



DEPARTMENT OF GEOLOGICAL SCIENCES

2006 ANNUAL REPORT

Northwestern University | Judd A. and Marjorie Weinberg College of Arts and Sciences

Overview

With the excitement of another academic year rapidly building, and the concomitant administrative tasks growing by the day, I must quickly steal a few moments to write to you, the alumni and friends of Northwestern's Department of Geological Sciences. After my first year as department chair, I have many new developments to report. But before I do, let me extend a heartfelt thanks for your continued support. Upon becoming chair, I felt a great sense of pride when I learned that our alumni are among the best in WCAS when it comes to giving. Your generosity makes so much of what we do possible. I speak for undergraduates, graduate students, and faculty alike when I express our deep appreciation.

In the last report from our former chair, Donna Jurdy, you heard about some of the superb hires the department has recently made. For example, Dr. Matthew Hurtgen (Ph.D., Penn State, 2003) joined the department in September of 2005. Matt has brought an entirely new dimension to our geochemistry and paleoclimate studies group with his expertise in Astrobiology and the Snowball Earth hypothesis. He wasted no time developing exciting new classes for our students (e.g., *Climate Catastrophes in Earth History*), in taking on new advisees for research projects, and in establishing a lab for extraction of sulfur-bearing compounds from ancient shales and limestones. Matt's inexhaustible supply of energy and expertise in sulfur biogeochemistry have made a big impact on the department, and we are thrilled to have him here.

This summer, Dr. Francesca Smith (Ph.D., U. of Chicago, 2002) concluded her postdoctoral appointment at Penn State University and moved to Evanston. Her expertise in organic and stable isotopic biogeochemistry further diversifies our geochemistry and paleoclimate studies group. Cesca's research on the Late Paleocene Thermal Maximum utilizes novel isotopic analyses of terrestrial floras and complements other faculty and student investigations of dramatic climate events.

With Cesca's addition to the faculty, the department has established a critical mass of analytically inclined researchers and is now in the final planning stages of a new laboratory suite to be located

in the Technological Institute. This facility will include an isotope ratio mass spectrometry (IRMS) lab with the capability to analyze C, O, N, H and S in modern and geological samples, as well as a Thermal Ionization Mass Spectrometer (TIMS) for the analysis of isotopic systems such as Sr and U. The IRMS lab will be managed by Drs. Hurtgen, Smith, and myself while the TIMS lab will be directed by Dr. Andrew Jacobson. A variety of preparatory rooms will stand adjacent to the instrument labs. These will include an organic geochemistry lab for separation and characterization of biomarker compounds, a sedimentary geochemistry lab for analysis of elemental concentrations in modern and ancient sediments, and an aqueous geochemistry lab and clean room for water chemistry

analysis and heavy element isotope sample preparation. The construction of this laboratory represents the first stage of the department's planned move to north campus, and its completion will herald a new era in our research efforts. Integrating the results of new studies conducted in this lab with the department's traditional theoretical and numerical strengths in biogeochemistry will create a powerful synthesis of techniques.

Lest you think our efforts have focused solely on geochemistry and climate studies, let me report on our most recent hire. Dr. Steven Jacobsen is a mineralogist and mineral physicist specializing in the physics and chemistry of Earth and planetary materials. He holds a Ph.D. from the University of Colorado (2001) and has already received several prestigious awards and fellowships, including the Mineral and Rock Physics Outstanding Student Award from AGU, an Alexander von Humboldt Fellowship from the German government, and the Barbara McClintock Fellowship from the Carnegie Institution. Dr. Jacobsen has been described as "the very best young experimentalist in the field" of high pressure-temperature materials research. Already demonstrating a gift for innovative research methods, he has developed the GHz ultrasonic interferometry



The Department of Geological Sciences, May 2006.

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technique, which measures the physical properties of nanogram quantities of materials at high pressures and temperatures. Dr Jacobsen currently operates the only such laboratory in the nation at the Carnegie Institution and has begun moving it to NU. With his addition to existing faculty working at the interface of seismology and mineral physics, we are poised to address some of the most pressing questions in Earth structure and to identify the driving forces behind plate tectonics.

In addition to the exciting news about our new hires, there have been some notable developments among the resident faculty. For example, Professor Lerman had a productive year, authoring or co-authoring nine publications in a variety of technical journals and research volumes. Professor Okal, one of the busiest seismologists on the planet since the 2004 Indonesian tsunami, was invited to give over forty presentations at professional meetings and academic institutions, including the "Frontiers in Geophysics" lecture at the fall 2005 AGU meeting--quite an honor! In addition to maintaining a hectic lecturing schedule, Emile also proved quite prolific this year, publishing eighteen first- or co-authored articles. Finally, Seth Stein received two honors. He was named a Distinguished Lecturer for IRIS and the William Deering Professor of Geological Sciences by the NU administration.

Other recent developments include changes in our undergraduate curriculum and the initiation of a departmental field trip program. This academic year we will introduce a new curriculum to the undergraduate major, the *Earth System Science* track. This new option will include a broader range of prerequisites and a more structured set of major requirements in Earth and Planetary Science. It will provide both a solid background in basic math and

science and a sampling of topical material spanning major subfields of modern geoscience. Although our traditional curriculum, now known as the *Geological Science* track, may remain a preferred path for students intending to pursue advanced degrees in geoscience, the *Earth System Science* track will offer a degree path for students bound for professional schools such as law, business, or medicine. In conjunction with these new curricular initiatives, we have established a complementary field trip program. The department now subsidizes two field excursions per year for all interested students. During spring break 2006 we visited Big Bend National Park in west Texas while our fall trip took us to Yellowstone and Grand Teton National Parks. To highlight these program changes and to make the department more accessible to NU students, the faculty voted to rename the department. Sometime next year we expect to become the *Department of Earth and Planetary Sciences*.

As you can see from this abbreviated overview of our activities, the department has continued to pursue the highest levels of excellence in teaching and scholarship. We are now engaged in an exciting growth phase with many new initiatives. Your past support of our endeavors has been crucial, and we hope you will continue to assist us as we expand the department's programs. During the coming years we will likely ask you for contributions in support of undergraduate research awards, field trips and field work, general operating funds assisting junior faculty in starting their research, or other initiatives. If you are interested in learning more about any of our funds, or about how your contributions have been put to use, please visit our website and check the section on alumni support (<http://www.earth.northwestern.edu/alumnisupport>). Once again, we thank you for your generous contributions.--Brad Sageman



Craig Bina: Wayne V. Jones II Professor of Geological Sciences (Ph.D., Northwestern University, 1987). Professor Bina performs thermodynamic modeling of phase relations in the mantle, under equilibrium and disequilibrium conditions, to investigate the seismology and geodynamics of the mantle and subducting lithosphere. He also studies the composition and mineralogy of the mantle, investigating the possible effects of thermal and compositional variations, elemental partitioning relations, redox reactions, and structural transitions. Insights into such behavior can be gleaned from the geophysical properties of the mantle, such as small scatterers of seismic energy as well as the larger seismic wavespeed structures detected by seismic tomography.

In 2005-06, Professor Bina presented his work on deformation of subducting slabs at the 9th International Workshop on Numerical Modeling of Mantle Convection and Lithospheric Dynamics in Erice, Sicily, and at the 2006 meeting of the Japan Geosciences Union in Chiba, Japan. He later updated these results at the 5th Biennial Workshop on Subduction Processes in the Japan-Kurile-Kamchatka-Aleutian Arcs in Sapporo, Japan. As a member of the NU Institute on Complex Systems, he presented his analysis of the propagation of strain energy in networks at the 2005 fall AGU meeting in San Francisco and later spoke on its implications for triggered seismicity at the University of Tokyo. He also lectured on other topics at the University of Tokyo and at Ehime University in Matsuyama, Japan.

Matthew Hurtgen: Assistant Professor (Ph.D., Pennsylvania State University, 2003). Dr. Hurtgen's research addresses both modern and ancient sedimentary systems, integrating elemental abundances, stable isotopes and sedimentological data to understand the causes and consequences of extreme climate change and the redox evolution of the coupled ocean-atmosphere system in deep time. In his first year at Northwestern, Matt has concentrated on establishing a functioning laboratory, most notably by constructing carbonate-associated sulfate and pyrite extraction lines. Both lines are now working overtime processing samples from India, Arctic Canada, Namibia, Newfoundland, the United States, the Bahamas, and China.

More recently, Matt and two colleagues spent much of the summer in Australia collecting 800 million year-old carbonates for geochemical analysis. At the same time, Matt's first-year graduate student, Kumar Sahoo, endured extreme heat and monsoons during his initial field season in India where he obtained Mesoproterozoic carbonates and shales. Finally, Matt and undergraduate student Joe Hoover just returned from Minnesota where they acquired water column, pore water and sediment samples from a sulfate-rich lake. Hurtgen will use the samples to assess their utility as a relatively new paleoceanographic proxy--the oxygen isotope composition of sulfate. Ultimately, Matt hopes to use this proxy to constrain the chemical evolution of Earth's ocean-atmosphere system.

Steven Jacobsen: Assistant Professor (Ph.D., University of Colorado, 2001). Dr. Jacobsen is an experimental mineralogist specializing in the physics and chemistry of Earth and planetary materials as they pertain to solid-Earth geophysics, geochemistry, seismology, and mantle petrology. Our newest faculty hire, he has recently arrived at Northwestern. Please read more about Dr. Jacobsen on pages 1-2.

Andrew D. Jacobson: Assistant Professor (Ph.D., University of Michigan, 2001). Dr. Jacobson specializes in low-temperature aqueous and radiogenic isotope geochemistry. His research uses a combination of field work, laboratory experiments, and modeling to quantify the rates and mechanisms of chemical, physical, and biological phenomena cycling elements at or near the Earth's surface. His current interests include controls on the major ion and radiogenic isotope (Sr, Ca, U-Th) geochemistry of major rivers, streams, and groundwater systems; the delivery of Ca, Sr, and Nd to seawater via the deposition of calcite dust; and the biogeochemistry of microbial interactions with geologic materials.

In the spring of 2006, Jacobson published an article in *Earth and Planetary Science Letters* addressing how the atmospheric supply of calcite dust to the Japan Sea influences the cycling of Nd isotopes in seawater. He also presented this research at the most recent AGU meeting in San Francisco. The work provides a new hypothesis explaining a long-standing paradox about the origin of Nd in seawater. Jacobson is now preparing a manuscript focusing on the use of Sr and Ca isotopes as hydrologic tracers of water-rock interaction in the Wyodak-Anderson Coal Bed aquifer, Wyoming. He currently advises two graduate students, Lingling Wu and Matt Weiss. Wu is undertaking laboratory-scale experiments designed to elucidate the effect of bacterial metabolism on basalt dissolution under P- and Fe-limited conditions. She is also investigating the fractionation of Ca isotopes during microbe-rock interactions. Meanwhile, Weiss is examining the Sr and Ca isotope geochemistry of rivers draining the North Slope of Alaska to understand the effects of climate change on elemental cycling in the arctic. Last year, Jacobson was appointed as an Adjunct Professor in the NU Department of Civil and Environmental Engineering and also taught courses in geomicrobiology and introductory physical geology, the latter of which included a field trip to Baraboo, WI.

Donna M. Jurdy: Professor (Ph.D., University of Michigan, 1974). Professor Jurdy's current research focuses on the tectonic activity of Earth, Venus, Mars, and Jupiter's satellites. As part of NASA's Mars Data Analysis Program, she and Michael Stefanick analyze the magnetization of the Martian crust to decipher the origin and history of the planet's strong magnetic lineations. The Red Planet unexpectedly records a strong magnetization in its heavily-cratered southern hemisphere in the absence of any current field. Results will soon be published of magnetic measurements collected at the satellite level of 400 km and continuing downward to the planet's surface. They attempt to establish when and how Mars' crust became magnetized and to understand the subsequent process of demagnetization in some areas. Work on Venus examines its distinctive tectonics. With Paul Stoddard, Jurdy is attempting to relate the formation of coronae to the uplift of the regiones, Venus' topographic and geoid highs. Coronae, unique circular features ranging in diameter from 100-2600 km, may be caused by diapirs. She is also collaborating on a project investigating microplate motions in the hotspot reference frame.

Recently, Professor Jurdy was named a co-editor of a GSA *Special Paper* on plumes. This volume will publish contributions from the recent AGU Chapman Conference discussing the "great plume debate". She continues as chair of the DOSECC (Drilling Observation and Sampling of Earth's Continental

Crust) Education Committee, overseeing the Internship Program, and is initiating a lecture program for the drilling project. An original member of EPA's STAR Fellowship Program Panel, she served on this committee for the eighth time this past year. Finally, Jurdy also filled an advisory role in two areas: to the Canadian government, on funding for new geoscience facilities; and to Earth Images, an educational film group.

Abraham Lerman: Professor (Ph.D., Harvard University, 1964). Professor Lerman is pursuing three areas of inquiry. His first project examines the roles of the global biogeochemical cycles of carbon, nitrogen, and phosphorus in the evolution of the Earth's surface environment. He seeks to identify the mechanisms responsible for the rise in atmospheric carbon dioxide in both the Industrial Age and the pre-industrial time after the last glacial maximum. A second study focuses on the transport of argon and other gases from the sedimentary crust to the atmosphere, a process arising from the diagenesis of clay minerals. This project has determined the escape rates of radiogenic isotope argon-40, which makes up most of the present-day atmospheric argon, and it further addresses clay mineral formation in oil-bearing and other sediments. Lerman also studies the carbon budget and carbonate-mineral saturation of the paleo-oceans, attempting to reconstruct their chemical state and saturation with respect to carbonate-minerals forming biogenically and/or inorganically under the variable carbon-dioxide atmospheric levels.

In 2005-06 he co-authored a book, *Carbon in the Geobiosphere*, with Fred Mackenzie; published numerous articles; and participated in or organized several conference panels. Most notably, at the 15th Goldschmidt Conference, he organized a symposium, "The Land and Oceans as Regulators of Atmospheric CO₂". The session addressed new research on the regulation of atmospheric CO₂ on land and in the ocean, at short and long time scales. He gave invited lectures at the annual GSA meeting and at the triennial Geochemistry of Earth Surface International Symposium, held in Aix-en-Provence. In the latter paper, on "CO₂ and sulfuric acid controls of weathering and river water composition", Lerman and graduate student Lingling Wu calculated the consumption of carbon dioxide and sulfuric acid in weathering reactions, the chemical composition of a world average river from a mineral dissolution model, and the order of rock-forming minerals' stability in weathering.

Emile A. Okal: Professor (Ph.D., California Institute of Technology, 1978). Professor Okal studies the generation, propagation, and coastal effects of tsunamis following large earthquakes and underwater landslides. On the theoretical front, Okal studies the properties of tsunamis generated by both earthquakes and underwater slumps. After the 2004 Sumatra disaster, he and Seth Stein were first to propose that the source of the earthquake was initially underestimated. More recently, he has analyzed records of the Sumatra tsunami from technologies as varied as hydroacoustics, GPS, satellite altimetry and classical seismological stations to quantify the excitation of the tsunami across several frequency bands. In 2005, Okal led field surveys of the Sumatra tsunami in Madagascar and Oman, and plans additional field work in the Comoros later this Fall.

Okal also studies the generation and propagation of acoustic energy in the water body of the world's oceans, from sources as varied as earthquakes, underwater landslides, volcanic eruptions, icebergs and man-made explosions. One of his central concerns is to define discriminants allowing the identification of such sources. Okal has directed the deployment of seismometers on Antarctic icebergs, which have reaped a considerable dataset of unexpected results, from the motion of the bergs induced by the Sumatra (and at least one other) tsunami to their response to ocean swell

originating during major storms at the other end of the Pacific Ocean.

In the past year, Okal presented his research in the U.S.--most notably, giving the "Frontiers of Geophysics" lecture at the fall AGU meeting and a tutorial lecture to the Acoustical Society of America--and abroad in locations such as Potsdam, Rome, Paris, and Bangkok. He was one of three lecturers in the UNESCO Tsunami Training Sessions held in Kuala Lumpur, Malaysia and Oostende, Belgium, for scientists in developing countries.

Bradley B. Sageman: Professor and Chair (Ph.D., University of Colorado, 1991). Professor Brad Sageman is a sedimentary geologist whose research focuses on siliciclastic facies and their use as recorders of changes in climate and tectonism during geologic history. Much of his work has examined the causes and consequences of organic matter burial in ancient marine mudrocks, the impact of this process on the paleo-carbon cycle, and its role in the development of hydrocarbon source rocks and unconventional reservoirs. His scientific interests range, however, from studies of sea level history and subsidence patterns in ancient epeiric basins, to investigation of orbital forcing in hemipelagic deposits, to analysis of the ecological-evolutionary implications of oxygen deficient conditions thought to attend organic matter burial events. Additionally, Sageman currently advises or co-advises six graduate students whose research projects include development of orbital time scales for rhythmically bedded hemipelagic deposits and their application to biogeochemical analyses; paleobotanical assessment of changes in pCO₂ across a major carbon cycle perturbation; analysis of nutrient cycling during the Cenomanian-Turonian Oceanic Anoxic Event II; use of facies and sediment thickness patterns to test alternate hypotheses for the origin of the Cretaceous Western Interior sea; and analysis of mineral surface area as an agent in organic matter burial and hydrocarbon generation during thermal maturation of organic-rich shales.

Brad wrote or contributed to three 2005 publications and expects four more papers to be published in 2006. In the past year, he was invited to speak at a symposium on oceanic anoxic events in Sapporo, Japan; at an NSF-sponsored workshop on geochemical proxies; at the annual AAAS meeting St. Louis; and at the European Geophysical Union meeting in Vienna. In May 2006 he was elected as a Fellow of the Geological Society of America.

Francesca Smith: Assistant Professor (Ph.D., University of Chicago, 2002). Dr. Smith is a biogeochemist who uses the isotope signatures of organic biomarkers to reconstruct climates and ecosystems in the geologic past. She develops novel proxies and generates paleoclimatic and paleoecologic records through molecular isotopic techniques. In developing proxies, her approach involves characterizing isotope systems in modern environments and employing field and greenhouse studies of living plants. Her work on modern grasses, published in *Geochimica et Cosmochimica Acta* (2006), demonstrates that the compound-specific hydrogen isotope ratios of leaf wax lipids reflects aridity, indicating their promise as a paleoaridity index. In addition, the study shows that C₃ and C₄ grasses grown side by side in a greenhouse record different hydrogen isotopic signatures, reflective of differences in leaf anatomy.

For the past three summers, Smith has been working in collaboration with Scott Wing (Paleobotanist, Smithsonian), Jon Bloch (Vertebrate Paleontologist, Florida Museum of Natural History) and Kate Freeman (Isotope Geochemist, Penn State) to develop a recently identified field area in the Bighorn Basin. This area, Cabin Fork, contains the first fossil floras from the Paleocene Eocene Thermal Maximum (PETM) (~55 Ma) and demonstrates large plant migrations during this abrupt and extreme warming

as published in the November 2005 issue of *Science*. Smith has developed both bulk carbon isotope chemostratigraphy as well as compound-specific carbon and hydrogen isotope records of leaf wax n-alkanes across this interval and has presented her results at the GSA meeting in Salt Lake City, and at the Climates and Biota of the Paleogene meeting in Bilbao, Spain. These records are providing new insights into terrestrial carbon cycling and paleoclimate during an extreme warming event similar to what is anticipated for the coming centuries.

Seth Stein: Professor (Ph.D., California Institute of Technology, 1978). Seth Stein's research investigates plate boundary processes and deformation within the lithosphere, using a variety of techniques. His work can be divided into three general themes. One is the geometry of plate boundaries, the motions there, and how these evolve. A primary focus is a collaborative effort studying plate convergence and mountain-building in the central Andes by integrating topographic, GPS, seismological, and geologic data with numerical modeling. A second focal point is the Adriatic where a joint effort produced a model of plate motion evolution. A parallel study investigates North American plate rigidity and intraplate deformation. Finally, a joint program using GPS to quantify the rate and distribution of strain accumulation in the New Madrid seismic zone, when combined with seismological studies, implies that the earthquake hazard here has been overestimated and that building codes may not require expensive anti-seismic construction. A related project uses GPS data to observe postglacial rebound and explore its effects in intraplate seismicity.

In the past year, though, much of Stein's attention focused on the great 2004 Sumatra earthquake. With Emile Okal, Stein used long period normal modes to show that the earthquake was about three times bigger than first estimated. The larger moment reflects slip along the entire rupture zone (suggested by aftershocks), rather than only the southern 1/3 as originally inferred from body wave inversions. This observation explains the large Sri Lankan and Indian tsunami amplitudes because they are greatest perpendicular to the fault. Importantly, it also implies that strain on the entire rupture zone has been released, leaving no immediate danger of a comparable oceanwide tsunami arising from this part of the plate boundary. Stein and Okal are now examining subduction zones worldwide to determine if the risk of similar earthquakes can be predicted from plate convergence rate and the age of the subducting lithosphere. They are also working with University of Nevada colleagues to deploy GPS in tsunami warnings.

Suzan van der Lee: Assistant Professor (Ph.D., Princeton, 1996). Suzan van der Lee investigates the structure of and processes in the Earth's upper mantle by analyzing seismic waves that have traversed the upper mantle. Van der Lee is currently examining the North American upper mantle with one graduate student, Heather Bedle, and the South American mantle with another graduate student, Simon Lloyd. The work on North America occurs within the context of Earthscope, a long-term national facility dedicated to exploring the structure and evolution of our continent.

Bedle and Van der Lee recently published a paper in *Tectonophysics* suggesting that a fossilized Proterozoic flat subduction zone lies beneath the Illinois Basin; Heather presented this work at the fall AGU meeting and at a workshop in Argentina. Lloyd and Van der Lee are also studying the effects of ignored observed anisotropy on isotropic tomographic models, and Simon presented their results at the EGU meeting in Vienna and at an IRIS workshop in Arizona. Additionally, Van der Lee submitted three more papers with former students Christian Schmid and Mei Feng--and one of these is already in press. Finally, with new faculty member Steven Jacobsen, she completed editing a book on "Earth's Deep Water Cycle".

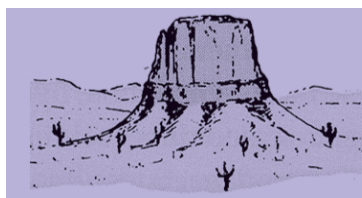
OTHER APPOINTMENTS

G. Edward Birchfield: Professor *emeritus* (Ph.D., University of Chicago, 1962). *Research Interests:* Climates of the Tertiary to Holocene; causes of climate change, its dependence on the deep ocean circulation, carbon chemistry, and Milankovitch orbital perturbations; coupling models of ocean-atmosphere-ice sheets; geophysical fluid dynamics.

Jean-François Gaillard: Associate Professor of Civil Engineering, joint appointment with Geological Sciences (D. ès Sci., Université Denis Diderot [Paris 7], 1987). *Research Interests:* Aqueous and sedimentary geochemistry; transport processes; cycles of trace elements; environmental biogeochemistry.

Michael Stefanick: Research Associate (Ph.D., Princeton University, 1980). *Research Interests:* Analysis of geophysical datasets and the statistical treatment of errors; earlier work on MAGSAT and UARS pre-flight simulations, Venus Data Analysis Program developing gridding techniques and data analysis. Current work on Mars magnetic analysis.

Johannes Weertman: Walter P. Murphy Professor of Materials Science and Engineering *emeritus*, Adjunct Professor of Geological Sciences (D.Sc., Carnegie Institute of Technology, 1951). *Research Interests:* Fatigue of metals; creep of crystalline solids; dislocation theory; geothermal energy; mechanics of glaciers; ice ages; processes on Jovian moons.



GRADUATE STUDENT RESEARCH



Derek Adams: A second-year student interested in sedimentary geochemistry, Derek is advised by Matthew Hurtgen and Brad Sageman. With Dr. Hurtgen, Derek is studying stable sulfur isotopes in the Late Cretaceous Western Interior Seaway (WIS). He plans to develop a WIS sulfur isotope dataset to be correlated with existing carbon isotope data, particularly information surrounding the Oceanix Anoxic Event near the Cenomanian/Turonian boundary. With Brad Sageman, he is investigating the Laramide orogeny by refining and adding to isopach maps for the Western Interior Basin.

Hanmantha Chary Allepalli: Chary is a second-year student interested in seismic tomography. His research, supervised by Suzan van der Lee, measures the delay times of P- and S-wave arrivals at Indian earthquake recording stations so he can find the lateral and vertical shear-wave velocity variation in the crust and upper mantle below.

Richard Barclay: Advised by Brad Sageman and Adjunct Assistant Professor Jennifer McElwain, Rich is studying the terrestrial record of the Cenomanian-Turonian Oceanic Anoxic Event II. This event suggests a major perturbation in the global carbon cycle and climate. Rich will use the stomatal index method, developed by McElwain and colleagues, to test for changes in atmospheric CO₂ levels and trends in plant diversity and morphology across the event so he can reconstruct the climate history of his study area in SW Utah..

Barclay, R. S., D.L. Dilcher, J.C. McElwain, and B.B.Sageman, Calibrating atmospheric CO₂ changes with the cuticle database, *Advances in Paleobotany Meeting*, Gainesville, FL (2006).

Barclay, R. S., J.C. McElwain, and B.B. Sageman, Testing the pCO₂ draw-down hypothesis for oceanic anoxic event 2 (94 ma) using fossil plant cuticle, *European Paleobotany and Palynology Conference*, Prague, Czech Republic (2006).

Titus, A.L., L.B. Albright, and R.S. Barclay, The first record of Cenomanian (Late Cretaceous) insect body fossils from the Kaiparowits Basin, northern Arizona, *Symposium at the Grand Staircase Escalante National Monument*, Kanab, UT (2006).

Heather Bedle: Heather's research, directed by Suzan van der Lee, uses seismic tomography to investigate the upper mantle structure of the North American plate. She recently concluded work on the mid-continent U.S. and is now using data from Earthscope's USArray seismic stations to improve tomographic images for the Western U.S. Heather was an Atmospheric, Earth and Energy Department Technical Scholar at Lawrence Livermore National Laboratory during spring quarter.

Bedle, H., and S. van der Lee, Fossil flat-slab subduction beneath the Illinois Basin, USA. *Tectonophysics*, in press (2006).

Bedle, H., and S. van der Lee, Using USArray data to better resolve the upper mantle in S-wave tomography, *IRIS Annual Workshop*, Tuscon, AZ (2006).

Bedle, H., and S. van der Lee, Evidence of fossil flat subduction in tomographic images, *GSA Backbone of the Americas Conference*, Mendoza, Argentina (2006).

Bedle, H., and S. van der Lee, Slow Mid-Lithosphere beneath the Mid-continent, USA, *Fall AGU Meeting*, San Francisco, CA (2005).

Joniell Borges: Joniell's first project, directed by Brad Sageman, investigates the factors that determine the fate of organic materials in sediments. He is studying the interactions between mineral surfaces and organic materials and the roles of clay minerals during organic material sequestration, burial, preservation and storage. A second project with former faculty member Youngsook Huh, now at Seoul National University, examines the constraints on river bed sediment compositions in contemporary large river systems.

Borges, J.B., and Y. Huh, Petrography and chemistry of the bed sediments of the Red River in China and Vietnam: Provenance and chemical weathering, *Sedimentary Geology*, in press (2006).

Borges, J.B., and B.B. Sageman, Mineralogical control on mineral surface measurements and its relationship to organic carbon concentrations in sediments, *Fall GSA meeting*, Salt Lake City, UT (2005).

- Jason Flaum:** Under Brad Sageman's direction, Jason is investigating the cycling of phosphorus during Oceanic Anoxic Event II, which was characterized by widespread deposition of organic carbon-rich strata. OAE II is widely believed to have resulted in a global increase in marine primary production, and Jason is attempting to identify and quantify the nutrient sources necessary to initiate and sustain such a surge.
- Flaum, J.A., B.B. Sageman, and P. DeJtrakulwong, Phosphorus cycling during transgressive phase of the Cenomanian–Turonian Greenhorn Cyclotherm - Western Interior Basin, *Fall GSA Meeting*, Salt Lake City, UT (2005).
- Flaum, Jason A., B.B. Sageman, M. Hurtgen, and P. DeJtrakulwong, Controls on phosphorus recycling during Cretaceous oceanic anoxic events, *ASLO Summer Meeting*, Victoria, B.C. (2006).
- Simon Lloyd:** Simon's research, guided by Suzan van der Lee, uses receiver function analysis and seismic tomography to investigate the structure of the Precambrian South American crust and upper mantle. He is also analyzing potential cases of bias in isotropic tomographic models of the Mediterranean, North America and South America. This bias may be caused by ignored anisotropy.
- Lloyd, S., and S. van der Lee, Influence of observed mantle anisotropy on isotropic tomographic models, *European Geosciences Union General Assembly*, Vienna, Austria (2006).
- Lloyd, S., S. van der Lee, and M. Assumpção, Crustal structure and thickness of Precambrian South America from receiver function analysis, *IRIS Workshop*, Tucson, AZ (2006).
- Robert Locklair:** With Brad Sageman, Rob is working on regional correlations of strata from the Cretaceous Western Interior basin. His research uses observations and measurements of outcrops and boreholes in the Southern Rockies along with geochemical, biostratigraphic, chronostratigraphic and cyclostratigraphic datasets to characterize temporal and spatial patterns of lithofacies and sedimentary accumulation rates. Ultimately, Rob hopes to understand the patterns of and controls on organic carbon enrichment in the epicontinental seaway. His summer field work was supported by Encana Oil and Gas, Inc.
- Alberto López:** Advised by Emile Okal and Seth Stein, Alberto recently completed his dissertation, which analyzes two major 1946 Aleutian tsunamis to determine their causes and assesses the chances for similar events in the Caribbean and Atlantic. Alberto has been named a Mendenhall Postdoctoral Research Fellow and will continue his tsunami research at the Woods Hole Oceanographic Institute.
- López, A., and E. Okal, A seismological reassessment of the source of the 1946 Aleutian 'tsunami' earthquake, *Geophys. J. Int.*, doi: 10.1111/j.1365-246X.2006.02899.x (2006).
- López, A. M., S. Stein, T. Dixon, G. Sella, E. Calais, P. Jansma, J. Weber, and P. LaFemina, Is there a northern Lesser Antilles forearc block?, *GRL* 33, L07313, doi:10.1029/2005GL025293 (2006).
- López, A. M., D. Jurdy, S. Stein, M. Liu, T. Dixon, E. Norabuena, and D. Hindle, Plate boundary zone kinematics and Andean uplift, *GSA Backbone of the Americas Conference*, Mendoza, Argentina (2006).
- López, A. M., and S. Stein, Effects of a possible Northern Lesser Antilles Forearc block on Northeastern Caribbean kinematics and hazards, *Fall AGU Meeting*, San Francisco, CA (2005).
- Kumar Sahoo:** (M.S., Tulane, 2006) A first-year student advised by Matt Hurtgen and Brad Sageman, Kumar is interested in sedimentary geology.
- Kimberly Schramm:** Under Seth Stein's direction, Kim is studying a possible mechanism bias in oceanic transform earthquake magnitude measurements, or "slow" earthquakes. Using synthetic waveform modeling, she is calculating magnitudes at slow earthquake locations for strike-slip and thrust mechanisms. Kim will begin her postdoctoral work at New Mexico Tech in January.
- Schramm, K., S. Stein, S. van der Lee, L. Swafford, E. Klosko, J. DeLaughter, and M. Wyssession, Demonstrations in Introductory Geophysics, *Fall AGU Meeting*, San Francisco, CA (2005).
- Laura Swafford:** Directed by Seth Stein, Laura's research examines short earthquake records in slow deformation regions. She is currently trying to determine whether or not highly variable predicted earthquake hazards in northern Africa and eastern Canada are the result of a short earthquake record. Laura was a summer intern at ChevronTexaco.
- Swafford, L., S. Stein, A. Newman, and A. Friedrich, Are apparent spatial variations in seismic hazard artifacts of temporal sampling?, *Fall AGU Meeting*, San Francisco, CA (2005).
- Matthew Weiss:** (M.S., University of South Florida, 2006) A first-year student interested in geochemistry, Matt is advised by Andrew Jacobson.
- Lingling Wu:** Lingling's research, directed by Andrew Jacobson, investigates the contribution of microorganisms to basalt dissolution. She seeks to characterize elemental release during basalt-microbe interactions under P-limited conditions.
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- Wu, L., H.-C. Chen, A. Jacobson, and M. Hausner, Contribution of microorganisms to granite and fluoroapatite dissolution, *106th General Meeting of the American Society of Microbiology* (2006).
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ALUMNI NEWS



Donald Argus (Ph.D., 1990) recently received the 2006 JPL Ed Stone Award in recognition of his outstanding research article, published in the *Journal of Geophysical Research*, comparing earthquake strain buildup and man-made motion in metropolitan Los Angeles. Donald and his wife, Stacie, also recently celebrated the birth of their daughter, Aria Alexandra.....

Kodjopa Attoh (Ph.D., 1973) is a Research Associate at Cornell University where he is investigating the seismotectonics of the Romanche transform margin near Ghana. He was recently a Fulbright Professor at the University of Ghana and, prior to that, a Visiting Professor at the University of Kuwait.....**Erin Beutel** (Ph.D., 2000) was recently promoted to Associate Professor of Geological Sciences at the College of Charleston in South Carolina.....

Andrea Blecha-Erhardt (B.A., 2001) recently completed her Master's degree at the Colorado School of Mines and is now pursuing a Ph.D. in the Department of Geological Sciences at Stanford University.....

Patrick Brady (Ph.D., 1989) was appointed Senior Scientist at Sandia National Laboratories in Albuquerque, New Mexico, where he leads the company's advanced water treatment programs. He relates that on the day he was promoted, the highlight was having lunch at JPL with Don Argus, fellow departmental alum and former Locy Hall office-mate.....

Piyapa Dejtrakulwong (B.A., 2006) is a graduate student in the Department of Geological Sciences at Stanford University.....**Elmer Herbaly** (M.S., 1950) lives in Denver where he and his son own an oil exploration and production company. Mr. Herbaly recently visited Locy Hall and shared his memories of the department with current faculty members.....

Ben Horner-Johnson (Ph.D., 2000) lives in Portland and frequently teaches geology courses at Portland State University. He is also collaborating on several research projects with former NU Geology faculty member Richard Gordon, now teaching at Rice University.....

Richard Huszagh (B.A., 1956) has retired to the Oregon coast after thirty years practicing law in Chicago. He still has geological maps hanging on his bedroom wall and uses his geology background for investment purposes.....**Kathleen Johnson-Stark** (Ph.D., 1990) is working as a researcher for the USGS Minerals Group and recently moved to Denver. She is also an award-winning photographer who has displayed her work at many art fairs and competitions....

Keith Koper (B.A., 1993) was recently promoted to Associate Professor of Geophysics at St. Louis University.....**Sarah Krentz** (B.A., 2006) is studying in the graduate program at the Lamont-Doherty Earth Observatory of Columbia University.....

Robert Langan (Ph.D., 1981) recruits research and development Earth scientists for Chevron where he has also established a new microseismic monitoring program for detecting fluid flow in fractured reservoirs....**Lisa Leffler-Griffin** (Ph.D., 2000) teaches laboratory science to elementary school

students in Fairhope, Alabama. She has two children, Brennan, 8, and Brighid, 5.....**Dan B. McCullar** (B.A., 1975) lives in San Diego where he works for Shaw Environmental & Infrastructure, Inc., an engineering and construction firm.....

Katerina Petronotis (Ph.D., 1991) recently sailed on an Integrated Ocean Drilling Program expedition, serving as the ship's Yeoperson. The expedition's main objective was to study gas hydrate in the Cascadia Margin off the coast of Vancouver. Because gas hydrate rapidly dissolves when exposed to air and requires quick identification and storage in nitrogen dewers, this work was especially complicated. Katerina reports, however, that the ship's international science team persevered through

severe storms, thirty-foot swells, and fatigue from their six weeks of 12-hour work days to successfully achieve their objective.....

Mike Robotham (B.A., 1988) works in Hawaii as a Tropical Technology Specialist for the Natural Resources Conservation Service. He evaluates and adapts tools and technologies for use in tropical areas to help implement sustainable land use practices. Mike recently returned from a trip to Guam where he collected soil and vegetation data needed to develop a sediment source and delivery model for the Sasa-Atantano watershed.....

Edwin Shykind (B.A., 1953) has retired after more than thirty years working for the federal government in varying capacities. Mr. Shykind began his career in the Science Information Exchange, an office responsible for tracking all federally funded research. He later transferred to the President's Office of Science and Technology, serving through four administrations as a marine technology and data expert while authoring several hundred publications now deposited in classified vaults.....

Barbara Taylor-Aitken (M.S., 2001) recently gave birth to a nine-pound baby girl, Gabrielle Jerusalem. She

lives in Evanston with her husband, Eric, and is an Environmental and Health Safety Manager for Citation, Inc., an iron casting firm in Skokie.....

Peter Vail (Ph.D., 1964), Professor of Geological Sciences *emeritus* at Rice University, has started his own exploration and production company, P.R. Vail Oil & Gas. Details of his company's activities and objectives can be found on its website, <http://www.prvail.com>.....

Doug Wiens (Ph.D., 1985) was recently named a fellow of the AGU, collaborated on an article discussing "Earth's Deep Water Cycle" with current faculty member Suzan van der Lee, and performed field work in Cameroon. He is a Professor of Earth and Planetary Sciences at Washington University in St. Louis.

Attention Alumni:

Do you have personal or professional news you want to share? Email us at geodept@earth.northwestern.edu or complete and mail the enclosed form to update Departmental friends and colleagues on your activities. All entries received will be posted to our website and/or published in next year's Annual Report.



Department alumnus Katerina Petronotis aboard the Integrated Ocean Drilling Program's expedition vessel, the Resolution. Katerina recently spent six weeks at sea serving as the ship's Yeoperson and helping collect gas hydrate samples.

Student Achievements

Department Awards

HORACE SCOTT GRADUATE AWARD FOR OUTSTANDING RESEARCH: **Lingling Wu**

SEYMOUR SCHLANGER UNDERGRADUATE EARTH SCIENCES AWARD: **Piyapa Dejtrakulwong**

Honors Thesis: *Analysis of Sedimentary Phosphorus in Cenomanian-Turonian (Cretaceous) Deposits of the Western Interior Seaway: Implications for the Interpretation of Oceanic Anoxic Event II* (Advisor: Brad Sageman)

SLOSS FELLOWSHIP: **Jason Flaum, Alberto López**

SLOSS RESEARCH AWARD: **Derek Adams, Richard Barclay, Heather Bedle, Joniell Borges, Jason Flaum, Simon Lloyd, Rob Locklair, Alberto López, Swapan Sahoo, Kimberly Schramm, Lingling Wu**

Special Graduate Recognition

AGI MINORITY FELLOWSHIP: **Alberto López**

ALLIANCE FOR GRADUATE EDUCATION AND THE PROFESSORIATE FELLOWSHIP: **Alberto López**

FIELD DREAMS GRANT: **Richard Barclay**

GSA GRADUATE RESEARCH GRANT: **Jason Flaum**

GSA TRAVEL GRANT: **Heather Bedle**

MENDENHALL POSTDOCTORAL RESEARCH FELLOWSHIP: **Alberto López**

Special Undergraduate Recognition

NU KATHERINE L. KRIEGBAUM SCHOLARSHIP: **Piyapa Dejtrakulwong**

PHI BETA KAPPA: **Piyapa Dejtrakulwong**

NSF PROGRAM, RESEARCH EXPERIENCES FOR UNDERGRADUATES, SUNY-STONY BROOK: **Sarah Krentz**

NU MARCY-JAMES-BONBRIGHT SCHOLARSHIP: **Piyapa Dejtrakulwong**

Degree Recipients

Doctor of Philosophy

Han Li

Dissertation: *Remediation of Scattered Light in NEAR-Shoemaker MSI Imager: A Study of Martian Debris Aprons* (Dissertation Director: Donna Jurdy)

Alberto López

Dissertation: *Tectonic Studies of the Caribbean: I) Pure GPS Euler Vectors to Test for Rigidity and the Existence of a Northern Lesser Antilles Forearc Block; II) Constraints for Tsunami Risk from Reassessment of the April 1, 1946 Alaska-Aleutians and August 4, 1946*

Hispaniola Events (Dissertation Directors: Emile Okal and Seth Stein)

Master of Science

Simon Lloyd, Miriam Riner, Laura Swafford

Bachelor of Arts

Piyapa Dejtrakulwong, Sarah Krentz



From left to right: Lingling Wu, Han Li, Piyapa Dejtrakulwong, Professor Brad Sageman, and Miriam Riner at our June graduation reception and awards ceremony.

CONTACT INFORMATION

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Alumni Receptions

Philadelphia GSA Meeting
Monday, October 23rd, 7:00- 9:30PM
Grand Ballroom, Salon B
Philadelphia Marriott

San Francisco AGU Meeting
Check Dept. Website for Date and Time
San Francisco Marriott