

epicenters

News from the Department of Earth & Planetary Sciences at Northwestern University | Autumn 2009

Investigating the Geology of the Yucatán Peninsula



Last spring, twenty EPS students and faculty members ventured to Mexico's Yucatán Peninsula where they explored the complex environmental system shaping the area's carbonate geology. For many students, the eight-day field trip proved to be "the most unforgettable educational experience" of their lives. Read more about their excursion beginning on page 2.

Message from the Chair

Greetings from your friends and colleagues in Locy Hall, where the department remains ensconced for at least one more winter season. There have been a number of events in the past year that have made life in Locy very exciting and rewarding. Despite this being year five of my service as department chair, I feel energized by the many successes of my student and faculty colleagues—and privileged to be in a position where I can encourage and support these successes.

In the pages that follow, you will read about selected examples of recent departmental triumphs, like Seth Stein's Woollard Award from the GSA and Steve Jacobsen's designation by President Obama as one of the country's most promising young scientists. You will also learn about the record number of graduate and undergraduate students from our department who competed for and won prestigious awards, like the Churchill Scholarship and NSF Graduate Fellowship. And you will find out about some of our new educational initiatives, like the Yucatán Field Trip, which are playing a key role in boosting undergraduate major enrollments. Lastly, this edition of our newsletter will introduce you to our new assistant chair and lecturer, Trish Beddows, who joined EPS late last fall and has made tremendous contributions in the administrative and academic arenas.

The department continues to grow and excel, making it an exciting and vibrant place to be. This growth has been fueled in part by your generous support—alumni donations have underwritten several field excursions, funded student research, and contributed to the completion of the new cutting-edge, interdisciplinary analytical laboratory in Hogan Hall (Earth and Planetary Sciences Integrated Laboratories of Northwestern, or EPSILON), the opening of which is now just a few months away. We anticipate another exciting year and hope to hear news of your personal and professional activities, so please write to us or stop by Locy Hall when you find yourself in Evanston! —Brad Sageman

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EPS Welcomes New Assistant Chair



EPS received a significant boost to its administrative and academic efforts last fall when the department welcomed Dr. Patricia Beddows, a specialist in the hydrogeochemistry of karst environments, as assistant chair and lecturer. Although Beddows moved into Locy Hall less than a year ago, “her positive impact on the department has already been enormous,” says Department Chair Brad Sageman. In addition to helping manage the department’s everyday administrative affairs, Beddows has made crucial contributions to a broad array of special projects, including intensive technical planning for the department’s new multi-million dollar, interdisciplinary analytical facility, the creation and implementation of new strategies to recruit undergraduate majors, and the improvement of graduate student orientation and advising procedures.

Among EPS students, however, she is best known for organizing and leading a wildly successful spring break field trip to Mexico’s Yucatán Peninsula. According to Sageman, the excursion reflected Beddows’ impressive ability to translate her “substantial scientific and field knowledge into a richly textured learning experience for our students, who continue to rave about the trip six months after leaving Mexico.”

While Beddows is looking forward to teaching “a new course on instrumentation and field methods during winter quarter,” she finds it difficult to choose a single highlight from her first year in EPS. “Everyone in the department, from the most senior faculty to newly declared majors, is so engaged and enthusiastic that all of my work here has truly been a pleasure,” she says.

From Sageman’s perspective, the energetic spirit Beddows praises in her fellow department members is reflected equally in her own personality: “Her enthusiasm for her job is palpable and infectious,” he observes. “We’re lucky to have her in EPS.”

Exploring the Geology of the Yucatán

For Ryo Kita, graduation proved to be a bittersweet occasion. While last June’s commencement ceremony provoked a feeling of excitement in him as he prepared to embark on a new phase in his life, it was also tinged with sadness. Leaving Evanston, Kita realized, meant he “would no longer be an EPS major,” a gloomy prospect for someone who describes his experiences in the department as “the highlight” of his four years at Northwestern. Though Kita’s comments reveal a strong attachment to EPS, his sentiments are not unusual among its student population. Over the past few years, morale within Locy Hall has risen to new heights, and a growing number of students have come to regard the department as, in the words of another recent graduate, an “exciting and dynamic place.” While there are many reasons behind these feelings—including the addition of six new faculty members, implementation of a new undergraduate major curriculum, and augmentation of financial support for graduate students—significantly expanded field trip offerings have played an increasingly important role in maintaining the department’s considerable forward momentum.

Goldwater Scholar and EPS senior Ryo Kita best captured the wildly positive response to the Yucatán expedition when he asked: “Who wouldn’t love spending time outdoors in a beautiful natural setting while learning about the evolution of the planet from world-class professors?”

Following several recent, well-received excursions to such locations as Yellowstone, Grand Teton, and Big Bend National Parks, EPS sponsored its most ambitious trip thus far during last year’s spring break when three faculty members—Patricia Beddows, Brad Sageman, and Donna Jurdy—led a group of seventeen undergraduate and graduate students to Mexico’s Yucatán Peninsula. For eight days, EPS department members explored some of the region’s most important geological sites—snorkeling in an expansive cave system, boating through biosphere reserves, obtaining water profile measurements from an array of water bodies, taking core samples from white sand beaches and dense mangroves, and hiking through a quarry where they analyzed fresh exposures of ancient rock formations. While the group’s itinerary may sound exhausting, it formed the basis for what many students described as “the most unforgettable educational experience” of their lives.

According to trip organizer Patricia Beddows, the Yucatán expedition appealed to students because it allowed them “to broaden their intellectual horizons by making primary contact with subject matter they spend

so much time studying in the classroom.” To maximize the impact of the trip, Beddows designed it as an “immersive learning experience” that both exposed students to the complex environmental system shaping the Yucatán’s carbonate geology and provided them with technical and observational skills intended to increase their capacity to analyze that system. This multifaceted approach, she says, had a “powerful effect” on participants by “rapidly changing the way they understand their subject matter and themselves as scientists.” Beddows suggested that the experience also helped students become more confident in their identities as scientists because they now know they have the ability



Graduate student Rosemary Bush and Brad Sageman examine a core sample obtained from a Yucatecan lagoon.

Yucatán--continued

to visit a remote location, overcome the difficulties that inevitably arise in the field, and perform the work necessary to advance their research.

For Beddows, some of the most interesting examples of this transformation occurred “when the trip took unexpected turns, on occasions when the students were presented with circumstances that challenged or contradicted their expectations.” By making sense of the difficulties they encountered, the students learned as much about *doing* science as they did about the specific topics they were investigating. And it is precisely this process of “making decisions in the field, understanding problems that may arise, and



Patricia Beddows prepares the field trip group for their expedition to Yal-Ku lagoon.

then finding rational ways to resolve them,” Beddows concludes, “that characterizes the experience of becoming an Earth scientist.”

Although temporary setbacks can be deflating, students viewed it in positive terms because, as Stefan Jensen explains, it was indicative of the “exploratory” nature of the trip. For Jensen, what made the visit exciting was its “spirit of discovery” and the pervasive feeling that it was a “collaborative effort” to “investigate areas that were somewhat unknown.” In his estimation, the group’s “work in the Sian Ka’an Biosphere Reserve was particularly interesting in this respect because we spent a lot of time in water bodies that hadn’t been studied before while collecting data that will help characterize them and their transport mechanisms.” Involving students in this kind of “collaborative investigation” was “really important,” according to faculty member Donna Jurdy, “because it allowed them to see that their professors didn’t have immediate answers to everything, that they needed to think about, discuss, and debate things just like students do. This gave them more confidence to talk with their teachers—both on the trip and when they returned to the classroom. The whole experience helped students get to know their professors in a new way and built student enthusiasm as a result.”

Of course, there is another factor explaining the rising morale among the Yucatán group members—the fact that the trip was so much fun. As senior Rene Boiteau says, the excursion was an “amazing way to spend a week.”

EPS wholeheartedly thanks the following for their support of this educational experience: Dr. Paul Blanchon of the ICYMyL - UNAM, Dr. Guadalupe Velazquez, CALICA Quarries, Simon Richards, Centro Ecológico Akumal, Amigos de Sian Ka’an, X Caret Ecopark, CICY – Centro de Investigación del Agua, Hidden Worlds Cenote Park. Sponsorship is gratefully acknowledged from the Arthur



Latisha Brengman emerging from a water-filled cave entrance.

Faculty Research Highlights

For the past five years, **Craig Bina** has worked on the Stagnant Slab Project with several Japanese colleagues to understand



the origin and significance of transition zone seismic velocity anomalies that appear to be correlated with current or past subduction. The project culminated last February in Kyoto with an international symposium on deep slab and mantle dynamics. Bina served on the program committee for this symposium and spoke on phase stability and metastability in deep slab structure and dynamics. He will edit a special issue of *Physics of the Earth and Planetary Interiors* dedicated to the



symposium...**Neal Blair's** recent work has proceeded from the recognition that organic matter in soils and sediments is rarely entirely penecontemporaneous in origin even though it is often treated as such. Instead, the ages of the organic sources can span thousands to millions of years. Consequently, his research group has been developing new methods to resolve organic carbon pools by their age and history. This research has implications for understanding the contemporary carbon cycle and the interpretation of the organic geochemical record through time...

Matthew Hurtgen's research is driven by the hypothesis that sulfur plays a critical role in regulating the marine carbon cycle in low sulfate systems. Towards this end, Hurtgen's team has conducted a study that suggests massive volcanism triggered Cretaceous Oceanic Anoxic Event 2 by increasing marine sulfate concentrations, a phenomenon

Faculty Research, continued



that facilitated organic carbon remineralization, enhanced nutrient recycling, and caused a global increase in primary production. Separately, Hurtgen is studying sulfur isotope systematics and the link between fluctuating sulfate levels and phosphorus recycling in a low-sulfate, permanently anoxic lake in MN... **Andrew Jacobson** uses isotopic methods to study climate change. Recent work funded by NSF and the Packard Foundation employs



calcium isotopes to understand Earth's ancient and modern carbon cycle. Members of his research group—Joel Moore, Jong-Sik Ryu, and Greg Lehn—are leading projects in New Zealand, Greenland, and Alaska, respectively. Jacobson's new aqueous geochemistry laboratory and clean room will open in 2010-11...

Donna Jurdy recently accepted an appoint-



ment as a visiting professor in the graduate program at the Chinese Academy of Sciences

Jacobsen Wins Presidential Honor

Over the past eighteen months, Assistant Professor Steven Jacobsen has enjoyed a remarkable string of success. In early 2008, the mineral physicist was named a distinguished lecturer by the Mineralogical Society of America. Shortly after receiving that distinction, Jacobsen won a five-year CAREER Award from the National Science Foundation, that agency's most prestigious honor for young scientists. In 2009 he won another top prize for scientists in the early stages of their careers, a five-year \$875,000 Packard Fellowship. Finally, in June, President Obama named him among 100 beginning researchers to receive the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest recognition given to early-career scientists by the U.S. government. Jacobsen will receive the award at a White House ceremony in January 2010.

Nine federal departments and agencies initiate the PECASE selection process by identifying scientists whose work they judge most beneficial to their respective missions. Award recipients are chosen based their ability to conduct innovative research and their commitment to education and community service. Nominated by the NSF, Jacobsen will be honored for his investigations into the critical role water plays in shaping the physical properties of Earth's deep interior and for prioritizing science education at all levels, especially through efforts to expand minority student enrollment in advanced science and mathematics courses in Evanston public schools.

Jacobsen's research broadly examines the origin, structures, and properties of Earth and planetary materials ranging from the major Earth-forming minerals to unusual phases with surprising structures and advanced technological materials with novel properties. His major areas of study include water cycling in the deep Earth, effects of hydration on the elastic properties of mantle minerals, and hydrogen bonding in minerals. His experimental laboratory features diamond-anvil cells for generating static pressures in the megabar range, an ultrasonic system for sound velocity measurements in materials at high pressures, and a custom-built, micro-Raman spectrometer for vibrational studies of Earth and planetary materials. Much of Jacobsen's research is conducted at the Advanced Photon Source of Argonne National Laboratory where he and students use the nation's most brilliant x-ray source to study the atomic and electronic structure of minerals at high pressures.

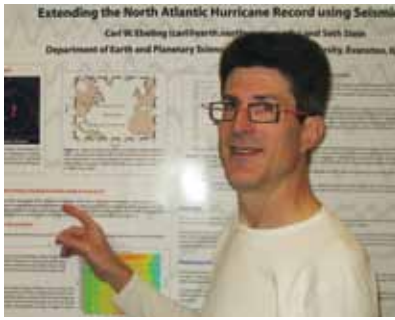


Jacobsen delivers a talk on water in the Earth to the David and Lucile Packard Foundation at the Monterey Bay Aquarium in September 2009.

Ebeling Wins NSF Fellowship

Are recently observed increases in North Atlantic hurricane frequency and intensity part of a naturally variable pattern or the beginning of a new trend caused by anthropogenic climate change? According to third-year graduate student Carl Ebeling, the answer to this vexing scientific question may lie in a surprising place—a decades-long archive of ambient seismic noise records. Last spring, Ebeling received a coveted three-year National Science Foundation Graduate Research Fellowship to develop a seismological method for the detection and assessment of hurricanes. When perfected, this technique will allow Ebeling to uncover a hidden thirty-year history of hurricane activity buried within those records. And it is the recovery of this "lost" history, in turn, that could play a significant role in helping resolve a substantial disagreement about the relationship between North Atlantic hurricanes and global warming.

Ebeling--continued



NSF Graduate Research Fellow Carl Ebeling uses his poster from the Fall GSA Meeting to explain some of the key ideas underlying his novel method for reconstructing North Atlantic hurricane history.

While the last decade in the North Atlantic has witnessed some of the most active and violent hurricane seasons on record, little can be definitively stated about how recent tropical storm seasons align with an extended pattern of regional cyclonic activity. The reason for this uncertainty is simple: no valid long-term history of North Atlantic hurricanes exists. "The problem," says Ebeling, "is that prior to the advent of satellite-based observation in the 1960s, hurricane detection methods such as land observation and photo reconnaissance were unreliable because they didn't provide sustained monitoring of sites where these storms could potentially occur." Consequently, scientists have inherited what Ebeling calls a "brief and incomplete" hurricane history. "Because we only have an accurate hurricane record for the past forty years, our documentation doesn't reach far enough into the past to support larger conclusions" about the meaning of recent storm activity.

But if a problematic hurricane record impedes such interpretations, seismic records may help facilitate them. According to Ebeling, seismograms are a potentially rich source of information about hurricanes because ambient seismic noise, the pervasive background signal bathing the Earth's surface with energy "can be understood as a proxy for the immense quantities of atmospheric energy released by hurricanes." In outlining this relationship, Ebeling describes a chain reaction in which atmospheric energy from hurricanes initially couples into the water column by generating unique countervailing wave patterns that exert unusually strong pressure on the ocean floor. This pressure, in turn, manifests itself within the solid Earth as a series of faint earth tremors—also known as microseisms—that register on seismograms as ambient seismic noise. Since some seismic stations in the vicinity of the North Atlantic have been recording seismic activity since the 1930s—thirty-five years prior to the dawn of satellite technology—analysis of their seismograms could potentially double the existing record of hurricane activity in the area.

Before Ebeling can interpret this vivid though cryptic history, he must develop a tool that will render it comprehensible. Here his challenge involves creating a hurricane assessment and detection method that operates by calculating the amount of anomalous power present in ambient seismic noise bands as a result of cyclonic activity. To begin this process, he will analyze a notoriously powerful and destructive storm, Hurricane Andrew, which struck the Florida coast in August of 1992. Ebeling believes Andrew will prove helpful in developing a seismological technique for detecting undocumented historical hurricanes because "it is extremely well constrained in its chronology, location, wind speed, and barometric pressure. This means I can work backwards from Andrew's meteorological features and show exactly how they translate into seismic characteristics." The resulting analysis will identify the storm's "signature," that can be used to begin creating a seismic noise-hurricane energy scaling relationship for detecting and characterizing past hurricanes lying hidden within an extensive archive of seismograms.

While Ebeling anticipates some difficulties as he proceeds with his project—older seismograms, for instance are recorded on paper and must be digitized through a labor-intensive process to be useful—he maintains a positive outlook about his work. Because his approach to understanding hurricane history is unique, it means he's "exploring unknown territory," a fact that "makes even the more repetitive data-processing work associated with it seem a bit more interesting," he says. Another factor that has intensified his enthusiasm for his research is the recent positive media coverage it has elicited. Following his presentation at the 2009 Fall GSA meeting, he received multiple interview requests to discuss his preliminary findings. Ebeling should perhaps become accustomed to this kind of attention. If his project continues to advance at its current pace, his creative method for analyzing a difficult climatological question will likely generate even greater notice in the future.

Faculty Research, continued

in Beijing. Last summer, she and alumnus Han Li (pictured with Jurdy p.4), a permanent faculty member at the Academy, co-taught a course there on current research in planetary geology. Her earlier work with Li suggested that as much as 40% of debris aprons in Mars' northern hemisphere could be comprised of ice. She and Li will continue their study in the southern hemisphere where debris aprons may have an even greater concentration of ice...**Abraham Lerman**, co-author of the recently published *Carbon in the Geobiosphere*, is studying the shallow coastal ocean, a regu-



lating junction between the land, atmosphere, and open ocean. Using a model analysis of the coupled carbon-nitrogen-phosphorus biogeochemical cycles, Lerman's team identified the times of reversal in the air-sea CO₂ exchange of the shallow coastal and open ocean, the limiting role of phosphorus in biological production on land, and the expected future hardships of the calcifying organisms in the coastal ocean due to atmospheric CO₂ increases...

Francesca McInerney (née Smith) continues to study the response of ancient ecosystems to climate change in Wyoming's Bighorn Basin. In particular, she is investigating the question of how precipitation patterns changed during the largest global warming event of the Cenozoic, the Paleocene/Eocene



Thermal Maximum. Her team, which includes graduate students Allie Baczynski and Rosemary Bush as well as colleagues from other institutions, combines evidence from

Faculty Research, continued

the chemical and morphologic properties of fossilized soils, plants, and animals to reconstruct changes in climate. This research will be highlighted in the new Washakie Museum in Wyoming. McInerney is one of the subjects in a short museum documentary called "Why we dig"...**Emile Okal** investigates tsunami hazard both theoretically and in the field. Following a recent tsunami in the Samoa



Islands, he participated in the post-tsunami survey that studied the site just five days after the event and investigated tsunami penetration in more than 70 locations on the Islands of Tutuila (American Samoa) and Upolu (Samoa). Such datasets are crucial to understanding how inundation is affected by local parameters such as reef structures and the 3-D geometry of harbors...

In the past year, **Brad Sageman** has been a co-author on five articles: two are in *Nature Geoscience* (one accepted, one in revision), another has been submitted for a special issue of *Sedimentary Geology*, and a fourth and fifth are being revised for *Chemical Geology*. These papers concern the Cretaceous



deposits of the Western Interior basin and they range from reconstructions of $p\text{CO}_2$ using paleobotanical methods, to sulfur isotopic analyses of pyrite and carbonate-associated sulfate, to investigations of mineral surface area and phosphorus concentrations. Each project advances the understanding of organic carbon burial processes and changes in the global carbon cycle and climate during Cretaceous oceanic anoxic events....

Stein Wins Woollard Award



Seth Stein lectures on the geology of Yellowstone Park during a recent EPS trip there.

After thirty years at Northwestern, Seth Stein, a geophysicist and the William Deering Professor of Earth and Planetary Sciences, still enthusiastically recalls the intellectual milieu in which he received his introduction to geology: "I came to Earth science in the early 1970s, which was an incredibly exciting moment for the discipline. Only a few years earlier, geoscience had been entirely redefined by the developing theory of plate tectonics. As a result, my professors often exhorted their students to disregard conventional wisdom so they could find the next big idea that would further advance our understanding of the Earth." Though Stein's colleagues describe him as a "unique individual" who has made "paradigm-shifting contributions" in his research and teaching, he is also representative of the fertile intellectual ground that gave rise to his scientific

career. Reflecting the spirit of the moment that, as he puts it, "hooked" him on geology, his research has long pursued the "big ideas" necessary to provide "global frameworks" for understanding how plate tectonics works. This innovative thinking has helped him establish a distinguished academic record that includes authorship of over 100 scholarly articles, co-authorship of the authoritative textbook on seismological concepts and methods, and recognition as one of the world's most highly cited scientific researchers. In light of these accomplishments, Stein was recently selected as the 2009 recipient of the George P. Woollard Award, one of the highest distinctions given by the Geological Society of America.

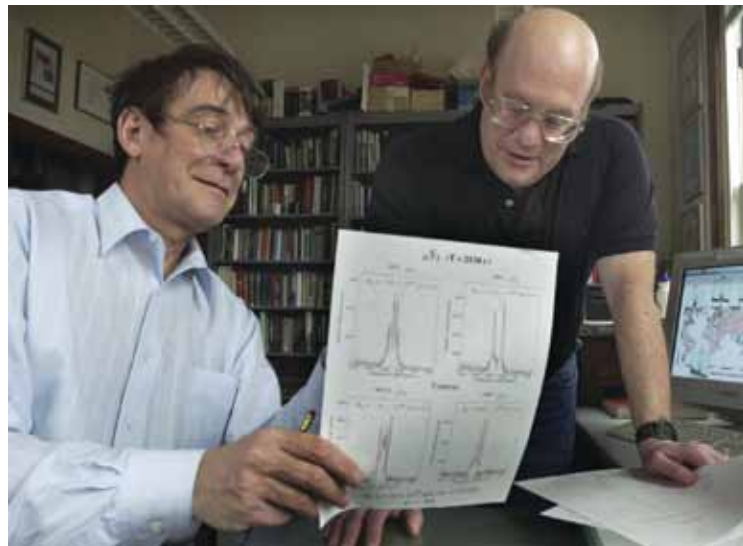
Stein's research has produced fundamentally important discoveries on many topics, including global relative plate motions, the state of stress in oceanic plates, the thermal structure of oceanic lithosphere, spatiotemporal variations in Andean mountain building, and the use of normal modes to assess large earthquakes. But it is his most recent work—a series of GPS studies across the New Madrid Seismic Zone (NMSZ)—that he says best captures his approach to scientific problems. In explaining his perspective, he is fond of quoting the physicist Niels Bohr, who once famously observed: "How wonderful that we have met with a paradox. Now we have some hope of making progress." This reflection appeals to him, he says, because it "demonstrates Bohr's delight in facing something that totally confounded him. It's another way of saying that the most interesting scientific results often arise from completely unexpected discrepancies." Thus, while he realizes that "contradictions can be a bit frightening," he views them as an "opportunity to learn rather than as an obstacle that prevents scientific progress."

Stein remembers encountering just such an "opportunity" in the mid-1990s, several years after he began monitoring the New Madrid Seismic Zone for evidence of accumulating strain. "Since large earthquakes felt across the Midwest occurred there in the early nineteenth century and small earthquakes still occur there today, we expected to find that the ground along the fault was storing energy the same way it does everywhere else prior to big earthquakes," he explains. "We were shocked to learn, however, that it wasn't moving at all." Even today, after nineteen years of vigilantly surveying the NMSZ, Stein describes himself as being "utterly amazed" that he has "yet to detect any motion there whatsoever." Here, then, Stein had found an intriguing contradiction: Even though the

Stein--continued

New Madrid fault has historically produced large earthquakes and continues to generate smaller shocks commonly viewed as harbingers of more destructive future events, all available monitoring data showed that it would be virtually impossible for such a convolution to occur in the near future. But which of these apparently mutually exclusive sets of evidence was valid? And is the NMSZ inactive or active?

Faced with a fork in the road, Stein jokes that he opted to “take it”—and consequently arrived at one of the most important realizations of his career. Recognizing that both components of his conflicting evidence were equally compelling, he came to understand them not as antithetically opposed possibilities, but as crucial pieces of a larger puzzle illustrating a “kind of behavior that hadn’t been previously recognized.” According to Stein, this paradox reflects the novel idea that mid-continent earthquakes are generically distinct from upheavals at plate boundaries where such events follow a somewhat predictable pattern generated by the steady influence of relative plate motion. In contrast, mid-continent earthquakes occur as part of a “complex system” shaped by multilayered fault interactions that render such events “episodic, clustered, and migrating.” For the NMSZ, this conclusion implies that, contrary to prevailing hazard estimates, recent earthquakes there are more likely aftershocks than foreshocks, and that the entire seismic zone itself is probably dying as strain accumulates in other parts of “the system.” These estimates



Former CalTech graduate school classmates and long-time EPS faculty members, Emile Okal (left) and Seth Stein.

have yet to be revised, however, because they have largely ignored the fork in the road Stein has “taken” en route to revising the established understanding of mid-continent earthquakes. While the dynamic intellectual atmosphere of the 1970s defined the eventual course of Stein’s career, he believes that the lively scholarly environment found in the classrooms and offices of Locy Hall has also helped his work flourish. “It has been enormously important for me to be here,” he says, “because this department has always welcomed new ideas. Even though the faces have changed, the receptiveness to work that might veer from prevailing opinion has been an enduring quality here. I feel lucky to have worked in a place like this...and equally lucky to have had the chance to help so many talented graduate students reach their potential.” What Stein’s modesty prevents him from saying, of course, is that for the past three decades, his ambitious research has been matched by an equally creative and committed pedagogical philosophy that has allowed his doctoral students to produce an unusually large number of first-author publications while enjoying a high degree of success on the job market. Taken together, these aspects of his work have insured his status as a cornerstone of the department and a major force in sustaining and amplifying its intellectual vitality. And for that, Stein’s colleagues—as well as his current and former students—should feel lucky, too.

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Faculty Research, continued

Suzan van der Lee has been guiding studies of the three-dimensional structure of the mantle beneath North America, South America, and the Tethys Belt in Europe, northern Africa, and the Middle East. Her postdoc, SungJoon Chang, and graduate students, Simon Lloyd and Xiaoting Lou,



have been applying new joint inversion and array data analysis methods and utilizing new data sets to approach these research problems. They’ve shared this research at the National Earthscope workshop and a NSF funded short course on processing USArray data, that she organized with Gary Pavlis from Indiana U at NU. You can read more about the short course at <https://researchcomputing.northwestern.edu/mapping-earths-interior>. Van der Lee concludes one year as National Earthscope Speaker and a three-year term on the IRIS Board of Directors. She also helped obtain NSF funding for a new computer system for computational research. The new system will facilitate research centrally and provide graduate students with modern desktop access to this system...

In Memoriam



Professor emeritus Edward Charles Dapples (BS, 1928 & MS, 1934) passed away at the age of 102 on May 10, 2009, in Peoria, Arizona. A member of the NU faculty from 1936 until his retirement in 1973, Dapples’ research focused on the origin and formation of coal, petroleum-bearing sediments, and broad regional problems of sediment deposition. He was president of the Society of Economic Paleontologists and Mineralogists (1970-1971) and the American Association of Petroleum Geologists (1979-1980), and a fellow of the Geological Society of America. Known as a charismatic teacher, Dapples was extremely popular with his students...

Graduate Student Highlights

Derek Adams is using the sulfur isotope composition of seawater sulfate, as recorded in carbonate-associated sulfate, and the sulfur isotope composition of pyrite to study the sulfur cycle. His work focuses



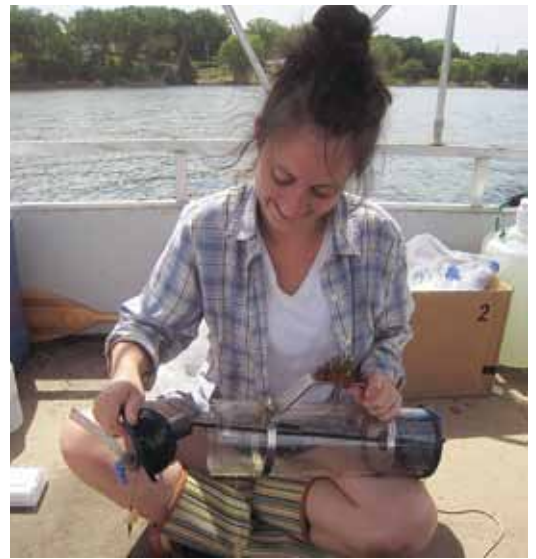
on the coupling of the biogeochemical cycles of carbon and sulfur in the context of Oceanic Anoxic Events, specifically OAE II near the Cenomanian/Turonian stage boundary in the Late Cretaceous....Fourth-year student **Kim Adams** recently gave an oral presentation, "Low temperature visible and infrared reflectance spectra of solid and liquid methane with applications to the outer solar system icy bodies," at the North Central GSA Conference in Rockford, IL... Second-year student **Allie Baczynski** spent the summer in Wyoming's Bighorn Basin where she collected ancient soil samples that record the Paleocene-Eocene Thermal Maximum (PETM), a period of large-scale global warming that occurred ~55.8 Mya. She will analyze these samples to reconstruct terrestrial paleohydrology across the Paleocene-Eocene boundary so she can



better understand this important analogue to modern anthropogenic carbon release and sequestration...

Gomes Wins NASA Fellowship

For most people, extracting mud samples from the bottom of a lake in the Upper Midwest might seem like an onerous if unusual way to spend a weekend. But for second-year graduate student Maya Gomes, the experience was "one of the exciting things" she could "imagine doing" at this point in her academic career. Given that her recent sampling expedition marked the beginning of a research project she believes "has great potential to help reveal how early life forms developed," Gomes' enthusiasm for her work is understandable. It is also, apparently, not unique. Last May, she won a prestigious three-year NASA Earth and Space Science Fellowship to complete her study, which will use water and sediment samples collected from McCarrons Lake in Minnesota to analyze sulfur isotope systematics within a low-sulfate system. When completed, her work will provide a mechanism for understanding how oxygen levels evolved during the Precambrian period, roughly the first 4 billion years of Earth history.



Graduate student Maya Gomes recently won a NASA Fellowship to analyze sulfur isotope systematics in a low-sulfate system.

Gomes' project proceeds from the recognition that sulfur, which enters the ocean as sulfate, can be used as a proxy for atmospheric oxygen levels. To track sulfate concentrations in the ancient ocean, scientists analyze the results of a biogeochemical process called bacteria sulfate reduction (BSR). During BSR, microbial organisms use organic carbon to reduce sulfate to hydrogen sulfide, which reacts with iron and is preserved with sulfate in the rock record as pyrite. This reduction process, in turn, is accompanied by a kinetic isotope effect in which the lighter of two sulfur isotopes (^{32}S versus ^{34}S) preferentially reacts to form sulfide. Because the size of this isotope fractionation increases as sulfate concentrations rise in a given marine environment, the fractionation process can be used to measure evolving sulfate concentrations, and inferentially, Earth surface oxygen levels.

Using isotopic analysis as a method for tracking oxygen levels requires, however, that the fluctuating magnitude of sulfur isotope fractionation be precisely understood at different levels of marine sulfate concentration. To ascertain these variations in the fractionation process, Gomes must, as she says, "replicate the low-sulfate environment of the Precambrian ocean" by performing laboratory bag incubation experiments with samples collected "from a modern analogue to the Precambrian ocean," McCarrons Lake. Here she will isolate muds containing sulfate-reducing bacteria and expose them to lake waters spiked with a range of sulfate concentrations mirroring those of the ancient marine environment. Gomes will then sample the lake waters for the next month to assess the S isotope fractionations induced during BSR.

The results from this work will help Gomes calibrate sulfate concentrations in the ancient ocean, reconstruct the chemical evolution of the ocean-atmosphere system on early Earth, and establish the environmental conditions under which early life forms evolved here and, potentially, on other planets. Reflecting on the far-reaching implications of her project, Gomes wonders, "Who would've ever thought that lake mud could help answer some fundamental questions about the existence of life on other planets? It's that element of the unexpected that keeps me excited about what I'm doing." Fortunately for Gomes, she has developed into the kind of scientist who can make such surprising connections. Her unconventional thinking will undoubtedly serve her well as she moves forward.

Boiteau Wins Churchill Scholarship

Brad Sageman believes 2009 EPS graduate Rene Boiteau may have completed his degree in the nick of time. "If he had stayed any longer," the EPS department chair recently quipped, "we might have run out of awards for him." Sageman's joke was only partially hyperbolic. While Boiteau hadn't completely exhausted Northwestern's supply of academic prizes by the time he graduated, he came close to doing so. During his four years at NU, Boiteau earned a reputation



One of the country's top undergraduates before completing his degree last June, Rene Boiteau won Churchill and Goldwater Scholarships as well as a NSF Fellowship while a student at Northwestern. He is currently completing a MS at Cambridge.

as one of the school's top students by amassing a nearly perfect grade point average, co-authoring two research publications for scholarly journals, and winning just about every academic award around, including three of the nation's most prestigious scholarships and fellowships. In the final eighteen months of his undergraduate career, Boiteau received a Goldwater Scholarship, widely regarded as the highest national award for math and science majors; a NSF Graduate Research Fellowship, the most prominent award given by that agency to current or future graduate students; and a Churchill Scholarship, one of the top awards for American students seeking international research experience. He will use his Churchill Scholarship to complete a master's degree at the University of Cambridge before commencing his NSF-funded doctoral research at the MIT-Woods Hole Joint Program in Oceanography.

Boiteau attributes much of his success to the curiosity his parents instilled in him at an early age. His father spent a great deal of time fixing and building things around the house. "My dad is a pretty skilled handyman," he says. "And he liked for me to help him, to have me dig right into things and see if I could figure them out. Having those early experiences of getting inside things, taking them apart, and really looking at them made me want to know how the world works on a larger scale. It's a question I've been pursuing in one way or another ever since."

At Northwestern, Boiteau found that it was in the Department of Earth and Planetary Sciences that he could most fully express his curiosity. "One of the reasons I love this department," he says, "is that the learning opportunities it offers are unrivalled...The courses here are great and the faculty are enthusiastic teachers who go out of their way to make themselves available outside the classroom.... And the field trip offerings are totally unique." For Boiteau, EPS field trips are emblematic of a departmental ethos that seeks to exceed normal expectations for what an undergraduate education can and should be. "It's just a department that tries to give as much as possible to its students throughout their NU careers—both inside and outside the classroom."

Despite his current enthusiasm for the department, Boiteau was initially reluctant to register for his first geology course, "Physics of the Earth," a requirement for the honors Integrated Science Program in which he also majored. "The idea of taking that class kind of scared me," he explains, "because I had finished a difficult physics sequence the previous year and wasn't looking forward to more of that material." After only a few lectures from the course's instructor, Craig Bina, however, he concedes that he was "sold" on the geosciences. "He's just a great teacher," Boiteau says of Bina. "He was able to bring the course's concepts to life with stories about scaling volcanoes in Japan and hiking across African jungles. The more he talked about his experience as a geoscientist, the more I wanted to hear about it."

Graduate Students, continued

Richard Barclay 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 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 Utah...**Rosemary Bush** recently received her MS in Plant Biology and Conservation for her work on molecular and isotopic variation in modern leaf wax n-alkanes...Second-year student **Yun-Yuan Chang** has co-authored a publication on "Phase relations of Fe-Si alloy in Earth's core" in *Geophysical Research Letters*... First-year student **Laurel Childress** is investigating how the stable isotopic composition of organic matter (carbon and nitrogen) in continental shelf cores can be



used as a proxy for terrestrial change in the Waipaoa River watershed during the Late Pleistocene and Holocene...**Jeremy Gould** recently submitted a manuscript, "Strontium and carbon isotope stratigraphy of the Llandovery (Early Silurian): Implications for tectonics and weathering," for publication...

Graduate Students, continued

Sutatcha Hongsresawat is a second-year student studying the connection between earthquake frequency and magnitude to location...**Young Ji Joo** has been investigating the biogeochemical cycles



of phosphorus, nitrogen, and carbon... First-year student **Greg Lehn** studies the relationship between calcium isotopes and the increasing rate of permafrost melting...

Dan Li is working with TOTEM, an Earth system model of the C-N-P-S coupled biogeochemical cycles, to study how land use changes interact with phosphorus behavior and atmospheric CO₂...**Simon Lloyd**, an advanced seismology student,

uses surface wave tomography to map crustal thickness in South America... **Xiaoting Lou** measures teleseismic P and S relative delay times from IRIS PASSCAL and EarthScope USArray data. His data suggests that lateral temperature variation may be causing velocity anomalies beneath both the tectonically active western U.S. and

the stable eastern U.S...**Miguel Merino** is cataloging earthquake features to connect them with geologic setting...**Emily Wolin** studies geophysical processes that affect continental interiors.



the stable eastern U.S...**Miguel Merino** is cataloging earthquake features to connect them with geologic setting...**Emily Wolin** studies geophysical processes that affect continental interiors.

Boiteau--continued

At Cambridge, Boiteau plans to focus on issues related to the ocean and environmental sustainability. Responding to contemporary concerns about ocean acidification as a consequence of rising levels of atmospheric CO₂, he will investigate what is believed to be a past example of a global decrease in ocean pH, the Mid Brunhes Dissolution Interval (MBDI). According to Boiteau, the MBDI, which took place between 200,000 and 500,000 years ago, presents an interesting challenge to earth scientists because it displays the characteristic sign of ocean acidification—globally intensified carbonate dissolution—but is apparently not accompanied by an increase in atmospheric CO₂ levels. A recent discovery that the ratio of boron to calcium found in ancient fossilized shells can be used to determine seawater pH during the MBDI, will be used to “map the changes in ocean acidity during this period.” Once he has reconstructed the history of ocean pH for the MBDI, Boiteau believes he can begin to answer questions about “the rates and mechanisms of carbonate dissolution,” information which should help scientists “better predict the pace and extent of future climate change.”

“One of the reasons that I love EPS is that the learning opportunities it offers are unrivalled. The courses are great and the faculty are enthusiastic teachers who go out of their way to make themselves available outside the classroom...Being able to accompany faculty members for a week-long immersion course on the geology of Mexico was incredible in itself, but the department’s willingness to heavily subsidize this experience was even more astounding...It’s just a department that tries to give as much as possible to its students throughout their NU careers.”--Churchill Scholar Rene Boiteau

Propelled by an intensely curious mind, Boiteau looks forward to the advent of his graduate work with great enthusiasm. “The opportunity to learn about and pursue new questions,” he says, “is incredibly exciting to me.” Even as he focuses on the challenges of the future, though, he cannot help reflecting on the lessons of the past. Referring to EPS as “perhaps my most important discovery at Northwestern,” Boiteau explains that he feels this way because it was in EPS that he “first realized that some of the most important learning you can do in school actually takes place outside the classroom, in conversations with faculty members during office hours, in hallways between classes, or on field trips.” “But for that learning to take place,” he adds, “you



Rene Boiteau, Rebecca Fischer, and Stefan Jensen determine depositional environments by analyzing coral fossils. They are receiving instruction from Paul Blanchon of Mexico’s National Autonomous University.

don’t just need a group of really smart people at the head of the classroom—you also need teachers like you have in EPS, faculty members who are deeply committed to helping students learn by creating a relaxed environment where students feel comfortable interacting with their teachers in a lot of different ways.” In Boiteau’s view, it is precisely this ability to engage students on a variety of levels that makes EPS “so great.”

Alumni News and Donor Honor Roll



Jason Flaum and son Jeremiah

Joniell Borges (PhD, 2008) and his wife, Lauren, are the parents of a baby girl, Genevieve, who was born on May 11th. Joniell lives in Houston where he is an exploration geologist for Chevron...

Jason Flaum (PhD, 2008) recently completed his first year working in Houston as an exploration geologist for Exxon. He and his wife are parents of a three-year-old boy, Jeremiah...**James Hebden** (BS, 2007) lives in Washington D.C. where he is an intern at the Federal Reserve...

Han Li (PhD, 2005) has returned to her native country of China where she is a tenure-track faculty member at the Chinese Academy of the Sciences...

Stephen Meyers (PhD, 2003) recently accepted an appointment as an assistant professor in the Department of Geosciences at the University of Wis-

consin-Madison, and he and wife Gigi are expecting their first child in 2010...

Kim Schramm (PhD, 2007) gave birth to a 5.75-pound baby girl, Madelyn, on January 23rd. Kim is currently a post-doctoral researcher at New Mexico Tech where she is helping generate a broadband Rayleigh-wave dispersion curve for the Yucca Flats region of the Nevada nuclear test site...

Phil Richardson (PhD, 1998) visited the department once again this Fall on one of his recruiting excursions and presented a talk on his research work for Chevron. Phil has been instrumental in maintaining the department's historically strong connection to the energy industry and we thank him for his efforts... **Peter Vail** (PhD, 1959) lives in Houston and remains active as



Kim Schramm and daughter Madelyn

a consultant in the oil industry. Dr. Vail's attendance at the EPS alumni reception during the 2008 Fall GSA Meeting provided one of the week's highlights for many departmental faculty and alumni...

Douglas Wiens (PhD, 1985) recently became chair of the Department of Earth and Planetary Sciences at Washington University in St. Louis...

Michael Wyession (PhD, 1991), an associate professor in the Department of Earth and Planetary Sciences at Washington University in St. Louis, recently completed a forty-eight lecture DVD "Great Course" series for an educational films company. The lecture series, entitled "How the Earth Works," addresses a variety of topics ranging from plate tectonics to climate change and has been advertised in *The New York Times* and other publications.



Joniell and Lauren Borges with their daughter Genevieve

2008-2009 Donor Honor Roll

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Undergraduate Program Gains Momentum



Top left: Cesca McInerney and Sara Bosshart

Bottom left: Latisha Brengman

For much of the department's recent history, geology majors have frequently described EPS as one of "the best kept secrets on campus" due its dynamic curriculum and comparatively small student population. In light of recent departmental recruiting successes, however, it must be concluded that the secret is out.

Over the past three years, the department has significantly boosted course enrollments and attracted a growing number of majors. These students have, in turn, collectively established an academic record that is the envy of many larger departments. Last June, for instance, the department graduated eight seniors—the largest such class in at least a decade—whose academic accomplishments more readily identify them as advanced graduate students than as undergraduates. In keeping with department tradition, these students, such as Sara Bosshart, Stefan Jensen, Tim Reber, and Latisha Brengman, were deeply involved with research, frequently co-authored academic articles, presented their work at national and international conferences, and completed honors theses.



Ryo Kita

Even more impressive was the rousing affirmation our graduates received at the national level through the success three students experienced in competing for the country's most prestigious academic honors. The past year's nationally recognized seniors included Rene Boiteau, who earned Goldwater and Churchill Scholarships before concluding his NU career with a NSF Graduate Research Fellowship; Ryosuke Kita, who was awarded a Goldwater Scholarship and a NIH Postbaccalaureate Intramural Research Training Award; and Rebecca Fischer, who garnered a NSF Graduate Research Fellowship. To win these awards, students must typically undergo a rigorous evaluation process and rank in the top 5% of vast nationwide applicant pools.

Not surprisingly, all of these students have extremely promising futures ahead of them. As an example, the list of schools admitting our seniors for graduate study—Cambridge, ETH Zurich, the University of Edinburgh, MIT, Princeton, Cal Tech, Harvard, Columbia, etc—reads like a survey of the top foreign and domestic universities. The faculty were thrilled to help these talented students reach a high level of achievement and look forward to maintaining the department's reputation for undergraduate academic excellence, especially as its major population continues to expand.