

DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES  
 106 GEOSCIENCE, L-DEO  
 COLUMBIA UNIVERSITY

TO: FACULTY, GRADUATE STUDENTS , AND RESEARCH STAFF  
 FROM: MISSY PINCKERT  
 RE: ANNUAL DISSERTATION TOPIC LIST  
 (ORALS PASSED THROUGH SPRING '08)  
 DATE: 8/15/08

NAME                                      DATE ORALS PASSED      ADVISORY COMMITTEE

SHAHLA ALI                                      3/06                      B. Anderson Stute Winckler

Helium Isotope and Rare Gas concentrations in Rocks

My thesis work applies the principles of Noble Gas Isotope Chemistry to two different topics, namely Helium isotope concentrations found in the marine record as a proxy for freshwater input from melting icebergs to the Southern Ocean and the distribution of rare gas concentrations in matrix fluids recovered from cores obtained at depth in the San Andreas Fault.

1. Freshwater budgets at sites of deep water formation influence the strength of the thermohaline circulation, which provides an important ocean atmosphere link to millennial scale climate change. Melting icebergs can be an important source of freshwater in Polar Regions. Ice rafted debris layers in marine sediment are used as indicators of melting icebergs, but they offer little information about the volume of ice involved. In this project, I am exploring the use of  $^3\text{He}$  as a tracer for the volume of freshwater released by melting icebergs.  $^3\text{He}$  is contained in Interplanetary Dust Particles (IDPs) which are accumulated in ice and marine sediments at a known rate. Because they are incorporated throughout the ice sheet, IDPs are released wherever icebergs melt.

2. The presence of superhydrostatic fluid pressures is used to explain the low friction slip along the San Andreas Fault Zone.

We are testing this hypothesis by direct sampling of cores obtained at depth in the San Andreas Fault and measuring the distribution of rare gas concentrations in matrix fluids. U/Th decay-series-elements and K decay in rock produce  $^4\text{He}$  and  $^{40}\text{Ar}$  as well as nucleogenic ( $^{21},^{22}\text{Ne}$ ) and fissionogenic ( $^{132},^{134},^{136}\text{Xe}$ ) rare gases. The entire suite of measured noble gas isotopes ( $^3,^4\text{He}$ ,  $^{20},^{21},^{22}\text{Ne}$ ,  $^{36},^{38},^{40}\text{Ar}$ ,  $^{84},^{86}\text{Kr}$ , and  $^{129},^{131},^{132},^{134},^{136}\text{Xe}$ ) are used to separate the non-atmospheric (produced and accumulated) from the atmospheric noble gas components. Rare gas concentrations in the matrix fluids are used to investigate fluid flow and constrain mechanics of earthquake rupture in the San Andreas Fault.

No change since 7/07.

PETER ALMASI

3/03

deMenocal

Cane

North Atlantic Holocene Paleoclimatology and Millennial Climate Cycles.

North Atlantic climate has varied on centennial to millennial time scales throughout the Holocene. To assess the magnitude and spatial pattern of sea surface temperature (SST) changes during the Holocene, the feasibility of paired planktonic  $\delta^{18}\text{O}$  and  $\text{Mg}/\text{Ca}$  is assessed. Reconstructions are generated for three sub-polar sediment cores at 40-60 year time resolution from 0-14000 BP.

I. Assessing paired  $\delta^{18}\text{O}$  and  $\text{Mg}/\text{Ca}$  in the Holocene North Atlantic

The potential of paired  $\text{Mg}/\text{Ca}$  and  $\delta^{18}\text{O}$  measurements to resolve 1-2 °C SST variability in the Holocene North Atlantic was evaluated in *G. bulloides* and *N. pachyderma* (d.) foraminifera. Individual components of external (calibration) and internal (measurement) errors were derived from existing calibrations, core tops from this study, and tests of cleaning procedures and laboratory reproducibility. To test the sensitivity of  $\text{Mg}/\text{Ca}$  in *G. bulloides* and *N. pachyderma* (d.) across a sub-polar North Atlantic SST gradient, paired  $\text{Mg}/\text{Ca}$  and  $\delta^{18}\text{O}$  were measured in 7 core top samples containing post-1950 radiocarbon. An exponential curve fit to  $\text{Mg}/\text{Ca}$  vs.  $\delta^{18}\text{O}$ -derived calcification temperature yielded the relation  $\text{Mg}/\text{Ca} = 0.851 \pm 0.052 * e^{(0.074 \pm 0.006 * T)}$ .  $\text{Mg}/\text{Ca}$  from *N. pachyderma* (d.) does not appear sensitive to calcification temperature in these samples, an unexpected result that may reflect sample dissolution during intense cleaning procedures.

## II. Holocene climate from $\delta^{18}\text{O}$ and Mg/Ca in *G. bulloides* down-core records

Surface water proxy reconstructions of temperature and salinity can provide insight into mechanisms of centennial-millennial Holocene climate change by the magnitude and spatial pattern of their variability. Foraminiferal  $\delta^{18}\text{O}$  and Mg/Ca from cores in the central and eastern North Atlantic suggest that temperature and salinity varied up to  $3^\circ\text{C}$  during centennial to millennial cycles throughout the Holocene. Modern gradients in foraminiferal  $\delta^{18}\text{O}$  and Mg/Ca were maintained between coring sites on the Björn Drift (Reykjanes Ridge) and Feni Drift (eastern Rockall Plateau) within sample replicate error throughout the Holocene. This suggests climate change in the spatial pattern representing southward movement of the sub-polar front during centennial to millennial scale cooling. Shifts in millennial-scale reconstructed  $\delta^{18}\text{O}$  and Mg/Ca are more consistent between the central and eastern North Atlantic cores than with petrologic tracer indicators of drift ice or cosmogenic proxies for solar variability.

JENNIFER ALLTOP

4/08

Rind

Del Genio

Gong

Will be submitted when she returns from field work in September.

JENNIFER ARBUSZEWSKI 4/08

deMenocal

B. Anderson

Cane

### A Global Multi-species Mg/Ca Calibration

In the past, temperature was thought to be the primary control on Mg uptake in foraminifera. This dependency gave rise to the Mg/Ca temperature proxy, which is frequently used in paleoceanographic studies. However, we have recently discovered what appears to be a salinity effect on the Mg/Ca signal recorded in planktonic foraminifera. This effect causes excess Mg to be taken up by planktonic forams in high salinity (or alkalinity) regions. We have developed a new set of calibration equations for the Atlantic Ocean using paired Mg/Ca and  $\delta^{18}\text{O}$  measurements, along with the  $\delta^{13}\text{C}$  carbonate, to predict for temperature and salinity. Preliminary results indicate that these equations are robust. My thesis work aims to extend this study globally with the goal of determining global equations for temperature and salinity for three species of planktonic foraminifera (*G. ruber* (white), *G. sacculifer*, and *G. bulloides*) using core-top samples and validating those

results. Additionally, I will be analyzing samples from plankton tows (using the same three species) to confirm the coretop results. I will also be working with LA-ICP-MS, SEM and other instruments to try to better understand how Mg heterogeneities in the foraminiferal shells may be linked to the excess Mg we observe. These results should be widely applicable to paleoceanographic studies and may allow more accurate reconstructions of both temperature and salinity in the past.

ZAHID AZIZ

11/05

Stute Schlosser van Geen

Local hydrology and arsenic (As) concentrations in shallow aquifers of Araihasar, Bangladesh.

Arsenic (As) is highly toxic but a common element found in the atmosphere, soils, and natural waters. However, As in drinking water probably poses the greatest threat to human health – ingested As causes cancer of the skin, bladder, and lung, and has been linked to other health effects, including reproductive and developmental effects, cardiovascular disease, and skin lesions. In term of drinking water standard, WHO and US-EPA permissible limit for As is 10 ug/L. In Bangladesh 30% of wells have elevated concentrations of As considering the Bangladesh standard 50 ug/L, which put approximately 35 millions people at risk. If we follow the WHO guideline, 46% exceed the limit and 57 million people are exposed. At the shallow depth (<30 m) of aquifers where hydrogeology and geochemistry are dynamic, this scenario get worse - 55% of wells exceed the safe limit. I am interested to take a closer look at this shallow part of aquifers to understand subsurface processes that control As concentrations in groundwater. My study area is in Araihasar, Bangladesh where six thousands wells have been tested for As concentrations. Nearly 60% of shallow wells (<30 m) in Araihasar have elevated concentrations of As and show a wide range of variability (1-1000 ug/L) both spatially and seasonally.

In my first chapter, I compared dissolved As concentrations in 5200 shallow wells with the nature of surface soils mapped with EM31 conductivity meter (a hand held geophysical instrument). The study showed that electromagnetic (EM) conductivity reading reflects the clay percentage and the recharge capability of surface soils. I also found that low dissolved As corresponds to areas where EM conductivities of surface soils are also low and vice versa. Based on these observations we concluded that

local recharge inhibits As concentrations from rising in shallow aquifers.

In second chapter, I tracked both physical and chemical processes that control dissolved As in shallow aquifers by installing a series of very shallow multilevel (depths range from 3 to 9m) monitoring wells at three different sites. A seasonal variation was observed in groundwater chemistry at one multilevel wells site related to a simple mixing between two water masses with different chemical compositions and depths. This mixing process was attributed to recharge processes controlled by the seasonal changes in vertical and horizontal flow directions. Data at this site also suggests a trapping mechanism of As in shallow aquifers that could explain about 50% of the spatial variability in As concentration in Bangladesh. Besides, groundwater chemistry and relative hydraulic head measurements at two other multilevel sites support the notion that long term irrigation pumping can lower the As concentration in shallow aquifers.

The final chapter includes a numerical groundwater model where I made an attempt to explain the observations and processes discussed in the second chapter. The groundwater flow model was simulated using the computer code known as "modflow" through a commercial interface GMS 6.0.

Over all, these works suggest that local hydrology plays an important role in the distribution of dissolved As in shallow aquifers.

DALIA BACH

3/07

Lerner-Lam Kushnir Uriate

Multi-scale landslide hazard and risk assessment: a modeling and multivariate statistical approach

AMY BALANOFF

4/07

Norell Flynn Olsen

The evolutionary history of Oviraptorosaur dinosaurs

Oviraptorosaurs are an unusual group theropod dinosaurs who possess an array of avian-like features. These morphological similarities between birds and oviraptorosaurs are used in some phylogenetic analyses to propose a close relationship between the two groups. Other analyses, however, suggest that this clade, along with

therizinosaurs, is most closely related to Paraves (Deinonychosaurs + Avialae). In order to more fully understand the placement of oviraptorosaurs within Theropoda the relationships within this less inclusive clade need to be resolved, yet most trees for Oviraptorosauria conflict with one another. Therefore, I propose to perform a phylogenetic analysis of the relationships within oviraptorosaur dinosaurs to help place this important group within a larger evolutionary context.

No change since 7/07.

ROB BIALAS

4/07      Buck      Lerner-Lam      Weissel

The Effects of Temperature, Sedimentation, and Erosion on Extensional Systems

The rifting of continental lithosphere can be accommodated in different ways, including narrow rifts, wide rifts, and core complexes. Many different factors can influence the style of extension expressed at a rift. Using numerical and analytical techniques, I will explore the effects of different temperature regimes, sedimentation, and erosion on extensional systems. These results are compared with gravity, seismic, topography, and geological data from different rifted systems, both active and ancient, to gain insight into these systems. My current work has focused on the West Antarctic Rift System and the Gulf of California.

No change since 7/07.

ANTONIO BUONO

5/08      Walker      Ebel      Kelemen

An experimental study of the formation and evolution of planetary cores.

We are using high-pressure/high-temperature techniques to study partitioning between the inner and outer cores of small planets, as well as the phase equilibrium that may govern the composition of those cores.

MERRY CAI

10/04      Goldstein      Spiegelman      Plank

My thesis using isotope geochemistry in three projects involving two different tectonic settings. The first project is about subduction zone volcanism in the central and eastern part of the Trans Mexican Volcanic Belt. Using major and

trace element chemistry of arc lavas together with Nd-Hf-Pb-Sr isotope tracers I will quantify the contributions from the subducting oceanic plate and its overlying sediments to the arc mantle source.

The second project focuses on the western Mexican Volcanic Belt, where ultrapotassic arc lavas erupt contemporaneously with normal arc calc-alkaline lavas. This chapter of my thesis will attempt to find a source enrichment model to explain the occurrence of both types of lava which will further our understanding of how subduction changes the composition of the mantle wedge.

The third project is focused on an ultra-slow spreading ridge, the Gakkel Ridge in the Arctic ocean. Recent geological and geochemical surveys revealed that not only abundant volcanism exist at Gakkel ridge, the lavas sampled from the Gakkel ridge encompass global scale chemical variability. My thesis will try to examine two major questions. One is the relative importance of lithosphere thickness and mantle temperature on the genesis of ocean ridge basalts. The other is the "veined mantle" hypothesis, which argues that small extent of melting preferentially sample the enriched components in the mantle and therefore produces higher heterogeneity in mid-ocean-ridge basalts. I will carry out a comprehensive isotope geochemistry study and use the geochemical data to test these models.

LICAO

3/05      Fairbanks      Goldstein      B. Anderson

The radiocarbon reservoir age of surface ocean water (the difference between the  $^{14}\text{C}$  age of the ocean surface and that of the atmosphere) reflects the balance among  $^{14}\text{C}$  production, the spatial variability and magnitude of  $^{14}\text{CO}_2$  flux across the air-sea interface, oceanic circulation, and mixing with  $^{14}\text{C}$ -depleted intermediate and deep waters. For the pre-anthropogenic ocean the sea surface  $^{14}\text{C}$  reservoir age is about 300 - 400 years in tropical oceans and increases to 1200 years at higher latitudes in the Southern Ocean and the North Pacific. By contrast, there is little surface reservoir age gradient in the North Atlantic Ocean between  $40^\circ\text{N}$  and  $70^\circ\text{N}$ . The radiocarbon reservoir age of these surface waters is almost constant, at about 400-500 years.

The radiocarbon reservoir age of the ocean surface water is essential for linking the continental and marine climate

records. I aim to measure the surface water reservoir age using fossil corals.

No change since 7/06.

ANN COOK

3/07   Goldberg   Ryan   Malinverno   Menke

Gas hydrate filled fractures in marine sediments: Insight into a unique methane reservoir.

I propose to study the distribution and composition of natural gas hydrate filled fractures in unconsolidated marine sediments using data collected during the Chevron/DOE Gas Hydrate JIP Expedition 1 (JIP1) in May 2005, the Indian National Gas Hydrate Program Expedition 1 (NGHP-1) in May-August 2006, and the Chevron/DOE Gas Hydrate JIP Expedition 2 planned for spring of 2009.

Gas hydrate distribution and saturation is evaluated using well logs and borehole images integrated with pressure cores, sediment cores and seismic surveys. Borehole images from both JIP1 and NGHP-1 depict gas hydrate primarily residing in quasi-vertical planar fractures. These fractures are generally well ordered and associated with the local shallow stress regime. Analysis of two borehole images exhibiting well ordered fractures from the same drill site in NGHP-1 suggests fractures tend to be small local features extending only a few meters and occur in a sequestered interval within the gas hydrate stability zone.

Additionally, quasi-vertical gas hydrate filled fractures effect the accuracy of several borehole measurements, especially resistivity. Because the resistivity measurement is primarily used to determine hydrate saturation, current research is focused on the effect of fracture anisotropy on resistivity.

MARTIN COLLIER

3/07    Spiegelman   Kelemen   Goldstein

Inferences about melt transport, chemical interactions and the mantle source beneath mid-ocean ridges from spatial variability in global MORB geochemistry

Although I am generally interested in the dynamics and chemistry of partially molten regions throughout Earth's crust and mantle (past and present), my graduate research has



become focused on the magmatic systems underlying mid-ocean ridges, which are favored by many geoscientists for their "simplicity". Advised by professors Marc Spiegelman and Peter Kelemen, my work pursues two main objectives, 1) predicting changes in magma chemistry caused by various phases of mid-ocean ridge basalt (MORB) petrogenesis using the approach of fluid dynamical modelling integrated with geochemical/petrological calculations and 2) comparing predictions from my models with global and regional compilations of MORB geochemistry. Results from this research are allowing for new and quantitative tests of MORB formation and evolution models, with potentially more general implications for the sensitivity of geochemistry to geodynamic variables.

WEI DU

5/08

Walker

Kelemen

Harlow

#### Grossular-pyrope Garnet Series Solution Properties

Garnet on the join  $Mg_3Al_2Si_3O_{12}$  –  $Ca_3Al_2Si_3O_{12}$  (pyrope-grossular) is considered to be one of the most important solid solutions in the Earth's crust and upper mantle. Agreement between the different models of garnet mixing properties based on former experimental data is not very satisfactory. So in my thesis, I will present the unit cell parameters of garnet solid solutions on the pyrope-grossular join synthesized at Lamont-Doherty Earth Observatory (LDEO) using multi-anvil technique and measured by X-ray diffraction at Lawrence-Berkeley National Laboratory. I measured the volume changes in this garnet solid solution between 25 and  $\sim 600^\circ\text{C}$  and calculated the excess volume and thermal expansion in this temperature region. By fitting my new data to a thermal dynamic model, the new coexisting PT region for two phases garnet with composition on this pyrope-grossular join will be found and we will also hope to know how the consolute temperature changes with pressure. Then I will compare the modeling result with the following phase separation experiment result. And also I will check some natural garnets to see how their growing PT conditions will change concerning my new data and the revised thermal dynamic model.

New cretaceous mammals from Mongolia and the early diversification of eutheria.

For their great diversity, complete (in comparative terms) fossil record, and well-studied life history, mammals (and particularly fossil mammals) have played a major role in our understanding of evolution. Many key concepts and ideas originated on the study of mammals were later applied to the more general theory of evolution.

The initial part of my research will consist on describing two newly discovered and fairly complete Cretaceous eutherians from the Gobi desert. Mesozoic eutherians are rare and usually fragmentary, and any addition has a potential large impact on our understanding of early eutherian diversification. Moreover, the two new taxa seem to be related to two of the most controversial groups in mammalian systematics, Zalambdalestidae and Zhelestidae. I will add these two new taxa and 20 other genera of eutherians to a recently published data matrix (63 taxa, 408 characters) (Wible et al. 2007), and perform a cladistic analysis based on morphology, using parsimony as the optimality criterion.

Currently, there are three competing general hypotheses about the timing of mammalian evolution: long fuse, short fuse and explosive radiation models. I expect the outcome of my phylogenetic analysis to support one model more than the other two. Constraining the time of origin of the more successful group of living mammals (Placentalia) would allow a better idea of the context in which that process took place. In turn, this will make possible to address questions such as the role that continental fragmentation, climate change, the K-T mass extinction, etc. played in driving eutherian and placental mammalian evolution.

No change since 7/07.

Cosmogenic nuclide systematics and applications to climate research

My research broadly focuses on the refinement and development of cosmogenic nuclide systematics and applications to questions in geomorphology and climate change. Although surface exposure dating using cosmogenic nuclides has proliferated in the literature recently, we are only beginning to understand the full potential of surface exposure dating, as well as the pitfalls of the method. Currently, a better understanding of the production rate of the various cosmogenic nuclides is most needed, followed by a better understanding of production scaling with geographic position, atmospheric depth, and influences of the geomagnetic field. To this end, part of my research includes production rate calibration studies in multiple locations for the nuclides  $^{10}\text{Be}$ ,  $^{26}\text{Al}$ , and *in situ*  $^{14}\text{C}$ . The former two nuclides are widely measured, while the latter is currently measured infrequently due to the difficulty of extraction and the existence of only a single lab with extraction capabilities. To make *in situ*  $^{14}\text{C}$ , with its many advantages by itself or when combined with other nuclides, I have established the second *in situ*  $^{14}\text{C}$  extraction lab worldwide. The lab at Lamont effectively doubles the number of  $^{14}\text{C}$  analyses available for surface exposure dating.

With a better understanding of production rate systematics, we can begin to apply cosmogenic nuclides in new and novel applications. One project involves a better understanding of cosmogenic nuclide inheritance in glacial systems, as well as the deposition age of glacial geomorphologies in the Scoresby Sund region of east Greenland. Until very recently, it was previously thought that the accurate dating of moraines with surface exposure dating on historical timescales would prove to be prohibitively difficult. A second project is to establish ages on presumed Little Ice Age moraines deposited by cirque glaciers in the Cascade Mountains of Washington State with the aim to better understand the structure of Little Ice Age climate variations. Finally, recent evidence suggests that glaciers in the European Alps and worldwide varied in size over the Holocene. In theory, if subglacial erosion is low enough, the bedrock in front of a glacier should record a history of advance and retreat of the glacier front. My goal is to use the nuclides  $^{10}\text{Be}$  and  $^{14}\text{C}$  to extract a history of glacier front variations, and hence climate change, from

the concentration of the above two nuclides in the bedrock. This work will involve the measurement of low levels of both nuclides, presenting a methodological challenge, as well as a better understanding of subglacial erosion rates and application of glaciological modeling linked to a model of cosmogenic nuclide production and decay.

AMY GUAN

3/06

Ou

Gordon

Chen

A numerical study of shear dispersion in the benthic layer and thermocline.

R. CHADWICK HOLMES

4/05

Webb

Tolstoy

Menke

Crustal Structure Variations in Mid-Ocean Ridge Environments

Advances in ocean bottom instrumentation and seismic data analysis have offered marine scientists a clearer picture of oceanic crustal structure. Yet with clarity comes complication; studies now indicate oceanic crust can vary significantly from the classic ~6 km thick velocity model comprising three gradient-defined layers bounded by a sharp discontinuity at the Moho. Much of this variability occurs near plate boundaries, particularly in close proximity to mid-ocean ridge systems where new crust is continuously created. Does this reflect local stress differences changing the thickness of young lithosphere, inhomogeneities in the upper asthenosphere leading to non-uniform melting and underplating, or more regional differences at the whole plate level? What controls thickness differences between individual seismic "layers," and can this vertically-stratified velocity model truly describe the physical structure of oceanic crust?

In my thesis, I examine these issues by analyzing the crustal velocity structure within several different tectonic settings. Using data captured by ocean bottom instruments hydrophones (OBHs) and ocean bottom seismometers (OBSs), I explore:

1. The structure of young (~6 Ma) oceanic crust in the southern East Pacific Rise region with a 2-D seismic refraction line crossing non-hotspot ridge systems seemingly unrelated to normal mid-ocean ridge processes.

2. The variation in crustal thickness along the Southeast Indian Ridge (SEIR) from seismic refraction data collected along several ridge segments that show a progressive change in axial depth, axial morphology, and the presence and depth of an axial magma chamber even though the parent melt source and spreading rate (~72 mm/yr) remain nearly constant.

3. The difference in crustal structure to either side of the Birubi Transform, which separates the robust axial high along zone A of the SEIR from the characteristically deep and chaotic segment B5 within the Australian Antarctic Discordance (AAD). As an extension of the previous SEIR seismic refraction study, these results offer new insight into the variability of accretionary processes and upper mantle dynamics associated with the AAD.

KEVIN JONES

3/06

Goldstein

Hemming

B. Anderson

Exploring Neodymium Isotopes of Seawater in the Modern and Ancient Oceans.

My dissertation focuses on the study neodymium (Nd) isotopes in seawater and in iron-manganese (Fe-Mn) oxy-hydroxide sediments to further explore their usefulness as a paleoceanographic tracer. I am using an ocean general circulation model to better understand Nd isotopes in the modern ocean and to identify the importance of internal sources in different ocean basins. Additionally, I am analyzing seawater collected near the coast of South Africa to test for the existence of internal sources of Nd in this region. In the same study area I will also compare the Nd isotope composition of proximal Holocene Fe-Mn oxy-hydroxide sediments from the same depths to determine their ability to record the Nd isotopes of modern seawater. If I find that the sediments do accurately record the Nd isotopes of seawater in this region and that internal sources of Nd are absent, then I will analyze sediments dating back to the Last Glacial Maximum (~18,000 years ago) to determine whether or not ocean circulation was different during this period of drastically different climate.

No change since 7/07.

KATIE LEONARD

3/06

Christie-Blick

Tremblay

MacAyeal

### Antarctic Snow Drift Processes

My research combines numerical modeling, field observations, and remote sensing to study the redistribution of snow by the wind, with particular emphases on the role of drift in reshaping the Antarctic ice sheet surface and fresh water input to the southern ocean. Aeolian transport of snow is important in many environments due to climatic and fresh water budget implications, but is principally studied at the interface between snowy regions and society, e.g. in relation to avalanching, or road management and construction. Snow drift is also a potentially significant but poorly understood component of the mass balance of the Antarctic ice sheet. The redistribution of snow by the wind can lead to substantial errors in local estimates of ice sheet mass balance as determined from stratigraphic methods. Such point measurements are used as checks for mass balance and ice sheet models, and understanding drift processes should provide better estimates of the error of such measurements. Additionally, the amount of snow blown off the edges of the continent into the Southern Ocean is very poorly constrained, and may be as much as 10% of the total annual snowfall over Antarctica. When this snow leaves the ice sheet it plays a role in sea ice and polynya formation as well as air-sea interaction over open water.

No change since 7/06.

JINBAO LI

4/05

Griffin

Cook

Peteet

### Moisture Variability across China and Mongolia from Instrumental Data and Tree-ring Records

China and Mongolia (CM) are located in a region characterized by complex topography and climate. Due to the varying effects of multiple climate forcings, moisture availability within the CM varies dramatically. Understanding on the occurrence of droughts/floods over this diverse area is limited, partly due to the shortness of instrumental data. In order to recover long-term moisture changes, tree-ring analysis is essential, as growth rings of trees provide the exactly-dated, annually resolved estimates of past climate. My research is focused on developing a large tree-ring network over China. Along with the

available data from Mongolia, we can reconstruct moisture variability during the last several hundred years for much of CM. With such a more complete record we are able to understand how moisture has varied and what are the forcings of its variability. This knowledge will help to improve the prediction of moisture variations on annual to decadal and longer time scales.

No change since 7/07.

ANDREW MADOF

3/07 Christie-Blick Anders Martinson

On the non-eustatic mechanisms modulating sedimentation: examples from offshore Louisiana and the eastern Book Cliffs, western Colorado

DAVID McGEE

4/08 Anderson Broecker Winckler

Isotopic flux tracers: investigations of constant flux proxies in the western North Atlantic, dust in the equatorial Pacific, and hydrothermal inputs at Mono Lake

My thesis research uses the tools of isotope geochemistry to investigate three separate questions related to past and present fluxes in ocean and lake settings.

1. *Response of  $^3\text{He}$  and  $^{230}\text{Th}$  to sediment redistribution at the Blake Outer Ridge, western North Atlantic*  
Extraterrestrial  $^3\text{He}$  and adsorbed  $^{230}\text{Th}$  are commonly used to calculate fluxes in ocean sediments and to estimate lateral sediment advection. In both these applications, it is assumed that  $^3\text{He}$  and  $^{230}\text{Th}$  are evenly distributed among different sediment size classes. Some researchers have questioned this assumption, suggesting that the use of  $^3\text{He}$  and  $^{230}\text{Th}$  may be biased by grain size fractionation during sediment resuspension and transport. This project examines these assumptions by measuring  $^3\text{He}$  and  $^{230}\text{Th}$  in sediments reflecting different amounts of lateral advection and in different grain size fractions of the sediment.

2. *Constraints on hydrothermal fluxes into Mono Lake, California from  $^{36}\text{Cl}$  and  $^3\text{He}$*

Mono Lake is a closed-basin lake located in a volcanically active region. Its solute balance thus reflects inputs both from precipitation-fed surface runoff and groundwater and

from hydrothermal sources. Establishing the present state of this balance will assist in determining the lake's age, evaluating potential sediment core proxies for lake salinity, and understanding the lake's unusual carbon budget and past changes in the carbon reservoir age. In this project, we use the very different  $^{36}\text{Cl}/^{35}\text{Cl}$  ratios of hydrothermal and surface inputs to constrain the balance of chloride sources to the lake. We also use  $^3\text{He}$  as an integrated tracer of hydrothermal inputs to the lake. Sediment porewater profiles provide additional insights into the relationship between infiltration of saline lake waters and upwelling of fresher hydrothermal waters.

### 3. *Dust provenance in the equatorial Pacific Ocean*

Recent dust flux studies across the equatorial Pacific have provided important calibration data for models of dust transport and deposition. In the western equatorial Pacific, flux data conflict with present dust models, indicating much higher fluxes than models can reproduce.

Information on dust provenance would provide key constraints for model improvement. This project will involve traditional isotopic provenance tools (Sr, Nd, and Pb isotopes), trace element signatures, and novel provenance techniques ( $^4\text{He}/^{232}\text{Th}$  ratios) to try to identify the dominant dust source(s) in the equatorial Pacific, with a particular focus on the western Pacific.

OUSMANE NDIAYE

11/05

Sobel

Ward

Martinson

"Predictability of Sahelian Climate Characteristics: rainfall total, intra-seasonal distribution and onset."

My thesis focuses on understanding and predicting Sahelian rainfall variability the rainy-season starting date, the seasonal total, and the seasonal distribution. A focus is on aspects of the rainy season that are known to have greatest environmental and social impact, and in addition. the predictability of some of the impacts are directly assessed. The Sahel region is a transition zone between desert to the North (Sahara desert) and tropical forest to the South. Rainfall in this region strongly influences many aspects of society, including agriculture (crop production and livestock), water resources, and vector born disease outbreaks (malaria is the by far the first cause of mortality). Predicting its variability can have a huge benefit for the society.



The first chapter deals with the predictability of the seasonal rainfall total. In addition to exploring the maximization of skill using GCM model output statistics, I focus on a key issue which is changes in SST anomalies that take place in boreal spring and that currently limit the lead-time of seasonal predictions for the June-September rainfall season. One aim of the study is to provide a definitive analysis of this limitation, along with its reasons and possible avenues to increase the lead-time of predictions. A comparison of statistical and dynamical methods will be made.

The second chapter investigates the extent to which the predictability of large-scale circulation features can be translated into an ability to provide information on small spatial scales, and on the statistics of weather events through the season. These issues relate to how predictions can be made for variables like crop yield and vegetation greenness, and environmentally influenced diseases such as malaria. Through analysis of datasets and model outputs, key space and timescale prediction issues will be addressed, along with some key impact variables. The work will include more focused and detailed analyses on Senegal, comprising the westernmost zone of the Sahel, bordering the Atlantic Ocean.

In the third chapter, I look at characteristics of the atmosphere (dynamic and energetic) during the onset of the seasonal rainfall in Senegal, and the predictability of the onset date. Well-defined local and regional circulation features before and during rainfall onset in Senegal are identified using observations (Precipitable Water, OLR and Wind). The wind anomaly circulation at 850 hPa shows wave-like propagations prior to and during the rainfall onset, including both eastward and westward propagating features. The extent to which these features are captured in a state-of-the-science model is investigated using CFS ocean-atmosphere extended-range weather forecasts, with a view to exploring predictability of the onset on the timescale of several days to a few weeks.

STERLING NESBITT

10/06

Olsen

Norell

Christie-Blick

The relationships and rise of the archosaurs.

No response.

KORI NEWMAN

4/06

Menke

Cormier

Nedimovic

Application of new geophysics techniques on margins and ridges.

No change since 7/07.

PHILIP ORTON

3/06

Martinson

McGillis

Sobel

Coastal Ocean Turbulent Mixing and Air-Sea CO<sub>2</sub> Fluxes

A major uncertainty in global carbon budgets and predictions of future climate is the role of the tidal rivers, estuaries and the coastal ocean. My Ph.D. research examines the physical controls on air-water transfer of carbon dioxide in these systems, primarily the role and sources of turbulent mixing near the sea surface. The overriding goal is to address how numerical models can most efficiently replicate this gas transfer, facilitating the inclusion of coastal ocean CO<sub>2</sub> fluxes in global carbon budgets and climate models. Possible components include:

Variability of internally generated turbulence in an estuary, from 100 days of continuous observations. In press, *Continental Shelf Research*. (with M. Visbeck): Recent publications have developed a methodology called the “variance method” for remotely quantifying turbulence through the water column using Acoustic Doppler Current Profilers (ADCPs). We present detailed ADCP observations of internally generated turbulence in a sheared, stratified natural flow, as well as an analysis of the external factors leading to its generation and temporal variability.

Turbulence and stratification in the Hudson River estuary (with M. Visbeck, W. McGillis): This is the first comprehensive summary of stratification and turbulence in the Hudson River estuary, including measurements from a wide range of along-estuary locations, riverflow, and semi-diurnal tidal range.

Physical controls on air-water transfer of carbon dioxide in a partially mixed estuary (with W. McGillis, C. Zappa): I have been anchoring a small catamaran in the Hudson to make measurements of currents, turbulence, water column density structure, CO<sub>2</sub> fluxes, and wind. I will analyze CO<sub>2</sub> flux data against ambient forcing variables and compare the observations against a series of theories and models of increasing complexity.

Physical controls on continental shelf air-sea CO<sub>2</sub> fluxes: Autonomous in situ observations (with W. McGillis, J. Moisan): I was awarded a 2007 summer fellowship to utilize NASA's autonomous 20' boat called OASIS (Ocean-Atmosphere Sensor Integration System) to study the physical controls on continental shelf air-sea CO<sub>2</sub> fluxes. An additional goal is to evaluate the potential for using multiple OASIS platforms, satellite remote sensing data, and model assimilation for a larger-scale study that covers multiple shelf provinces and quantifies the global role of continental shelves in the carbon cycle.

No change since 7/07.

KANDAGA PUJIANA

3/08

Gordon

Ou

Martinson

The Makassar Strait dynamics at intraseasonal timescale

My research focuses on the energetic intraseasonal variability [ $<90$ -day] in the main conduit of the Indonesian Throughflow, Makassar Strait. The plausible sources of variability vary from the oceanic and atmospheric features emanating from the Pacific and Indian Ocean such as Rossby wave and Madden-Julian oscillation to the locally generated instability. The complete picture of the dynamics is investigated in the realm of data analysis, analytical approach and numerical modeling.

BYRDIE RENIK

3/06

Christie-Blick

Anders

Kelemen

An evaluation of competing models for extension across the Death Valley region, California-Nevada.

JOY ROMANSKI

5/03

Del Genio

Rossow

Sobel

Investigating the Role of Diabatic Heating in Global Atmospheric Circulation and Climate Sensitivity: An Energetics Approach

The circulation of the atmosphere is driven by the equator-to-pole temperature gradient. Exactly how this takes place, however, is the result of complex interactions among the various components of the climate system. One way to look at these interactions is via the Lorenz energy cycle, which

describes the response of the atmosphere to different sources of energy.

This study focuses on the generation of the energy available to drive atmospheric circulation. Contributions to the zonal mean and eddy available potential energy from latent heating from precipitation, surface sensible heat fluxes and radiative flux convergence are examined to elucidate how the various processes responsible for diabatic heating affect the atmospheric energetics.

The energy cycle is characteristic of a particular climate. The extent to which it varies under different climates is investigated using model output generated for the Intergovernmental Panel on Climate Change's Fourth Assessment Report. Output from models exhibiting large and small sensitivity to doubled carbon dioxide is examined to determine how the energy cycle might change in a warmer climate, and how these changes relate to the models' climate sensitivity.

No change since 7/07.

PAUL SCHMIEDER

4/06

Schlosser

Ho

Simpson

My research investigates the small scale mixing dynamics and transport mechanisms associated with estuaries. Many coastal waterways currently suffer from the effects of urbanization and industrialization in the form of polluted and contaminated water. To understand the impact of contamination, the hydrodynamics of these water bodies must be quantified. Through the use of deliberate tracers such as SF<sub>6</sub> (sulfur hexafluoride), we can gain insight on how mixing is affected by water stratification, river geometry, and tides. We can also use our tracer technique to quantify advection, dispersion, gas exchange, and residence times for these water bodies.

No change since 7/07.

ADRIENNE SMITH

3/08

Bell

Buck

Lerner-Lam

Recent observation has shown the subglacial water can penetrate to the ice sheet bed and influence the velocity of an ice sheet on a relatively short time scale. Questions that this raises and my work aims to answer are 1.) Can we image the subglacial hydrological system? 2.) How is water transported beneath an ice sheet, in channels or broader

flows? and 3.) What impact do subglacial processes have on the long term stability of an ice sheet?

MICHELLE SPAULDING    4/08    Flynn    Norell    Christie-Blick

Phylogeny of the stem Carnivoramorpha

The living order Carnivora is one of the most diverse extant mammalian order. The fossil record of this order extends, undoubtedly, back to the early Paleocene, roughly 63 million years ago. However, it is not until roughly 42 million years ago that clear representatives of the crown group arise. The fossils found in the interim time (stem carnivormorphans') have typically received little detailed study, and many previous treatments of the order tended to lump them into untested groupings, or ignore them completely. My research is focused upon these basal specimens, in order to create a clear picture of the series of evolutionary transformations that led to crown Carnivora. Questions that will be addressed, primarily, are the phylogeny of the basal taxa - is there a clear stem line series of taxa or several clades within the stem? and locomotor behavior of primitive taxa, hoping to shed some light on the primitive locomotor method of the Carnivoramorpha.

ABBY SPIELER                      3/05                      Schlosser                      Smethie                      Martinson

Transient tracer studies of ocean circulation in the Arctic Ocean and Nordic Seas.

No change since 7/07.

SANPISA SRITRAIRAT                      3/07                      Peteet                      Griffin                      deMenocal

Multiproxies analyses of past vegetation, climate, and sediment dynamics in Hudson River wetlands.

No change since 7/07.

DANIELLE STROUP                      3/08                      Tolstoy                      Bohnenstiehl                      Menke

No response.

DEBRA TILLINGER

3/07

Gordon

Ou

Yuan

The Indonesian Throughflow and its variability.

The Indonesian Seas are only low latitude conduit in the world ocean. Through their complex set of straits, the Indonesian Throughflow carries 10 million cubic meters of water per second from the Pacific Ocean to the Indian Ocean, altering the heat and freshwater budgets of both. This flow is variable on multiple temporal and spatial scales.

The objective of my research is to investigate the interannual time variability of the ITF transport and along channel speed with respect to El Nino-Southern Oscillation and the Indian Ocean Dipole Mode. The research will also include a broader examination of the role of the ITF in global heat transport. It will include observational in situ data from moorings in the Makassar Strait, the main route of the Indonesian Throughflow. The work will also incorporate historical hydrographic data and model output into a framework of geophysical fluid dynamics.

No change since 7/07

JILL VAN TONGEREN

4/08

Kelemen

Mathez

Goldstein

Thermal and Chemical Evolution of the Bushveld Upper Zone.

The Bushveld Complex is the world's largest layered mafic intrusion and the only one of its kind with its roof still intact. My dissertation focuses on the thermal and chemical evolution of the uppermost portions of the Bushveld in order to understand the nature of heat loss and differentiation in large magma bodies. Focus will also be on how the magma chamber interacted with the rocks into which it was emplaced. Comparisons between crystallization and cooling in intra-continental layered intrusions as well as mid-oceanic spreading centers will ultimately be important in our understanding of igneous crystallization in various tectonic settings.

## Modeling Climate and Production-related Impacts on Ice-core Beryllium-10

In order to better understand contemporary climate change and anthropogenic climate forcings, it is necessary to quantify solar forcing, the most significant natural forcing on centennial timescales. One way to learn more about past solar changes, particularly those on multi-decadal to centennial timescales, is to study the ice-bound archives of cosmogenic isotopes: substances that are produced by collisions between galactic cosmic rays (GCR) and atmospheric oxygen and nitrogen. Examples of cosmogenic isotopes include beryllium-10 ( $Be_{10}$ , half-life of 1.5 My),  $Be_7$  (half-life 53 days) and  $C_{14}$  (half-life 5730 years). Cosmogenic isotope production is related to solar magnetic activity, which modulates Earth's exposure to GCR flux. Changes in solar magnetic activity, in turn, have historically been positively correlated with changes in solar irradiance, particularly over the course of the 11-year sunspot cycle. This relationship between cosmogenic isotopes, solar magnetic activity and solar irradiance is the basis for the potential use of substances like  $Be_{10}$  as proxies for solar activity.

Beryllium-10 is particularly well suited for this purpose for two reasons: its long half life (compared to  $Be_7$ ) means that it lasts long enough to record changes over glacial-interglacial timescales, and its short atmospheric residence time (compared to  $C_{14}$ ) means that it can provide high-resolution time series in well-dated polar ice core records.

However, it is possible for climate changes -- which may or may not be related to changes in solar irradiance -- to confound solar signals in the  $Be_{10}$  record. Processes that affect the distribution of  $Be_{10}$  in the troposphere -- such as changes in stratosphere-troposphere exchange (STE) or aerosol scavenging efficiency, both of which may change with climate -- could distort the degree to which ice core records reflect production changes. Similarly, because a more or less active hydrologic cycle may dilute or exaggerate  $Be_{10}$  snow concentrations, any process that affects precipitation could also obscure a production-rate signal. If  $Be_{10}$  is to be unambiguously used to infer solar variation, we first need a way to account for the effects of climate as they appear in the ice core record. My thesis will approach this issue in three different ways:

1. One set of modeling experiments will broadly examine how production- and climate-related changes impact Be10 deposition by separately looking at how changes in production and changes in climate (doubled CO<sub>2</sub>, reduced NADW production, volcanic eruptions) affect Be10, particularly over Greenland and Antarctica (the main sources of the ice core data).
2. A second set of experiments will address the ways in which solar-related changes in both climate and production affect Be10 over during periods of reduced solar activity such as the Maunder Minimum.
3. Finally, a set of transient 20th-century simulations will be performed to calibrate the ways in which which Be10 is recorded differently in Greenland as opposed to Antarctica. The results of this experiment will have implications on understanding the degree to which solar activity over the past century is unusually high with respect to the past several millenia.

DAVID WANG

3/05

Cane

Seager

Chen

The changes of the Pacific ocean tropical thermocline in response to global warming

Both observational and modeling studies have shown that the tropical thermocline is ventilated via the shallow meridional overturning circulation (aka. the subtropical cells, STCs) by the extratropical surface waters. Therefore both the changes of the STCs and of the properties of the extratropical source waters are capable to alter the characteristics of the tropical thermocline. In this study, we will first document the changes of the tropical thermocline in the Pacific ocean from a suite of IPCC AR4 climate model scenario runs. Then we will use both a backtracking trajectory algorithm and a transport matrix-based adjoint tracer method to quantify the changes of the locations and the hydrographic properties of the source waters of the tropical thermocline as well as the ventilation pathways and the transit time between the current climate and a warmer climate. Since the tropical thermocline is one of the most important components in the tropical ocean-atmosphere climate and climate variability such as El Nino - Southern Oscillation, this study has the important implication of better understanding how the tropical climate will respond to global warming.



### Mobilization of Arsenic from Contaminated Sediments

My research focuses on arsenic cycling in the environment and specifically on the mobilization of arsenic from contaminated sediments at the Vineland Chemical Company Superfund site in southern New Jersey. Arsenic is the second most common contaminant of concern at U.S. Superfund sites, and contaminated groundwater is often remediated using pump and treat technology. However, arsenic can sorb to iron and aluminum oxyhydroxides in the sediments making pump and treat remediation less effective and thus slower to reach the desired level of clean up, as has been the case at Vineland. Therefore, my current research aims to improve the efficiency of pump and treat by increasing the mobilization of arsenic from the sediment into the groundwater that will then be treated. This research involves laboratory experiments in which I make chemical amendments to soil columns and monitor their effect on arsenic mobility as well as hydrological modeling and in situ field testing of the most promising chemical amendments. The information gained from these laboratory and field studies should be applicable to numerous arsenic contaminated sites where pump and treat remediation is currently being used or where it may be used in the future. Additionally, what we learn from this work about factors that influence arsenic mobility may also help us understand arsenic cycling and mobilization in areas of the world where naturally occurring arsenic is contaminating groundwaters that are used for drinking water supplies.