



DEPARTMENT OF GEOLOGICAL SCIENCES 2006 ANNUAL REPORT

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

Overview



Greetings from Locy Hall, home of NU's Department of Earth and Planetary Sciences! It gives me great pleasure to update you, the alumni and friends of the department, on the many interesting developments that have recently taken place within our scholarly community. In the past year, the department has continued to build upon the momentum established by several significant changes I have previously detailed for you—including the appointment of five promising new faculty members, the implementation of a new undergraduate curriculum, and the initiation of a new field trip program—making the past twelve months an exciting time for our faculty and students.

Before I begin recounting the recent activities of our department members, though, let me once again extend a resounding thank you for last year's unprecedented level of alumni giving. I am proud to report that the percentage of EPS alumni donating in 2006 was the highest in WCAS. Additionally, the total amount raised surpassed our previous departmental high for an annual solicitation. Your support has been instrumental in helping us offset the costs associated with enhancing the department's educational opportunities and research programs. Further, it has also provided us with an important vote of confidence, communicating to the administration that our alumni are supportive of the department's growth. Consequently, your generosity has helped motivate the university to provide us with additional funding for departmental initiatives. As a result, we are well positioned to continue our recent improvements.

In my previous messages to you, I introduced our five new junior faculty members—Matthew Hurtgen (geochemistry), Steven Jacobsen (mineral physics), Andrew Jacobson (geochemistry), Francesca Smith (biogeochemistry), and Suzan van der Lee (seismology). I am now pleased to report that all five are making excellent progress in their research, a point underscored by their success in obtaining external funding. In addition to Suzan van der Lee's NSF-CAREER grant, Andrew Jacobson received a Major Research Instrument (MRI) grant from NSF and was just selected as a Packard Fellow. NSF also recently approved proposals for the

following projects: Matthew Hurtgen's study of sulfur cycling in the Neoproterozoic, Steven Jacobsen's acquisition of a broadband oscilloscope, and Francesca Smith's paleohydrological investigation of the Paleocene-Eocene Thermal Maximum. Further, Andy and Steve both await decisions on their NSF-CAREER grant proposals, and Steve was just named a distinguished lecturer by the Mineralogical Society of America.

Activity within the senior ranks of the faculty has matched the hectic pace of our junior faculty members. Craig Bina, in particular has been very busy lately. After spending much of the past academic

year in Japan as a visiting scholar at the University of Tokyo's Earthquake Research Institute and the Geodynamics Research Institute at Ehime University, he became WCAS associate dean for research and graduate studies upon returning to the U.S. Two other faculty members recently earned impressive honors: Seth Stein was named William Deering Professor of Geological Sciences while Emile Okal was elected a fellow of the AGU. Most significant, though, are two senior-level additions to the department. First among these is Dr. Gilbert Klapper, a retired professor from the University of Iowa and one of the foremost

authorities on conodont biostratigraphy. Having accepted an adjunct position here last year, Gil has already taught "Historical Geology" to our growing ranks of undergraduate majors, with whom he has proven extremely popular. At the beginning of the current fall quarter, the department also welcomed one more new faculty member, Dr. Neal Blair, an organic geochemist and biogeochemist from North Carolina State University. Dr. Blair has accepted the first joint professorship between EPS and the Department of Civil and Environmental Engineering, and will be a principal user of our new shared stable isotope lab.

Planning for this facility, which will include mass spectrometer labs, a clean room, sedimentary, aqueous, and organic geochemistry modules, and a mineral physics and spectroscopy lab, has recently intensified.

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The Department of Earth and Planetary Sciences, May 2007.

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Two Delta V mass spectrometers, both funded by NU, have been ordered and will arrive shortly. These instruments will support the research efforts of Professors Blair, Hurtgen, Smith, and myself. In addition, our radiogenic isotope expert, Andy Jacobson, will use his MRI grant to acquire a thermal ionization mass spectrometer. The third floor of Hogan Hall has been identified as the final destination for this equipment, and faculty have been meeting regularly with architects to discuss the renovation and design of lab space. Though much progress must be made before this unique integrated lab facility becomes operational, we plan to have the stable isotope instruments running in a temporary location by early 2008.

When the analytical lab is complete, EPS will truly enter the 21st century. Although we continue to expand our traditional areas of strength in seismology, solid-Earth geophysics, numerical biogeochemistry, and numerical mineral physics, the addition of serious analytical programs in stable and radiogenic isotope biogeochemistry and a state-of-the-art experimental lab for high P-T mineral physics will transform our program. In the years to come, the department will be poised to make further fundamental scientific contributions to our understanding of large earthquakes and their effects, the structure and behavior of the solid Earth, the mechanisms of plate tectonics, biogeochemical cycles and their

relationship to the Earth's oceans and climate system, and the future of the hydrocarbon economy, which is closely linked to the climate question. Standing at the cutting edge of geoscientific research, the department will thus be ideally positioned to intensify its recruitment of talented undergraduate and graduate students.

The above research programs investigate some of the most pressing issues that will confront humanity in the coming century. Other key topics, such as water supply and quality, the environmental impact of industrialization, and the economic and social ramifications of global change, are potentially fruitful areas of exploration given the wealth of talent distributed across the university. In the future, EPS will work to form cross-departmental collaborations that will better focus NU's resources on these areas. One needn't do more than glance at a daily newspaper to recognize the growing centrality of the Earth sciences. Recent population growth and the increasing vulnerability of population centers to major Earth System perturbations have placed geoscientists at the center of the most important social and scientific questions of our time. Thanks in part to your past generosity, EPS is better prepared to engage these questions in our work. We look forward to sharing the results of our efforts with you as we move forward and remain grateful for your support. --Brad Sageman, EPS Department Chair



Craig R. Bina: Wayne V. Jones II Professor of Geological Sciences (Ph. D., Northwestern University, 1987). Professor Bina performs thermodynamic modeling of phase relations, under equilibrium and disequilibrium conditions, to investigate the seismology and geodynamics of Earth's mantle and subducting lithosphere. He also studies the composition and mineralogy of planetary mantles, investigating roles of thermal and compositional variations, elemental partitioning relations, redox reactions, and structural transitions.

In 2006-07, Professor Bina presented work on deformation in subducting slabs at the 2006 meeting of the Japan Geosciences Union in Chiba, Japan (where he also chaired a session on the physics of the Earth's interior), at the 2006 Biennial Workshop on Subduction Processes in the Japan-Kurile-Kamchatka-Aleutian Arcs in Sapporo, Japan, at the School of Earth and Space Exploration at Arizona State University, and (as invited speaker) at the 2007 International Union of Geodesy and Geophysics general assembly in Perugia, Italy. His work (with Miriam Riner and Mark Robinson) on constraining the composition and interior structure of the planet Mercury was presented at the 2006 Meteoritical Society meeting in Zurich, at the 2007 Lunar and Planetary Science Conference in Houston, and at the First Western Japan Joint Symposium held in Matsuyama, Japan, in 2007. His earlier work on high-pressure ice was noted in the New York Times in early 2006. Professor Bina was a visiting researcher at the Earthquake Research Institute of the University of Tokyo in spring of 2006 and at the Geodynamics Research Centre of Ehime University in Matsuyama, Japan, in spring of 2007. In the fall of 2007 he became WCAS associate dean for research and graduate studies.

Neal E. Blair: Professor, joint appointment in Civil & Environmental Engineering (Ph.D., Stanford, 1980). A recent arrival from North Carolina

State University, Professor Blair's research focuses on the biogeochemical cycling of carbon, with specific emphasis on the novel use of stable and radiocarbon isotopes as probes into biogeochemical processes. Current studies include the evolution of particulate organic carbon as material travels from terrestrial sources to burial in the seabed, the preservation of potential soft-tissue organics in fossil bones, and the fate of organic pollutants in bioremediated soils. Blair currently advises or co-advises three graduate students who are participating in those projects.

Professor Blair is coauthor of two 2006 publications and one manuscript in press. He will assume the chairmanship of the advisory board for the National Ocean Sciences Accelerator Mass Spectrometry Facility this fall after serving on the committee in 2005-2006. He has recently been funded by NSF with his collaborator, Elana Leithold (NCSU) to study the source to sink generation of biogeochemical stratigraphic signals across the Waipaoa margin in New Zealand. Fieldwork for that project began this summer.

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 examine the relationship between the biogeochemical cycles of carbon and sulfur, ocean redox and climate change. To this end, Matt is thrilled to have six students working in the sedimentary geochemistry lab processing samples from Australia, Canada, India, Svalbard, and the United States. Matt was recently awarded an NSF grant to study the relationship between the geochemical cycles of carbon and sulfur and Neoproterozoic climate change.

Hurtgen and graduate student Swapan Sahoo recently traveled to Namibia where they studied Neoproterozoic sediments along the southern portion

of the Congo Craton. These sediments record the most extreme climatic events in Earth history—the hypothesized “Snowball” Earth events. At least twice during this period, glaciers reached sea level at tropical latitudes, and geologic evidence suggests that the entire ocean froze during these glaciations for millions of years. Hurtgen and Sahoo will examine the relationship between ocean redox and the geochemical cycles of carbon and sulfur for the middle Neoproterozoic to test hypotheses regarding possible mechanisms for “Snowball” glaciations. This work complements Hurtgen’s ongoing research efforts on Neoproterozoic sediments from Australia, Canada and Svalbard, and a NASA-funded project to study modern, low-sulfate lake systems in Minnesota as modern analogs to ancient seawater conditions. In the past year, Matt published two papers (with two more in press), presented eight papers at national meetings (GSA and AGU), and was an invited speaker at the University of Chicago.

Steven D. Jacobsen: Assistant Professor (Ph.D. Geophysics, University of Colorado, 2001). Dr. Jacobsen specializes in the physics and chemistry of Earth and planetary materials. His research spans problems in mineralogy, global geophysics and geochemistry, high-pressure physics and chemistry, water distribution in the Earth, and the role of materials in renewable energy technology. Jacobsen studies the origin and physical properties of Earth materials through experimental mineral physics. Here his central challenge is linking the atomic and geophysical scales in a variety of materials encompassing the major Earth-forming minerals, unusual phases with surprising structures, and advanced technological entities with novel properties. Jacobsen’s investigations range from Antarctic ice cores to the properties of iron-oxide at the core-mantle boundary. Much of his research, funded in part by the NSF, is conducted at the Argonne National Laboratory’s Advanced Photon Source. Jacobsen has authored or co-authored over 40 peer-reviewed research articles and has edited two special volumes.

Since arriving in 2006, Jacobsen has devoted much energy to establishing a new high-pressure mineral physics laboratory, teaching mineralogy and petrology and the future of renewable energy, and presenting and publishing his work. In his lab, he is installing high-pressure diamond-anvil cells capable of squeezing samples to ultra-high pressures found near the Earth’s core-mantle boundary. He is also building a unique ultrasonic probe to measure sound velocities and elastic constants of materials at high pressures and a confocal Raman microscope, which will facilitate investigations of vibrational properties in a variety of materials. In May, Jacobsen received an NSF grant to upgrade his GHz-ultrasonic interferometer. Recent publications include a *Geology* study on hydrogen diffusion profiles in mantle xenoliths, which may be used to constrain basaltic magma ascent rates, and a *Science* contribution on thermal conductivity in the lower mantle. In January, AGU released *Earth’s Deep Water Cycle*, a book he co-edited with Suzan van der Lee. Finally, Jacobsen was also recently named a Mineralogical Society of America distinguished lecturer.

Andrew D. Jacobson: Assistant Professor (Ph.D., University of Michigan, 2001). Dr. Jacobson specializes in low-temperature geochemistry, radiogenic isotope geochemistry, and geomicrobiology. His research combines fieldwork, laboratory experiments, and modeling to quantify chemical, physical, and biological phenomena that cycle elements and their isotopes at the Earth’s surface, both in the modern day and throughout geologic time. His current interests include: microbial controls on solute evolution in organic-rich groundwater systems; constraints on equilibrium versus kinetic Ca isotope fractionation in aquifers; development of microbial Ca isotope fractionation as a new biosignature; laboratory simulations of Ca isotope fractionation during Ca-for-Na ion-exchange on clay mineral surfaces; isotopic (Ca, Sr, and C) tracking of Arctic climate change and

permafrost stability at the watershed scale; the atmospheric supply of P to seawater via dust deposition and its implications for marine productivity and paleoproductivity estimates; and the rates and mechanisms of microbially-mediated rock weathering.

Jacobson received NSF funding to conduct the first-ever study of Ca isotope transport in aquifers. By providing new constraints on the extent of Ca isotope fractionation during calcite precipitation, ion-exchange, and microbial activity, his research is laying groundwork for using Ca isotopes to trace water-rock interactions on the continents. This past year, NU selected Jacobson to compete in two highly competitive limited submission funding opportunities. His first proposal, submitted to the NSF-MRI program for a thermal ionization mass spectrometer, was successful, while a decision from the Packard Foundation for an early career faculty fellowship is forthcoming. Jacobson is supervising research by departmental graduate students Lingling Wu and Jason Flaum, as well as the work of Eric Kramer, a sophomore ISP major. Wu recently published a manuscript in *Geochimica et Cosmochimica Acta* concerning elemental release during microbe-basalt interactions and presented this research at the 2007 Goldschmidt Conference. Flaum is investigating the occurrence of phosphorus in Asian loess to understand how atmospheric processes influence the cycling of phosphorus in the North Pacific Ocean and its marginal seas. Kramer worked with Jacobson to simulate numerically solute transport in aquifers and is currently examining Ca isotope fractionation during uptake on clays.

Donna Jurdy: Professor (Ph.D., University of Michigan, 1974). Professor Jurdy’s current research focuses on the tectonic activity of Earth, Venus, Mars, and the satellites of Jupiter and Saturn. She continues work on Venus to understand its distinctive tectonics. With Paul Stoddard, she is attempting to relate the formation of coronae to the uplift of the regiones, Venus’ topographic and geoid highs. Coronae, circular features unique to Venus, ranging in diameter from 100-2600 km, may be caused by diapirs. She and Michael Stefanick are analyzing the magnetization of the Martian crust to decipher the origin and history of the planet’s strong magnetic lineations. Mars records an unexpected and strong magnetization in its heavily-cratered southern hemisphere despite lacking any current field. Results are being published on downward continuing magnetic measurements collected at the satellite level of 400 km to the planet’s surface. This work attempts to establish when and how Mars’s crust became magnetized and to understand the subsequent process of sporadic demagnetization. With graduate students Heather Bedle and Kim Adams, Jurdy is also examining Ganymede’s sulci (linear features) on regional and global scales, and what may be cryovolcanically-induced pitted areas on Titan, Saturn’s largest satellite.

Jurdy has co-edited the GSA Special Paper, *Plumes: The Origins of Melting Anomalies: Plumes, Plates, and Planetary Processes*, which contains forty-six papers from the AGU Chapman Conference, “The Great Plume Debate”. This subject is highly controversial, and the volume encompasses a broad spectrum of views. Jurdy also continues as chair of the DOSECC Education Committee, overseeing the Internship Program, and has initiated a lecture program for the drilling project. Finally, she also recently served on the NSF Graduate Research Fellowship panel and acted as a consultant for Earth Images, an educational film company.

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 Earth’s surface environment. He seeks to identify the mechanisms responsible for the rise in atmospheric CO₂ 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 2006 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. 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 CO₂ 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, Okal 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. He has also continued field surveys of the Sumatra tsunami in Yemen and the Comoros.

Okal also studies the generation and propagation of acoustic energy in the water body of the world's oceans, acquiring data from a broad range of sources, including 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, an experiment which has reaped a considerable dataset of unexpected results, including information about the motion of the bergs induced by the Sumatra tsunami and their response to ocean swell originating during major storms at the other end of the Pacific Ocean. Okal regularly presents his research in the U.S. and abroad. Last year he gave invited talks in Woods Hole, Golden (CO), and Reunion Island; this year, he is scheduled to lecture in Australia, France and Uganda. He will also travel to Thailand and Malaysia so he can once again provide tsunami training to scientists from developing countries.

Bradley B. Sageman: Professor and Chair (Ph.D., University of Colorado, 1991). Professor Brad Sageman's research focuses on siliciclastic facies and their use as recorders of changes in "deep time" climate and tectonism (i.e., pre-Pleistocene). Much of his work has examined the causes and consequences of organic carbon burial in Paleozoic and Mesozoic 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 carbon burial events. Sageman currently advises or co-advises four graduate students whose research projects include analysis of changes in nutrient and redox-sensitive biogeochemical cycles associated with events of exceptional organic carbon burial; paleobotanical assessment of changes in pCO₂ across a major carbon cycle perturbation; and use of facies and sediment thickness patterns to test alternate hypotheses for the origin of the Cretaceous Western Interior basin.

Brad authored one 2006 publication and is a co-author on three others currently in press. In the past year, he was invited to participate in several scientific meetings, including a shale gas consortium at the Colorado School of Mines, the second workshop of the Earth-Time Project, as well as the inaugural meeting of IGCP Project 555 and ICDP Workshop on Scientific Drilling in Songliao Basin, China. He also received NSF funding for a project to reconstruct pCO₂ across the Cenomanian-Turonian boundary.

Francesca Smith: Assistant Professor (Ph.D., University of Chicago, 2002). Dr. Smith is a biogeochemist who uses the isotope signatures of lipid biomarkers to reconstruct the response of terrestrial ecosystems to past climate changes. Her research involves working with both living plants and ancient leaf waxes preserved as molecular fossils in sedimentary rocks. Studies with modern plants aim to calibrate paleoclimatic and paleoecological proxies. For example, this past summer Smith and a graduate student collected plants from the Chicago Botanic Garden to examine the taxonomic and leaf-anatomical controls on carbon and hydrogen isotope ratios of leaf waxes. Taxonomic and anatomical controls on hydrogen isotope ratios of plant lipids are of particular importance to calibrating this new paleohydrologic proxy, and as a result Smith was invited to give a talk on this topic at the American Chemical Society meeting in Boston.

Smith applies these isotopic proxies to understanding climate-ecosystem interactions during climatic crises. Her work on the abrupt and extreme global warming that occurred 55 million years ago, the Paleocene-Eocene Thermal Maximum, demonstrates that plant communities in the Bighorn Basin in Wyoming changed dramatically in response to warming and played a major role in amplifying the carbon isotopic excursion observed in terrestrial reservoirs across this event. Smith's findings will be published in *Earth and Planetary Science Letters* and were presented at the International Meeting on Organic Geochemistry in Torquay, England. These results suggest that future global warming may bring large scale changes in plant communities as well as changes in terrestrial carbon cycling.

Seth Stein: William Deering 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.

Recently, much of Stein's attention has 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 ocean-wide tsunami arising from this part of the plate boundary. They 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 while also working with 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. Currently, Van der Lee and graduate students Heather Bedle and Simon Lloyd are imaging the North and South American upper mantles with an emphasis on reducing uncertainty and non-uniqueness in these models. They seek to interpret the imaged seismic velocity distribution in terms of spatial variations of mantle temperature and hydrogen content.

With departmental colleague Steven Jacobsen, Van der Lee co-edited a new book (published by AGU), *Earth's Deep Water Cycle*. The book integrates cutting-edge seismology and mineral physics research on the mantle's potential water content. Van der Lee routinely participates in Earthscope's Transportable Array Working Group and was recently elected to the IRIS Board of Directors. She also presented a mini-course on seismic tomography at the 2007 national Earthscope workshop. Last year, she, Bedle and Lloyd presented their seismological research at various professional meetings.

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.

Sung-Joon Chang: Postdoctoral Researcher (Ph.D., Seoul National University, 2004). *Research Interests:* Seismic tomography; plate tectonics.

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

Christopher Holl: Postdoctoral Researcher (Ph.D., University of Colorado,

2006). *Research Interests:* Solid-Earth geophysics and geochemistry; mineral physics.

Gilbert Klapper: Visiting Professor, Professor *emeritus*, University of Iowa (Ph.D., University of Iowa, 1962). *Research Interests:* Conodont biostratigraphy.

Michael Stefanick: Research Associate (Ph.D., Princeton University, 1980). *Research Interests:* Analysis of geophysical datasets and the statistical treatment of errors; Mars magnetic analysis.

Johannes Weertman: Walter P. Murphy Professor of Materials Science *emeritus*, Adjunct Professor of Earth and Planetary Sciences (D.Sc., Carnegie Institute of Technology, 1951). *Research Interests:* Fatigue of metals; creep of crystalline solids; dislocation theory; geothermal energy.



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), a shallow, epicontinental sea. He plans to develop a WIS sulfur isotope dataset to be correlated with existing carbon isotope data, particularly information surrounding the Oceanic 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.

Adams, D.D., M.A. Hurtgen, B.B. Sageman, and J.A. Flaum, The Sulfur Isotope Composition of Carbonate-Associated Sulfate and Pyrite From the Middle Cretaceous Western Interior Seaway, *Eos Trans. AGU* 87(52), V11C-06056, (2006).

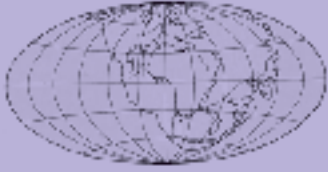
Adams, D.D., M.A. Hurtgen, B.B. Sageman, and J.A. Flaum, The Sulfur

Isotope Composition of Carbonate-Associated Sulfate and Pyrite From the Middle Cretaceous Western Interior Seaway, Fall AGU Meeting, (2006).

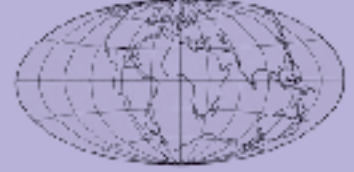
Kim Adams: Under Donna Jurdy's direction, Kim, a second-year student, studies planetary geology. Her current project examines pit chains and pit fields on Titan, Saturn's largest satellite. She is analyzing the distribution of these pits while also seeking clues that will illuminate their formation process.

Richard Barclay: Advised by Brad Sageman and 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 Southwestern Utah.

- Barclay, R.S., J.C. McElwain, and B.B. Sageman, Testing the pCO₂ draw-down hypothesis for oceanic anoxic event II (94 Ma) using fossil plant cuticle, 7th European Paleobotany and Palynology Conference, Prague, Czech Republic (2006).
- Barclay, R. S., J.C. McElwain, and B.B. Sageman, Ecological change across the Cenomanian-Turonian boundary, *Abstract for the Annual Meeting of the GSA*, vol. 38, Philadelphia, PA (2006).
- Barclay, R.S., J.C. McElwain, and B.B. Sageman, Fighting for an invisible food source? CO₂ and Paleoclimate during the rise of angiosperms, Monthly Meeting of the Interdisciplinary Committee in Evolutionary Processes, Evanston, IL (2006).
- Heather Bedle:** Advised by Suzan van der Lee, Heather uses seismic tomography to model upper mantle seismic heterogeneities. Her project seeks to illuminate the underlying causes of these variations and the effects of upper mantle dynamics on preservation of Archean and Proterozoic lithosphere.
- Bedle, H., and S. van der Lee, Fossil flat-flab subduction beneath the Illinois basin, USA, *Tectonophysics* 424, 53-68, (2006).
- Bedle, H., and S. van der Lee, Progress on a new regional model of the upper mantle S-velocity structure beneath the North American Continent, *Earthscope National Meeting*, Monterey, CA (2007).
- Bedle, H., and S. van der Lee, Estimating and presenting variance in tomographic models: A North American example, *Fall AGU Meeting*, San Francisco, CA (2006).
- Joniell Borges:** Joniell's first project, directed by Brad Sageman, investigates the factors determining 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 Youngsook Huh of Seoul National University examines the constraints on river bed sediment compositions in contemporary large river systems.
- Borges, J., and Y. Huh, Petrography and chemistry of the bed sediments of the Red River in China and Vietnam: Provenance and chemical weathering, *Sedimentary Geology* 194, 155-68, (2007).
- Carl Ebeling:** A first-year student interested in seismology, Carl is advised by Suzan van der Lee and Emile Okal. Carl received his B.S. from St. Olaf College and a M.S. from Portland State University.
- Jason Flaum:** Under Brad Sageman's direction, Jason's research focuses on the role of the marine phosphorus cycle on oceanic anoxic events. This work has largely focused on the Late Cretaceous Oceanic Anoxic Event II and attempts to identify the nutrient source for the proposed increase in global marine primary production.
- Flaum, J.A., B.B. Sageman, and S.R. Meyers, + 2006, Causal mechanisms for OAE's III: The role of phosphorus?, *GSA Abstracts with Programs* 38 (7), 513, (2006).
- Sageman, B. B., J.A. Flaum, and S.R. Meyers, Causal mechanisms of OAE's II: The role of weathering?, *GSA Abstracts with Programs* 38 (7), 513, (2006).
- Young Ji Joo:** A first-year student studying geochemistry, Young Ji is advised by Andrew Jacobson. Young Ji holds a B.S. and M.S. from Seoul National University in South Korea.
- Simon Lloyd:** A seismology student advised by Suzan van der Lee, Simon is investigating the crust and upper mantle beneath South America. He is using seismic data for receiver function analysis and surface wave tomography to determine crustal thickness and to image the mantle structure.
- Lloyd, S., S. van der Lee, G.S. Franca, and M. Assumpcao, Crustal thickness and structure of Precambrian South America from receiver function analysis, *Fall AGU Meeting*, San Francisco, CA (2006).
- Lloyd, S., and S. van der Lee, Influence of observed mantle anisotropy on isotropic tomographic models, *Fall AGU Meeting*, San Francisco, CA (2006).
- Lloyd, S., S. van der Lee, G.S. Franca, M. Assumpcao, and M. Feng, Towards a new Moho map for South America from receiver functions and surface waves, *AGU Joint Assembly*, Acapulco, Mexico (2007).
- Xiaoting Lou:** A first year student studying seismology, Xiaoting is advised by Suzan van der Lee. Xiaoting received his B.S. and M.S. from Peking University in China.
- Emily Martin:** A first-year student interested in planetary geology, Emily is advised by Donna Jurdy. Emily received her B.S. from Wheaton College.
- Swapan Sahoo:** A third-year student interested in geochemistry, Swapan is advised by Professors Hurtgen and Sageman. He is studying sulfur and carbon isotopes of Proterozoic and Cretaceous basins in India so he can correlate S and C seawater isotope datasets from vastly different locations.
- Laura Swafford:** Laura studies seismology under the supervision of Seth Stein. Her research examines the relationship between the magnitude of great earthquakes and the age and convergence rate of subducting lithosphere. This work aims to identify the relationship between the physical properties of subduction zone arcs and their potential to produce giant earthquakes. In the summer of 2007, Laura was a geophysical intern with Chevron in Bakersfield, California.
- Swafford, L. and S. Stein, Seismic behavior and seismic to aseismic slip along the Aleutian Islands as inferred from great earthquakes, *Earthscope National Meeting*, Monterey, CA (2007).
- Lingling Wu:** A geochemistry student working with Andrew Jacobson, Lingling's research investigates microbe-rock interactions under simulated Earth surface conditions. Through laboratory experiments and theoretical modeling, she explores how microorganisms influence the rates and mechanisms of elemental release in whole rocks such as basalt and granite and rock-forming minerals such as calcite and dolomite.
- Wu, L., A.D. Jacobson, H.-C. Chen, and M. Hausner, Characterization of elemental release during microbe-basalt interactions at T = 280C., *Geochim. Cosmochim. Acta* 71(9), 2224-39, (2007).
- Wu, L., and Y. Huh, Dissolved reactive phosphorus in large rivers of East Asia, *Biogeochemistry* 85, 263-288 (2007).



ALUMNI NEWS



Gary Acton (Ph.D., 1990), an associate research scientist in the Paleomagnetism Laboratory at UC-Davis, is preparing for a drilling expedition in Antarctica. Gary will serve as leader of the project's chronostratigraphic team....**Sarah Andre** (Ph.D., 2004) is a geologist at the Center for Earth and Planetary Studies, a division of the National Air and Space Museum. Her current projects involve characterizing craters and basins on Mercury using image and topographic data and detecting Mercurian impact basins and shallow craters missed in the initial analysis of Mariner 10 images.....**Wendy Barrow** (M.S., 1997) recently completed her doctoral degree in geological sciences at the University of Nevada-Las Vegas (UNLV). Her dissertation, a field study of the Klamath mountains, employs structural analysis, petrology, geochemistry and radiometric dating to investigate models for an inverted metamorphic gradient in one of the mountain range's terranes. Wendy recently accepted an appointment as a visiting assistant professor at UNLV....**Howard Cramer** (Ph.D., 1954), a retired faculty member at Emory University, teaches adult classes in geology at that school....**Richard Debus** (B.A., 1978) is vice president for Oak Exploration and specializes in natural gas. He is currently editing a book relating to his work and is happily engaged....**Piyapa Dejtrakulwong** (B.A., 2006) is an Earth Sciences graduate student at Stanford University where she is currently studying thin-bed layering....**John DeLaughter** (Ph.D., 1998) recently left his position as Earthscope's educational director to become science director of the Miami Science Museum....**Mark Dring** (M.S., 2003) recently left his job as a high school science teacher in Chicago to become an F.B.I. agent. His training will commence shortly in Quantico, VA. Only one applicant in five thousand is selected for training.....**Kathleen Johnson-Stark** (Ph.D., 1990) recently moved to Boulder County, CO, where she is teaching courses at Arapahoe Community College. An accomplished photographer, Kathleen is preparing to launch a professional photography website....**Eryn Klosko** (Ph.D., 2002), a faculty member at Westchester Community College, and **Audeliz Matias** (Ph.D., 2005), a visiting assistant professor at Skidmore College, are collaborating on an article discussing the use of museums in introductory geology courses. The idea for the article arose after the two instructors brought classes to the American Museum of Natural History on a joint field trip....**Robert Mitchum** (Ph.D., 1954) recently received the American Association of Petroleum Geologists Sidney Powers Memorial Award, the highest award conferred by that organization. Bob was recognized for his distinguished scientific contributions to his field as well as his influential role as a mentor and teacher throughout academia and industry. Mitchum is best known for his role in helping define and organize the key concepts of seismic stratigraphy, discovering important stratigraphic relationships relevant to deep-water petroleum exploration, and finding new applications

for sequence stratigraphy in development geology, groundbreaking work he accomplished along with his long-time Exxon colleagues and fellow departmental alumni, **Peter Vail** (Ph.D., 1959) and **John Sangree** (Ph.D., 1960).....**Alberto Lopez** (Ph.D., 2006), a Mendenhall Postdoctoral Research Fellow at the USGS in Woods Hole, recently took a three-week cruise around Nantucket Island to collect seismic data.....**Paul Niles** (B.A., 1997) received a Ph.D. from Arizona State University in 2005 and is now a space scientist for NASA at the Johnson Space Center in Texas.....**Virginia Sand** (B.A., 1950) passed away on February 13, 2007. The first woman to graduate from Northwestern with an undergraduate geology degree, she later earned an M.S. in the teaching of Earth Science from Kent State University and

taught geology at that school's campus in Tuscarawas, OH for over thirty years. Her classes were among the most popular in the school and earned her several teaching awards. Virginia is survived by three children and four grandchildren....**Paul Shiverick** (B.A., 1975) is the co-founder and a general partner at Seminole Capital Partners, an equity hedge fund based in New York City. He is married and has four children ranging in ages from fourteen to twenty....**Thomas Shoberg** (Ph. D., 1993) a faculty member in the Physics Department at Pittsburg State University, was recently promoted to associate professor....**Justin Sweet** (B.A., 2004) is a geophysics graduate student at the University of Washington, Seattle, where he is studying seismic tremors under the supervision of



Department alumnus Steve Meyers (Ph.D., 2003) exchanges vows with his wife, Gigi, at their June wedding, held in New York. Among the wedding guests was alumnus Eryn Klosko (Ph.D., 2002), who introduced the couple.

Ken Creager....**William Wadsworth** (Ph.D., 1966), a retired professor of geology at Whittier College in California, lives in Marshfield, ME, where he enjoys spending time with family and singing in two local choirs....**Michael Wyession** (Ph.D., 1991), a faculty member in the Department of Earth & Planetary Sciences at Washington University in St. Louis, organized a summer geophysics teaching workshop for the University of Michigan's Camp Davis in Wyoming. Among the workshop attendees were **Donna Jurdy** and departmental alum, **Jeff Nunn** (Ph.D., 1981), of LSU. Another faculty member, **Seth Stein**, presented one of the camp's keynote addresses....**Elizabeth Zbinden** (B.A., 1979), a mineral exploration and mining consultant based in Reno, recently returned from a six-month copper and gold exploration project in Mongolia....

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.

Student Achievements

Department Awards

HORACE SCOTT GRADUATE AWARD FOR OUTSTANDING RESEARCH: **Heather Bedle**

MARION SLOSS AWARD FOR OUTSTANDING TEACHING ASSISTANT: **Simon Lloyd**

SEYMOUR SCHLANGER UNDERGRADUATE EARTH SCIENCES AWARD: **James Hebden**

SLOSS FELLOWSHIP: **Jason Flaum, Robert Locklair**

SLOSS RESEARCH AWARD: **Derek Adams, Kim Adams, Heather Bedle, Joniell Borges, Jason Flaum Simon Lloyd, Swapan Sahoo, Lingling Wu**

Special Graduate Recognition

AGU OUTSTANDING STUDENT PAPER AWARD: **Simon Lloyd**
Awarded in recognition of his presentation, *New Moho map for South America from receiver functions and surface waves*, given at the 2007 AGU Joint Assembly in Acapulco, Mexico.

EARTHSCOPE TRAVEL GRANT: **Heather Bedle**

EVOLVING EARTH FOUNDATION GRANT: **Richard Barclay**

NASA ASTROBIOLOGY INSTITUTE TRAVEL GRANT: **Lingling Wu**

WCAS OUTSTANDING TEACHING ASSISTANT AWARD: **Jason Flaum**

Special Undergraduate Recognition

INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY INTERNSHIP: **James Hebden**

PHI BETA KAPPA: **James Hebden**

Degree Recipients



Award winners Simon Lloyd, Heather Bedle, and James Hebden at the department's June graduation reception, held in Locy Hall's Sloss Room.

James Hebden, B.A. and M.S.

B.A. Thesis: *Rayleigh Wave propagation in mid-ocean ridge waveguides* (Advisor: Seth Stein)

M.S. Thesis: *Time-dependent Earthquake Hazard Maps for the New Madrid Seismic Zone* (Advisor: Seth Stein)

Robert Locklair, Ph.D.

Dissertation: *Causes and Consequences of Marine Carbon Burial: Examples from the cretaceous Niobrara Formation and the Permian Brushy Canyon Formation* (Dissertation Director: Brad Sageman)

Alberto Lopez, Ph.D.

Dissertation: *Tectonic Studies of the Caribbean: 1) Pure GPS Euler Vectors to Test for Rigidity and the Existence of a Northern Lesser Antilles Forearc Block; 2) 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)

Kimberly Schramm, Ph.D.

Dissertation: *The role of source mechanism geometry in biasing estimates of earthquake slowness* (Dissertation Director: Seth Stein)

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*