide us with information about he hydrogeologic setting of the spring. Our initial data show that not only does each spring have different pathways and traveltimes from the others, but also these properties can vary substantially in a single spring.

Arch Spring in Blair County, the largest of the three springs, responds to many storms with similar conductivity patterns, but the timing of peak suspended sediment concentration can vary on the order of half a day in a system that responds very quickly to precipitation. Nolte Spring in Lancaster County exhibits low sediment concentrations during storms and changeable conductivity patterns from storm to storm. Chemically, Nolte show the most surprising behavior both at baseflow and during some storms. Under certain antecedent aquifer conditions, Nolte discharges calcium-rich suspended sediment (that is most likely calcite) in water well below saturation with respect to calcite. The third spring, Bushkill Spring in Northampton County, is a very small spring along Bushkill Creek. Bushkill responds to storms with consistent conductivity patterns, but again, time lags between precipitation and sediment concentration peaks can be quite different.

This suggests that, depending on the storm and the antecedent condition in the basin, different flow pathways are mobilized under different conditions. Preliminary work indicated that predictions of peak sediment (and likely peak contaminant) arrival time demand knowledge of several factors including storm and spring type, and basin conditions. Additional storms at each site and two additional sites will yield additional information of the timing and character of sediment flows in the coming year. We are working on this project in collaboration with Laura Toran and Jennifer Tancredi of the Temple University's Department of Geology.

LITHOSPHERIC STRUCTURE OF NORTH AFRICA

Minoo Kosarian
Advisor: Charles Ammon

Mapping Earth's structure remains an important, challenging problem. Although, considerable research has been devoted to map lithospheric structure with different data sets, less attention has been given to estimate Earth's structure using multiple data sets.

The objective of this research is to map the lithospheric structure of the North African continent by applying joint inversion of receiver functions and surface wave-dispersion methods to provide constraints on the character of the lithosphere (crustal velocities and thickness, crust-mantle transition velocity contrast). The African continent presents a variety of tectonic regions with a large contrast in age. We examined receiver function for 8 permanent and 28 temporary three-component broadband seismic stations located in the North Africa. Many of the sites have been carefully investigated by other researchers using receiver functions, which provide good benchmarks comparing our result. Most crustal thickness estimates are consistent with previous geophysical work but several stations differ from standard models. For instance, our results indicate significant variations in the crustal thickness beneath Hoggar region, located in southern Algeria.

The Hoggar dome is on of the most important swells (elevations > 2000 m) on the African continent because of its complex structure. The near-surface includes a succession of horsts and grabens bound by north-south striking faults. A negative Bouguer gravity anomaly associated with the swell has been interpreted to indicate reduced mantle density. The receiver functions show the crust is about 10 km thicker beneath the highest elevations. This suggests the existence of crustal root that may contribute greatly to the gravity anomaly and questions the need for significant mantle density variation.

K-, BA-, and CS-EXCHANGE IN SYNTHETIC BIRNESSITE USING SYNCHROTRON X-RAY DIFFRACTION

Christina Lopano
Advisor: Peter Heaney

Birnessite is an abundant layer-structure Mn-oxide phase in soils, desert varnishes, and ocean nodules that plays a significant role in soil and groundwater chemistry. In particular, birnessite has an adsorption affinity for a variety of heavy metals. In this study, aqueous K^+, Cs^+, and Ba^{2+} cations were exchanged for interlayer Na^+ in synthetic birnessite using a simple flow-through cell, and the exchange products were monitored via time-resolved X-ray powder diffraction at the National Synchrotron Light Source. Powder X-ray diffraction patterns were collected every two to three minutes.

The starting structure for Na-birnessite was based on the triclinic unit cell of Post *et al.* (2002) Rietveld analyses (using the GSAS program) of the X-ray diffraction patterns for K- and Ba-exchanged birnessite revealed decreases in the *a*, *c*, and *beta* unit-cell parameters, with a decrease of 1.4% and 0.5% respectively in the overall unit-cell volume relative to Na-birnessite. In contrast, the exchange of Cs^+ into the birnessite structure led to a decrease in the *a* and *beta* parameters but an increase in the length of *c*, generating an overall increase of 0.9% in the total unit-cell volume. This structural expansion can be attributed to the larger size of Cs^+ relative to Na^+ and to the lower charge of Cs^+ in comparison to Ba^{2+}.

Fourier electron difference syntheses revealed that the structural changes were a function of the configuration of the interlayer species. Split electron density maxima with centroids at (0 0.5 0.5) were present for both Na and K end-members; however, with increased substitution of K for Na, the axis connecting the split-site maxima rotated from an orientation parallel to the *b*-axis to along the *a*-axis. The split electron density maxima of interlayer Ba, on the other hand, exhibited no rotation, but splitting was more pronounced. The exchanged interlayer Cs cations revealed yet another arrangement, with positional disorder over four proximal sites.

These findings for K, Ba, and Cs-exchanged birnessite have shown that this time-resolved synchrotron method combined with Rietveld structure analyses is an ideal way to monitor how birnessite incorporates metals into the interlayer regions of its structure. Future experiments exchanging heavy metals such as Pb, Cu, Zn, Ni, and Cd will be performed in hopes of capturing how birnessite accommodates these large and environmentally significant metals into its structure.

MICROBIOLOGY AND GEOCHEMISTRY FO ACIDIC CAVE BIOFILMS IN THE FRASASSI CAVES, ITALY

Katja Meyer
Advisors: Katherine Freeman, Lee Kump
Co-authors: L. Cleaveland (Carleton College), S. Galdenzi (Italian Speleological Institute, Genga, Italy), and J. Macalady (Carleton College)

Acidic (pH 2-4) and extremely acidic (pH 0-1) biofilms in sulfidic regions of the Frasassi cave system are relatively simple, chemoautotrophic microbial communities. As such, they serve as model systems to test relationships between microbial diversity and physical and geochemical factors. Both biofilms types are isolated from surface sources of C and N and are ultimately powered by oxidation of H_2S present in the cave atmosphere. pH 2-4 biofilms consist of cells in close association with sub-m to sub-mm mineral grains (primarily $CaSO_4$) coating cave walls. Direct counts of cells stained with 4',6-diamidino-2-phenylindole, hydrochloride (DAPI) yield a biomass estimate of 7.5×10^6 to 1.3×10^7 cells per cm^3. The great majority of these cells are either dormant (contain few ribosomes) or cells which do not hybridize with either bacteria- or archaea-specific oligonucleotide probes. Sparse clusters of short rod and coccus-shaped cells hybridized with a bacteria-specific Fluorescent In Situ Hybridization (FISH) probe. Polymerase Chain Reaction (PCR) amplification of 16S rDNA was successful with bacteria-specific primers as will as with several sets of archaeal-specific primers, suggesting that some of the dormant cells are archaea. Extremely acidic biofilms (snottites) drip from macroscopic (1-2 cm length), reddish $CaSO_4$ crystals on the cave walls. DAPI-staining and FISH revealed abundant bacterial rods, bacterial filaments, and fungi in the snottites. Future work will characterize the acidic cave wall biofilms, as well as neutral-pH cave stream biofilms, using 16S rDNA clone libraries in order to determine whether pH is an important factor controlling microbial diversity.

GPS STRATEGIES FOR DETECTING SIGNS OF A NEW ERUPTION SITE WITHIN THE AUCKLAND VOLCANIC FIELD

Vicki Miller
Advisor: Barry Voight

Prior to the eruption of Mount Usu, Japan, in March 2000, there were four days of seismic activity. This did not, however, indicate where around the mountain the eruption might occur. It was the observance of deformation that enabled fairly accurate assessments of where eruptions would occur; thus enabling all affected areas to be evacuated. When attempting to establish where an eruption may occur within a volcanic field, particularly if it is within or near an urban area, any monitoring system must have three main attributes. These are widespread coverage, data obtainable on a short timescale, and precursor signals large enough compared to noise to ensure reliable prediction and avoid false alarms. Here we propose a deformation monitoring strategy for the Auckland region. The first step is to set up a regional backbone of continuous-monitoring dual-frequency GPS receivers at ~20 km spacing. If seismic activity occurs, the expected 25-100 km^2 area of activity would be more closely monitored. A kinematic GPS survey of existing Land Information New Zealand 4^{th} and 5^{th} order survey marks should be commenced at ~1 km intervals. This would provide a rapid indication of the deformation field, providing that an assessment of the accuracy of the existing mark coordinates has been done in advance. A concentrated network of real-time receivers should then be set up in the deforming area, and their data analyzed and interpreted in close to real time. Based on preliminary studies in New Zealand and elsewhere, these GPS surveys will be able to detect movements of 1 cm horizontal and 3 cm vertical if they occur over time periods of days to months. Relative motions, significantly smaller than these, may well be detectable within a small area or over short time periods. During the recent eruption of Mount Usu there were precursory horizontal movements on the order of 2 centimeters per day, well above the detectability level. If seismic or ground deformation activity continued for weeks, months or longer, differential InSAR would play an important complementary role to the continuous GPS observations.

SETTING OF USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM TO STUDY THE HYDROLOGY OF THE HIERAKONPOLIS ARECHAEOLOGICAL SITE IN EGYPT

Laure Montandon
Advisor: Shelton Alexander

The Hierakonpolis (a.k.a. Nekhen) archaeological site is located in Upper Egypt at approximately 650 km south of Cairo, just North-West of the town of Idfù. The site has been investigated by archaeologists since the late 19th century. Many important artifacts have been found there and the area has been recognized as the most important site for the understanding of the foundations of ancient Egyptian society. Unfortunately, the excavation process on parts of the site has been greatly slowed down due to the rise of the local water table to about 1.5 meters of the surface. In this area, the structures of what used to be the temple and town of Nekhen are buried at depths that reach 3-4 meters below the surface, and as a result, are now inundated.

In an effort to find a solution that would allow further excavations, a project was launched in 1997 by a joint team of Penn State faculty. Presently, the now called Temple-Town Hierakonpolis Project is led by Dr. Elizabeth Walters of the Art History Department at Penn State. As part of it, yearly investigations have been conducted for the last five years; including seismic surveys, regular monitoring of the water table depth, several core drilling and hydrogeological measurements. The aim of this project is to isolate the main source of the underground water and develop an efficient and adapted scheme for the dewatering of the site.

My work as part of the project is to use Geographical Information System (GIS) combined with satellite imagery to help study the evolution and spatial distribution of the regional hydrological setting. We hope that such an approach will help address this issue by providing a more global approach than the one of in-situ measurements. This is further supported by the fact that the hydrological issue seems to find its source on a more regional scale. Intensive irrigations have been suspected of contributing to the local rise of the water table. However more recent observations might highlight the more specific role of a water canal built 10 km south of Hierakonpolis. Remote sensing will provide unique time sequence information that will help us reconstruct the history of the building of the canal. These data will be compared to in-situ measurements to see if any correlation can be found.

Another objective of my research is to use thermal imagery to study the groundwater depth in the desert area between the canal and the site. Finally, I expect to gather clues on the origin of the underground water located on the site, and provide a better understanding of the local dynamic of the groundwater (its sources and its outlet). The relevance of this project is supported by field observations that have shown that the local population is also being affected by the rise of the water. Many houses have collapsed due to the destruction of their mud brick walls as water is being soaked from the bottom. It the use of satellite imagery proves to be useful for this particular investigation, one can hope that similar studies could be undertaken on other parts of Egypt suffering from similar groundwater issues.

PROCESSES CONTROLLING SAPROLITE DEVELOPMENT EVALUATED USING WEATHERING RIND DEVELOPMENT ON BASALT CLASTS AS A SMALL SCALE PROXY

Alexis Navarre
Advisor: Susan Brantley

Chemical weathering of silicate minerals is an important control on concentrations of atmospheric carbon dioxide. Long term dissolution rates currently used in numerical global carbon cycle modeling have been constrained by soil/saprolite formation studies. As bedrock weathers, silicate minerals dissolve and bedrock is converted to saprolite. If the age of exposure of bedrock is known a rate of saprolite development can be calculated, but the processes controlling conversion of bedrock to saprolite are not well understood. In addition, it is difficult to quantify the amount of weathered material lost to physical erosion leading to large uncertainties in estimated rates. We use weathering rinds on basalt clasts as a small-scale proxy of saprolite development to examine the processes occurring at the rind/core (saprolite/bedrock) interface in a well constrained environment. These clasts were deposited approximately 120,000 years ago in alluvial terraces of the Rio Parrita in Costa Rica. Clasts are weathering within the terrace deposit shielding them from physical weathering. Because no weathering products are removed, calculated rates of rind advancement when exposure age is known have low uncertainties. Clasts used this study are collected from the same terrace and it is assumed that climate, topography, time, and biologic activity are the same for all samples.

Computed tomography (CT), scanning electron microscopy-energy dispersive x-ray (SEM-EDX), and petrographic techniques have been used to analyze chemical and physical properties of the rind/core interface. Preliminary results indicate that plagioclase is the first mineral to dissolve at the interface. The dissolution of plagioclase produces secondary porosity that increases reactive surface area of other minerals at the interface. Measurement of weathering rinds on 67 basalt clasts shows that thicker rinds develop on clasts with larger grain size. Dissolution of larger grains of plagioclase results in a larger increase in reactive surface area at the rind/core interface.

DETECTION, OCCURRENCE, TRANSPORT AND FATE OF PHARMACEUTICALS AT PENN STATE'S LIVING FILTER PROJECT

Jennifer Nemitz
Advisor: Richard Parizek

The occurrence, fate, and transport of pharmaceuticals in the environment has burst into the scientific spotlight and the consciousness of the general public. Discover Magazine listed the growing awareness of pharmaceuticals in drinking water as its 8th out of 100 top science story of 2002 based largely on a sweeping study of US streams by the United States Geological Survey (USGS). (Discover, 2002)[1]. Of the 139 streams sampled across the United States, the USGS detected a total of 82 organic wastewater contaminants with as many as 38 contaminants found in any given stream sample (Kolpin, *et al*., 2002)[2].

The most common pathway by which pharmaceuticals enter the environment is through sewage system discharge. Pharmaceuticals may not be fully metabolized within the human body and the straight pharmaceutical or by-products of the pharmaceutical are released into the sewage treatment system through excrement. Pharmaceuticals are also introduced into the sewage system when extra or expired prescriptions are flushed down the toilet. Once in the environment, pharmaceuticals generally occur in the aqueous phase and can rapidly degrade in soil or environments with organic matter. However, the constant loading from sewage discharge and other sources can have the same effect on organisms as if the pharmaceutical did not degrade.

The Living Filter offers a unique opportunity to analyze the fate and transport of pharmaceuticals as a result of 20 years of continual loading. The Living Filter is comprised of four systems: a surface water/overland flow system, a wetland system, an infiltration/percolation system, and a groundwater system. The present study seeks to trace the transport and fate of pharmaceuticals through the 4 systems over period of one year. Results from a preliminary sampling run are presented in this poster. In the future, the effectiveness of the four systems of the Living Filter for removing pharmaceuticals can be used as a model for other water remediation systems in areas where water must be continually recycled.

References:
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EARTHQUAKE FOCAL DEPTHS AND THE STRENGTH OF THE CONTINENTAL LITHOSPHERE

Yongcheol Park
Advisor: Andrew Nyblade

The effects of Cenozoic tectonism on the rheology of the lithosphere of East Africa remain obscure. In this study, we investigate earthquake focal mechanisms and depth distributions using local and regional seismic data within the continental lithosphere of East Africa. We use an exhausted grid search algorithm to find acceptable solutions and wavenumber integration to determine focal depths with depth phases Pmp, pPn, sPmp and sPn. By examining the focal depths of earthquakes in the continental lithosphere we are able to further constrain the strength of different layers in the lithosphere. In this way, we reassess our understanding of the rheology of this area.

We relocate events from two earthquake clusters from Northern and Southern Tanzania recorded by the 1994-1995 Tanzania Broadband Seismic Experiment. These earthquakes are particularly interesting because there are no observed faults or volcanic centers associated with them. The relocated focal depth distribution will help us to determine whether new geodynamic activities happen there.

ASSESSING THE RISK OF TSUNAMI EARTHQUAKE OCCURRENCES IN THE PHILIPPINE TRENCH

Winchelle Sevilla
Advisor: Charles Ammon

Most large, shallow earthquakes under the sea floor generate tsunamis, i.e. tsunamigenic earthquakes. An earthquake therefore should be very large and shallow to expect an occurrence of a sizeable tsunami. In fact, tsunami-warning systems base their advisories on the magnitude and location of the earthquakes. There is a type of earthquake, however, which is called a tsunami earthquake that can undermine the effectiveness of real-time warning systems. Tsunami earthquakes excite tsunamis larger than what would be expected from its conventional magnitude. Thus, the study of tsunami earthquakes is of particular interest since run-up heights of tsunami earthquakes may deviate from predicted height calculated from empirical relations. By merely using magnitude as a basis for estimating tsunami heights may affect the effectiveness of a tsunami warning system.

An emerging consensus suggests that tsunami earthquakes are associated with slow rupture in sediment at the plate interface near the Earth's surface. Ruptures propagating through the unconsolidated and semi-consolidated sediments at the shallow plate interface and to the accretionary prisms take much longer to break because of the materials' low rigidity, which gives the source an anomalously long duration. To asses the risk of tsunami earthquake occurrences in trenches with small sediment budgets, I applied multi-station deconvolution to extract the rupture duration of the interplate earthquakes in the Philippine trench. Bathymetry, seismic reflection studies, and offshore drilling show that the trench has a small sediment budget and poorly developed accretionaly prisms. I compared the resulting duration with those of the tsunami earthquakes to determine if the rupture durations of earthquakes in the Philippine trench are anomalously slow.

Plots of rupture durations with depth including the duration of tsunami earthquakes show that the earthquakes in the Philippine trench are consistently shorter than that of the tsunami earthquake durations. This implies that the frictional characteristics of the interface may not be conducive to the occurrence of the tsunami earthquakes as far as the available data are concerned.

WETLAND CRENARCHAEOTA LIPID BIOMARKERS: IMPLICATIONS FOR CRENARCHAEOTA DISTRIBUTION AND A NOVEL PALEOTEMPERATURE PROXY

Courtney Turich
Advisor: Katherine Freeman

Crenarchaeota, first defined as a phylogenetic cluster of hyperthermophilic Archaea are now known to be diverse and abundant in marine and terrestrial environments, making up ~20% of marine plankton and 0.5-3% of soil microbes. They have unique lipid membranes consisting of C40 isoprenoid chains linked to glycerol backbones via 4 ether linkages. The chains also contain 1 to 8 pentacyclic rings with the number of rings increasing with increasing temperature. Another ring moiety call "crenarchaeol" has a distinctive hexacyclic ring which helps increase membrane fluidity at lower growth temperatures. It was first reported as a ubiquitous marine compound, estimated at 6.5 megatons in the oceans.

We report the first detection of crenarchaeol in a terrestrial setting, in sedge-dominated bog margin sediment and acidic (pH 4.84) surface waters of Bear Meadows wetland (N40° 43.796' W77° 45.310' 554m elevation). Crenarchaeol concentration ranges from 0-2.0 μg/g in 23 samples from two 55 cm cores, averaging 5.2% of total Crenarchaeota lipids. It is also present in surface waters. The detection of Crenarchaeol in aquatic sediments suggests the compound imparts membrane fluidity in cold temperatures regardless of environmental context (i.e. salinity), and also provides evidence of the cosmopolitan distribution of Crenarchaeol synthesis.

These findings are also significant because the ratio of lipid structures (those containing 1-4 rings) have been correlated to surface temperatures in marine settings (TetraEther index or TEX86), and used as a paleotemperature proxy. The presence of crenarchaeol in aquatic settings indicated TEX86 may provide a record of temperature fluctuation on land as well. TEX86 calculations from the top of one core provide a good correlation with water temperature (20.8 and 21.3 degrees C). However, calculated temperatures down core are offset (1.5269 * calculated Temp – 18.436, r^2=0.58), yielding temperatures 5 to 17 degrees lower than actual subsurface temperature. This probably results from the mixing of lipids from planktonic and sediment-dwelling microbes but may also reflect other factors, such as seasonal population blooms or slow growth. Further research on seasonal population changes using real-time PCR on surface water particulate organic matter and surface sediment will be used to gauge the physical conditions under which the bulk of biomass is generated, and the influence on the TEX 86 signature.

A BROADBAND SEISMOLOGICAL INVESTIGATION OF THE UPPER MANTLE STRUCTURE BENEATH THE TRANS ANTARCTIC MOUNTAINS AND EAST ANTARCTIC CRATON

Timothy Watson
Advisor: Andrew Nyblade

The Trans Antarctic Mountains (TAM), among the world's foremost mountain ranges, consist of gently tilted fault blocks resulting from vertical crustal movement during the Cenozoic. Paralleling much of the West Antarctic Rift System, the TAM are considered by many to be a classic example of rift flank uplift, however evidence supporting a clear uplift mechanism has yet to be provided. Additionally, the adjacent East Antarctic Craton exhibits anomalously high elevation for a cratonic block, approximately 1 km above sea level, when corrected for glacial loading. To investigate these two unique tectonic features I plan to image the thermal structure of the upper mantle beneath portions of the TAM and East Antarctic Craton with data collected from the broadband seismic experiment TAMSEIS (Tran Antarctic Seismeic Experiment) from 2000-2003. We believe that the thermal state of the upper mantle beneath these regions will provide the information necessary to discriminate between competing uplift models.

To date, I have picked over 1800 P-arrivals from the data set, obtaining excellent event coverage for the Indonesian and Andean seismic regions and am continuing to pick events from Southeast Asia and mid-ocean ridge regions to even out the azimuthal coverage. Additionally, I have begun developing a model parameterization for the tomography code of VanDecar and Crosson (1991). This method obtains P and S wave travel time delays obtained from a multi channel cross-correlation, for the tomography. Initial P-wave travel time residuals exhibit clear azimuthal variability. The tomography will resolve the velocity of the upper mantle to evaluate the rift flank model.