Fall 2000 Issue 6

Department of Earth and Planetary Sciences

Washington University in St. Louis

Newsletter

IN THIS ISSUE . . .

Message from the Chair

Ray Arvidson

Greetings to everyone! We had lots of good feedback from our previous newsletter so we thought we should get another one to you. It has been a very busy year. Michael Wysession was honored this spring with the St. Louis Science Academy Innovation Award, which recognizes scientists under age 40 who have exhibited great potential and emerged as leaders in their fields. Larry Haskin and Everett Shock received two of the First Annual Outstanding Faculty Mentor Awards given by the Graduate Student Senate of Arts and Sciences for commitment to graduate students and excellence in graduate training. Our new building is in the final stages of approval. We are also gearing up to search for an additional geodynamicist to start in the fall of 2001. Perhaps the most significant event this year occurred at the Meteoritical Society Meeting when Meenakshi Wadhwa, PhD 1994, won the Nier Prize for outstanding publication in the field of Meteorites and Planetary Science by a scientist younger than 35. Ghislaine Crozaz, her PhD advisor, gave the introductory citation before Mini graciously accepted the award.

The new U.S. News and World Report has ranked the department's graduate program as 23rd and our geochemistry program as 10th in the country. We are very proud of what we have accomplished over the past two decades and we look forward to getting even better. Please consider helping us by contributing to the Washington University Capital Alliance Campaign that is now underway. Let me know if you need information about the campaign and ways of giving. Enjoy the Newsletter. Please let us know what you are doing, and stop by if you are in St. Louis.

Haskin, Shock Recognized as Outstanding Faculty Mentors, Others Honored

This past spring Larry Haskin, Ralph E. Morrow Distinguished University Professor, and Everett Shock, Professor, received two of the First Annual Outstanding Faculty Mentor Awards given by the Graduate Student Senate of Arts and Sciences. Graduate students in the Senate created these awards to honor faculty members whose commitment to graduate students and excellence in graduate training has made a significant contribution to the success of graduate students in Arts and Sciences at Washington University. Ray Arvidson, James S. McDonnell Distinguished University Professor; Julie Morris, Associate Research Professor; and Roger Phillips, Professor, also received special recognition for excellence in mentoring.

The Mentoring Committee of the Graduate Student Senate named Larry and Everett Outstanding Faculty Mentors based on letters that both current and former Washington University graduate students wrote in support of their nominations. The committee was impressed not only with the professors' clear dedication to providing graduate students with the skills and resources needed to succeed as scholars, but also with their sincere and active interest in the well-being of their students. As Panjai Prapaipong, one of Everett's graduate students, commented, "He enjoys his work and always makes sure that his students

Continued on next page

Continued from page 1

and staff are also happy with what they do. Everett has proven that what really matters in graduate schools is the research advisor." Larry's graduate student Ryan Ziegler agrees. "I have learned more from Larry than from anyone else while at Washington University. Larry and the rest of our research group are helping me understand how things work in all aspects of academia and science in general."

EPSC IN ACTION

New Pathfinder Program in Environmental Sustainability

The Pathfinder Program in Environmental Sustainability welcomed its first freshman class in August. The program, a successor to the Hewlett Program, gives participating students a chance to engage in interactive study of the environment with a small group of motivated undergraduates, a senior faculty member (Ray Arvidson), and graduate fellows. Through case studies and field trips, students are examining issues surrounding environmental sustainability and the preservation of the environment for future generations. Field trips include such diverse sites as the Missouri River flood plain, the Mojave Desert National Preserve, and the Big Island of Hawaii. While participating in the Pathfinder program, students may pursue a major in the sciences or mathematics in the College of Arts and Sciences, or a major within the School of Engineering and Applied Sciences. In addition to taking the Pathfinder core courses, students also take courses tailored to their interests and major. The Pathfinder program supports the concept that taking interrelated courses and learning both analytical and technical skills will help the students not only complete a senior year "capstone" research experience, but also further their research careers or graduate studies

Hofmeister and Dymek Edit 'American Mineralogist'

Professor Robert F. Dymek and Research Professor Anne M. Hofmeister continue as Co-Editors of the *American Mineralogist*, positions that they have held since August 1997. The *American Mineralogist* publishes original scientific research in the fields of mineralogy, crystallography, geochemistry, and petrology. It is the flagship publication of the Mineralogical Society of America. Bob and Anne are both fellows of the society. Anne is the first female editor of the journal in its 85-year history.

Bob and Anne have overseen several changes while editors, including expansion of the journal from 6 to 8 issues per year, and a now-completed transition to desktop publishing for manuscript production, which has helped to ensure a rapid and on-time publication. As their first official action as Editors, Bob and Anne added a subtitle to the journal, which now reads: "An International Journal of Earth and Planetary Materials." This subtitle reflects the diversity of subject matter as well as the authors of articles, since more than half are based outside of North America. Articles from the *American Mineralogist* are the most widely cited in the field, and the journal is considered the international standard for excellence in mineralogical studies.

Criss Defines 'Principles'

Professor Robert Criss' new book, *Principles of Stable Isotope Distribution*, published by Oxford University Press, explains the variations of stable isotopes found in nature in terms of basic physical principles. Bob often found that many leaders in the area of stable isotopes were unable to answer questions about the principles of the field. This, along with years of teaching courses on stable isotopes, led Bob to the conclusion that a book was needed that focused on fundamental principles and applications. *Principles of Stable Isotope Distribution* provides an excellent reference for researchers, as well as a comprehensive resource for students taking courses in stable isotope geochemistry.

DEPARTMENT RESEARCH

Experimental Mineralogy In Situ on the Sea Floor

By Jill Pasteris

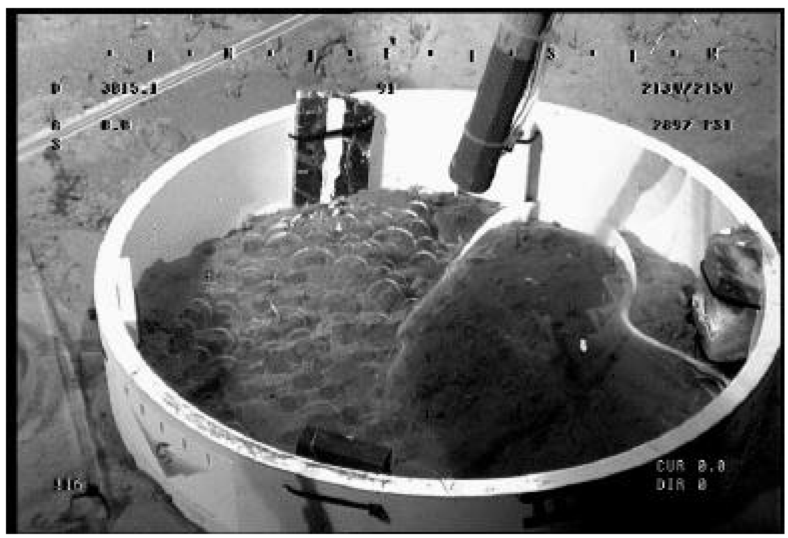
Professor Jill Pasteris and her colleagues, research scientists Dr. John Freeman and Dr. Brigitte Wopenka, are collaborating with oceanographers at the Monterey Bay Aquarium Research Institute (MBARI) in Moss Landing, California, and chemical engineers from Colorado School of Mines. From their research ships, the MBARI group under Dr. Peter Brewer deploys advanced remotely operated vehicles (ROV's) that can take samples and make videos on the sea floor at depths to 4 km. MBARI is particularly interested in making accurate geochemical and mineralogical measurements in conjunction with its on-going experiments involving the placement of liquid CO_2 on the sea floor. The reason for these experiments is to help evaluate the feasibility and desirability of sequestering so-called greenhouse gases deep in the ocean. All three collaborative groups have agreed that Raman spectroscopy, an analytical technique typically applied in a laboratory setting, would be an excellent way to investigate the solid, liquid, and gas products of reactions on the ocean floor. The challenge is to carry out such analyses *in situ* at several kilometers depth.

Jill's group has helped MBARI to select and specify a Raman spectroscopic system that MBARI will purchase and encapsulate in pressure-resistant housings to enable its operation on the sea floor. The Washington University group will be involved in testing the "undersea worthy" Raman spectrometer and interpreting spectra. Raman measurements have never been made on the sea floor. When Jill participated in a 4-day MBARI scientific cruise in March 2000, she got to experience firsthand (complete with sea sickness, alas) what it will be like to take and interpret Raman measurements in real time from the sea floor.

Clathrate hydrates are considered to be one possible answer to the question of how humans could benignly re-package (sequester) the CO_2 that we now dump in such huge abundance into the atmosphere due to the burning of carbon-based fossil fuels. Well-recognized laboratory experiments on the pressure-temperature phase equilibria of CO_2 and water indicate that below about 500 m in the ocean, CO_2 and water should react to form a solid, ice-like compound called a clathrate hydrate. Clathrate hydrates are minerals that occur naturally on the sea floor, most commonly as methane (*i.e.*, CH_4, natural gas) clathrate hydrate. In these minerals, water molecules form a framework similar to that in ice, but many of the voids (sites) that are created are filled with gas molecules. In typical clathrate hydrates, there is about one gas (CO_2 or CH_4) molecule for every six water molecules.

The possibility of injecting CO_2 into the ocean depths brings up several questions. At what depth and temperature does liquid CO_2 react to form a stable compound, such as a clathrate hydrate, that sinks to the sea floor? How long does that compound remain stable on the ocean floor, and what affects its longevity? What are the environmental impacts to both the local geology and biology of large-scale emplacement of CO_2 deep in the ocean?

Peter's group at MBARI is the first to place liquid CO_2 on the deep ocean floor. They successfully formed and videotaped the formation of synthetic CO_2 clathrate hy-



Photograph taken on the sea floor at 3015-m depth in Monterey Bay. Open-ended, PVC tube, about 54-cm in side diameter and 10 cm high, resting directly on clay-rich sea floor; 5 rock slabs are affixed to inner surface. PVC acts as a "corral" and reaction vessel for liquid CO_2 injected via vertical tube connected to a tank on the nearby remotely operated vehicle. Each rock slab has vertical white paint stripe to act as barrier against reaction, thereby providing "control" material that will not undergo dissolution. Large, heart-shaped coalesced globule of liquid CO_2 resting on clayey sediments in right half of corral. Additional CO_2 has just been injected from the vertical tube, seen as colorless bubbles in left half of corral. Jill's group will study dissolution effects on the rock samples after they have resided at depth for about 6 weeks. Photograph courtesy of Peter Brewer, Monterey Bay Aquarium Research Institute.

drate at over 3600-m depth in Monterey Bay. Now they want to be able to take Raman spectra of the actual phase that forms in order to confirm its identity and to specify its crystal structure. The group at the Colorado School of Mines, under Dr. Dendy Sloan, plans to use Raman spectroscopy to measure the concentration of CO_2 in the seawater at incremental distances from the clathrate. These data will provide a means of evaluating the long-term stability of the clathrate and its rate of conversion to dissolved CO_2 in seawater. Jill's group will focus its attention on mineralogical changes that may occur in sediments when CO_2 is introduced. It is well known that the pH of the immediately surrounding seawater should plummet, which could cause dissolution of carbonate sediments or even acid attack on silicate minerals.

During the experiments on the cruise in March 2000, Jill and her collaborators placed 5 different mineral and rock samples (mostly carbonates) at 3000-m depth in an artificial corral (see figure) that then was filled partially with liquid CO_2. The samples included polished blocks of fine-grained limestone, coarse-grained limestone, marble, and calcite-veined serpentinite, as well as a large cleavage rhomb from a single crystal of calcite. In April the MBARI group returned to retrieve the samples from the sea floor so that Jill's group can determine if they underwent appreciable dissolution. In principle, the different grain sizes of the calcite will affect its dissolution rate, and the cleaved or polished surfaces of the samples will make it readily evident if and where any dissolution occurred.

Toxic Trace Elements in Soil Solutions

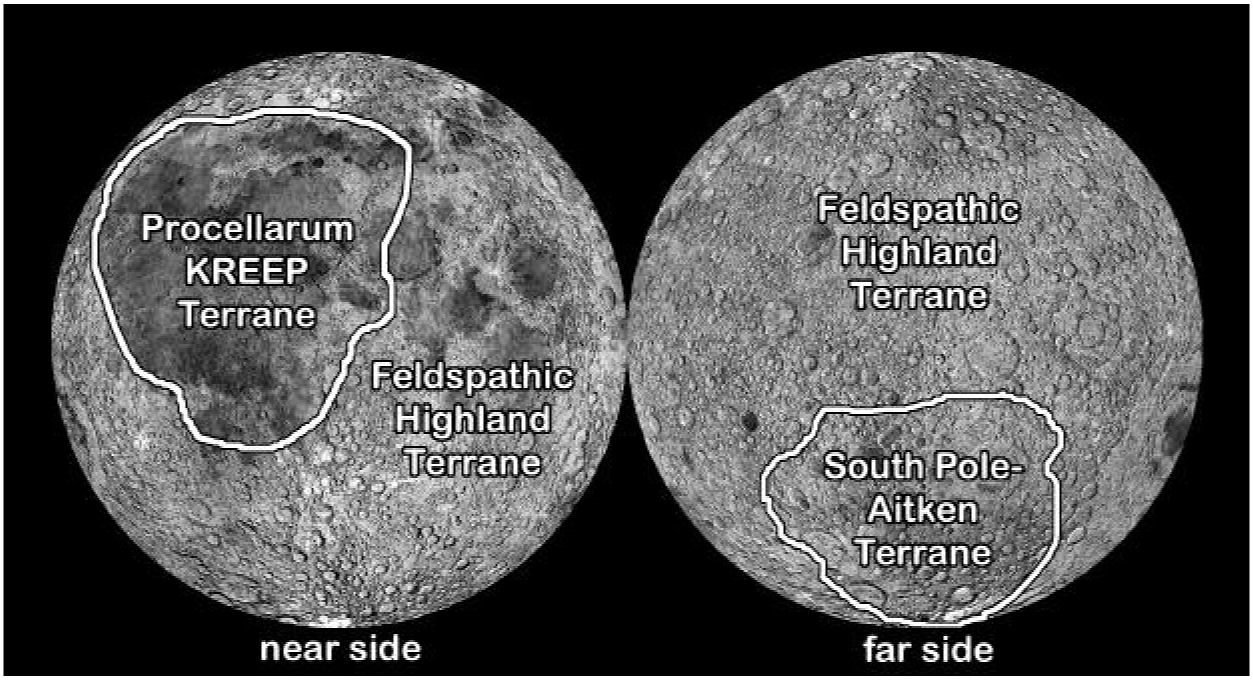
By Panjai Prapaipong

Despite the fact that lead is relatively immobile in soil, previous studies in the department by Kate Crombie, Lara Douglas and Colin Ennsle suggest that Pb is transported from soils to boles and leaves of white oak and red cedar trees. In a related study, Panjai Prapaipong has investigated the forms of Pb and other trace metals available for plant uptake in soil solutions. She has found that in some cases, organic compounds may affect the bioavailability of trace elements.

To measure the fraction of trace metals, Panjai extracted soil solutions from soil samples that she and Colin Ennsle collected near the Glover lead smelter in Southeastern Missouri. She analyzed the soil solutions for major and trace metal cations with the department's ICP-MS (Inductively Coupled Plasma- Mass Spectrometer), and major anions and organic acid anions by ion chromatography.

Panjai found that Pb concentrations in soil solutions range up to 250 ppb; those of Co, Ni and Cd range up to 40 ppb; those of Cu are as high as 60 ppb; and Zn concentrations vary up to 350 ppb. Up to 5 ppm of acetate, 3 ppm of formate, 1 ppm of oxalate, 1 ppm of succinate and 0.5 ppm of citrate were detected. Concentrations in soil solutions are highest in the uppermost soil horizons, where Pb is typically thought to be very strongly bound to soil particles. Using results from the theoretical work on metal-organic complex formation (Prapaipong et al. 1999 *Geochim. Cosmochim. Acta*), Panjai calculated the speciation of Pb and other trace metals in the soil solutions. The speciation of Pb and other trace metals appears to be insignificantly affected by acetate, formate or succinate. Less than 1% of the dissolved trace metals are present as complexes of these organic acids. On the other hand, despite its lower concentration, oxalate plays a significant role in the speciation results. At the highest oxalate concentration, copper-oxalate dominates the speciation of Cu by 72%; 20% of Ni is present as Ni-oxalate; and 8% of dissolved Pb, Co and Zn forms oxalate complexes. In samples with a typical oxalate concentration of only 0.10 ppm, around 50% of Cu is present as Cu-oxalate complexes, and oxalate complexes of Co, Ni, Pb and Zn are present at 2-5% level. Panjai also determined that at their low concentration levels, inorganic anions form negligible amounts of complexes with trace metals. Therefore, they do not compete with oxalate in complexing toxic trace elements. Overall, the majority of Co, Ni and Zn (over 75%) in soil solutions is present as free cations; Cu is dominated by its oxalate complex; and over 65% of dissolved Pb forms hydroxide complexes.

These results suggest a link between short-chain carboxylic acids and the bioavailability of both toxic and nutrient trace metals to different extents. Panjai is continuing to probe the question of bioavailability of toxic trace metals by measuring concentrations of Pb in bulk samples and different soil phases including organic matter. Large organic molecules like humic substances are thought to sequester trace metals and are believed to retain Pb in the top soil horizon. Panjai hopes to test this idea.



Shaded relief map of the two hemispheres of the Moon illustrating the surface expression of the three major lunar crustal terrains delineated using global remote sensing data sets (e.g., iron from Clementine data and thorium from Lunar Prospector data).

New Views Offer New Insights into the Geology of the Moon…

By Jeff Gillis

The last Apollo mission left the Moon's surface almost 30 years ago. Nevertheless, lunar science continues to day, spurred by two recent remote sensing missions, Clementine and Lunar Prospector. The geochemical data acquired by these missions offer new perspectives and enable us to extend the insights of the Apollo samples to the whole Moon. Our Planetary Surface Materials research group is a leader in interpreting these remotely sensed, global data sets with the aid of chemical and petrologic data from Apollo and Luna samples and meteorites from the Moon. This group includes experienced scientists Larry Haskin, Randy Korotev, Brad Jolliff, and Jeffrey Gillis, and graduate students Kathleen Abbott and Ryan Zeigler. (For more information about the Planetary Surface Materials research group, visit our web site at http://epsc.wustl.edu/haskin_group/lunar/index.htm.)

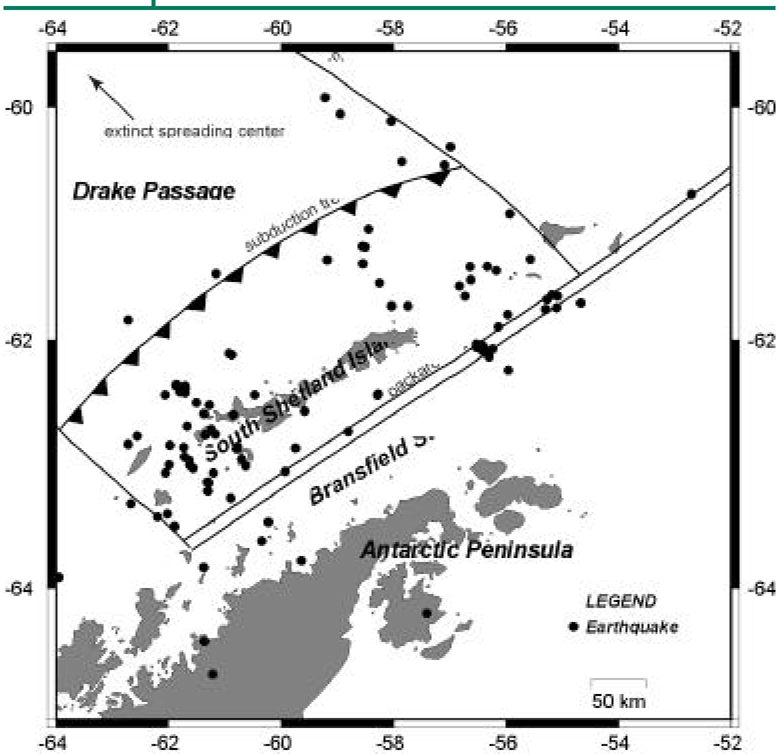
Our research shows that the traditional "mare-highland" dichotomy is no longer a practical classification of the lunar surface. The Moon's topography, surface chemistry, and rock types better fit a classification based on three large lunar terrains, whose locations are shown in Figure 1. The Procellarum KREEP Terrane is an area of high thorium concentration and contains a large amount of basaltic resurfacing. This region is probably the sole source of the relatively magnesian plutonic rocks found among the lunar samples and of the trace-element-rich material called "KREEP" (The acronym represents the high concentration of the incompatible elements Potassium, Rare Earth Elements, and Phosphorus). The Feldspathic Highlands Terrane is the largest of the three terrains, occupying most of the far side as well as much of the near side. It is plagioclase-rich, has low concentrations of thorium, and much of its thorium appears to be in debris ejected from the Imbrium basin, which lies within the Th-rich Procellarum KREEP Terrane. The Feldspathic Highlands Terrane has experienced less volcanic activity than the Procellarum KREEP Terrane. The South Pole-Aitken Terrane, located on the southern far side, is hidden from the view of the Earth. In comparison to the Feldspathic Highlands Terrane, it has somewhat raised concentrations of thorium and iron, and may represent exposed lower crust. The existence of basaltic material in all three terrains is a common feature between each terrane. This new "terrane" view of lunar geology thus recognizes the compositional asymmetry of the Moon's crust and is causing us to refine early models for the solidification of the "lunar magma ocean" (the name given to the early and extensive global magma that is required by isotopic and chemical data).

Many questions of global significance remain that will require robotic and human field trips to the Moon. For example, is there water in permanently shaded craters at the Moon's poles, as suggested by the Lunar Prospector neutron and Clementine bistatic radar experiments? Are the basalts in the Procellarum KREEP Terrane as thorium-rich as we propose, or are their surfaces simply more "contaminated" with KREEP rock debris than we think? Is the chemistry of the South Pole-Aitken Terrane that of deep crustal material exposed by the impact of a large planetesimal, or does that terrane have a special igneous evolution different than the Feldspathic Highlands Terrane or Procellarum KREEP Terrane? Until field trips become commonplace, lunar geology will have to be conducted using remotely sensed data hand-in-hand with available samples. The knowledge gathered from the two new global data sets has enabled large advances, however other global data sets promised by the Europeans and Japanese will help further. We trust we can use the global information to ask better questions about the Moon's evolution and thus maximize the scientific return of the next missions that reach the Moon's surface.

Department Faculty and Students Involved in SEPA

By Stacey Robertson

Graduate student Stacey Robertson and professor Doug Wiens are currently working on the Seismic Experiment in Patagonia and Antarctica (SEPA). The focus of Stacey's research is the seismicity and tectonics of the Antarctic Peninsula, a region that has a very complicated tectonic setting and has undergone major changes in recent years. Approximately 4 Ma the spreading center off the northwestern coast of the Antarctic Peninsula ceased spreading, causing the lithosphere subducting beneath the peninsula to slow significantly. Many scientists believe this change may have caused subduction beneath the peninsula to halt completely. At approximately the same time as the cessation of spreading, backarc rifting was initiated in Bransfield Strait behind the South Shetland Islands. Stacey and Doug hope to learn more about these transitional processes through the SEPA deployment. Previous studies of this region have been limited by the sparse number of Antarctic earthquakes recorded by global seismic networks, but their local seismic array has provided them with a large amount of new data. The goals of the SEPA project are to determine whether subduction is still occurring in the South Shetland trench, to study earthquakes and tectonics associated with extension in Bransfield Strait, and to investigate the regional upper mantle structure.



Tectonic setting of the South Shetland Island region, shown with earthquake locations from the SEPA deployment.

During 1997 and 1998 seven continuously recording broadband seismometers were deployed in the South Shetland Island–Antarctic Peninsula region. Three of these stations were installed at Chilean Antarctic bases where they received power and occasional technical support. Four other stations were established at unattended sites in the field and were only visited one or two times each year during the Antarctic summer. This was the first broadband array of this type on the Antarctic Peninsula, and the instruments successfully recorded large amounts of data, despite the harsh Antarctic conditions. In December 1998, 14 ocean bottom seismometers (OBSs) were deployed in collaboration with Leroy Dormanof of Scripps Institute of Oceanography. These instruments remained on the ocean floor for five months and were also very successful in data acquisition. The four field sites and the OBS's have now been removed from the Antarctic, but the three seismometers at Chilean bases are still operating.

The data obtained from 1997–1999 indicates a surprisingly high level of local seismicity (m_b 2-4), suggesting that subduction is currently continuing along the South Shetland Trench. If subduction is indeed occurring beneath the Antarctic Peninsula, it is extremely slow subduction of young lithosphere, comparable to subduction zones such as Cascadia and the Austral Andes. Some earthquakes occurred beneath the inner trench slope, with depths indicative of subduction-related thrust faulting. Other earthquakes were located on the outer rise and in fracture zones near the edges of plates. Earthquakes associated with backarc rifting are found throughout Bransfield Strait. Several clusters of earthquakes are located on large submarine volcanoes, suggesting current eruptive activity associated with rifting. The seismicity in the southwest portion of the strait is more diffuse than that in the northeast, suggesting that the rift might be gradually propagating from northeast to southwest. The tectonics of this region are indeed very complex, and the seismologists hope to eventually have a clearer picture of the structure and tectonic processes active around the Antarctic Peninsula.

STUDENT LIFE

A Chilean in St. Louis

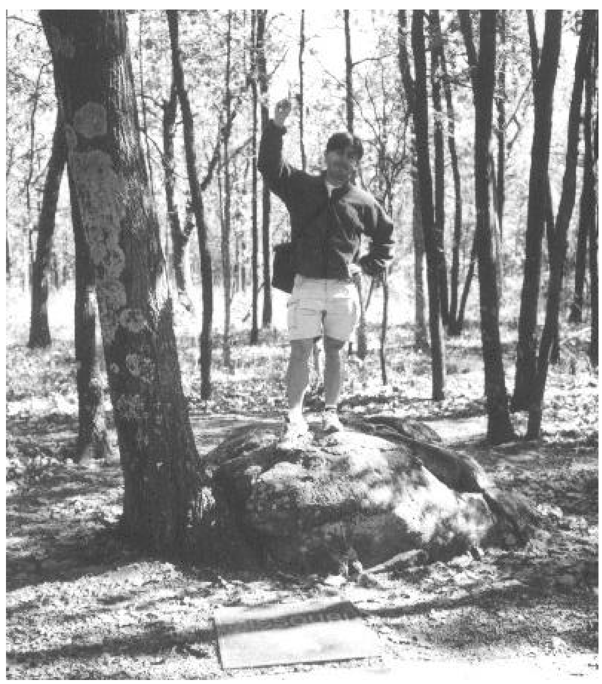
By Rodrigo Adaros, translated by Cassie Bowman

"Where is St. Louis? Is it big or small?" Those were only some of the questions that I had before coming to work at Washington University on a project researching Patagonia's seismicity. The story starts in December of 1998, when I met Doug Wiens and Stacey Robertson who had come to collaborate on fieldwork in the south of Chile and Antarctica, in conjunction with the University of Chile. I arrived in St. Louis in the middle of July 1999, a time of blazing heat, especially for a "penguin" like me accustomed to the cold of southern South America. My new friends assured me, however, that the temperature would make a rapid descent soon enough.

Working helped me forget the heat and my nostalgia for my homeland. I started the lengthy task of processing two years of seismological data from Chile and Antarctica—there were times when I thought I'd never finish! I finally concluded my work with a poster and presentation at the fall AGU meeting in San Francisco.

One of the things that I remember most from my experience at WU was getting to know a diverse and varied group of people. My weekends were filled with activities (hiking, camping, parties, baseball games) as were the evenings after work. It was these times of relaxation and activity that helped me forget how far I was from my country and helped me enjoy my stay.

To my surprise, despite having been in St. Louis only 5 months, it was very hard for me to leave—I left fun roommates, true friends, but also with a sense of a task well completed and a desire to return. Fortunately, I've been able to keep in touch via email so I am still current on what goes on in the Department of Earth and Planetary Sciences. I am sincerely grateful for the opportunity to get to know all of you and thank you for making my brief visit so great!



Rodrigo Adaros at Taum Sauk Mountain State Park in Ironton, Missouri.

A year in the Life of a New Grad Student

By Brian Hynek and Frank Seelos

It all started with last year's prospective graduate student weekend (see Figure 1, #1). From the far corners of the country a number of us that would become this year's "first years" gathered in St. Louis for a preview of what our lives might be like for the next half of a decade. After much merriment, unauthorized participation in an intramural soccer game, a questionable night's sleep on a graduate students' couch, and a few academic presentations thrown in for good measure, we were armed with the information necessary to make an informed decision as to where we would conduct our advanced studies.

When faced with a decision of such magnitude, it seems everyone had their own method of reaching the appropriate conclusion (#2). Some rolled dice, some wrote complex mathematical formulas, some asked the spouse, and some accepted the only offer they were given. Whatever the method, once the decision was made we were all left with the formidable task of tying up the loose ends from our pre-graduate school lives (3).

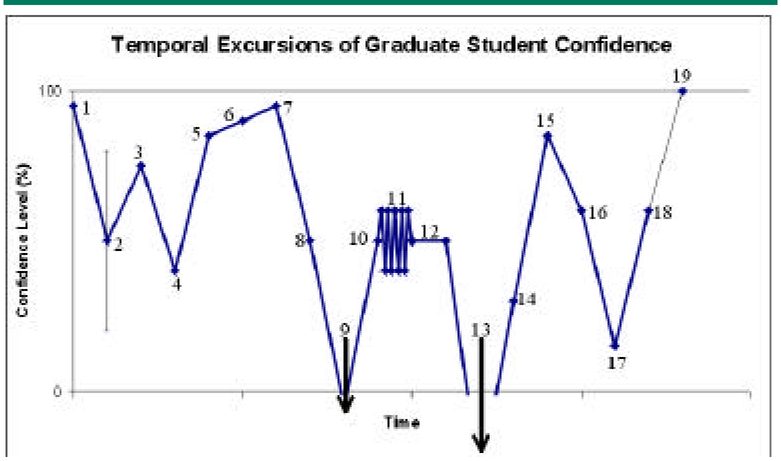


Figure 1

Upon our arrival in the fine city of St. Louis we were presented with a whole new suite of challenges (4). Finding a place to live was obviously an important task, but there were more significant questions that had to be answered, like "How do you pronounce 'Schnucks'?" and "Who *is* Ted Drewes?!?!"

Orientation was reminiscent of the prospective weekend, with the important caveat that at the end of the day we returned to our own places of residence, as opposed to someone else's couch (5). The first major challenge we faced concerned the organization of the first year's office, affectionately called "The Zoo." We were charged with defying the laws of physics (an everyday occurrence here at Wash. U.) in fitting nine desks, four filing cabinets, four bookshelves, and nine graduate students into a room no larger than a VW bug (6).

The start of classes brought a reality check of sorts (7). "Montmorillonite", "nucleosynthesis", and "fugacity" became staples of our vocabulary. The excitement of a new semester was dampened a bit by the first round of problem sets (8), and it's safe to say that the arrival of the first set of exams did not improve our morale (9). The prevailing thought in the Zoo seemed to be something to the effect: "What was I doing for four years as an undergraduate… I must not have learned anything!" Fortunately, there were frequent reprieves in the form of Fitz's, Blueberry Hill, Forest Park, and the infamous Ethel House (10). However, as the workload increased without an associated increase in the length of a day, the social outings tended to dwindle (Figure 2).

After a period of adjustment to the reality of graduate school in its full form (11), we achieved something of a steady-state equilibrium (12)… a delicate balance between the rigors of school and a life outside of the university. More precisely it was a balance between burnout and sanity. This balance persisted until term project due dates and final exams approached. The end-of-semester was humbling (13) to the point that the winter break that immediately followed was not so much a vacation as necessary recovery time (14).

At the start of the second semester (15), we were all presented with the daunting but welcome task of actual research! As opposed to the first semester, in which wall to wall classes were the norm, we now had a significant class load as well as a research project to occupy our time. It should be noted that the day was still not getting any longer, much to our dismay. Some things did carryover from the first semester, like our reaction to the first set of assignments from our new classes (16), and the all-too-familiar and humbling experience of the first round of tests (17).

However, as the second semester progressed, feelings of dismay were replaced by the determination to succeed (18). Fear of failure yielded to the knowledge that given enough effort, we could thrive as graduate students. The combination of an inspiring research project and the onset of spring to raise our spirits. Spring also brought another Graduate Preview Weekend (19), with a new batch of potential students who had the privilege of sleeping on our couches. Although the weekend was designed for the prospectives, it was also enlightening for us. There we were, a year later on the other side of the fence, honestly and sincerely encouraging the prospective students to join us here in St. Louis. Somewhere along the way it had become clear to us that our decision to join the graduate program at Washington University was the best that we could have made.

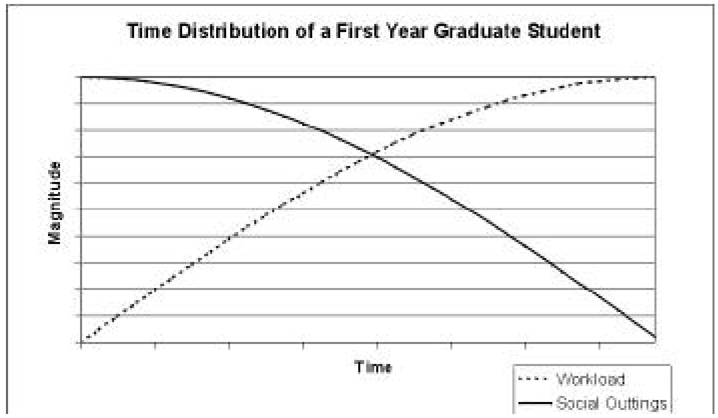


Figure 2

NOTES FROM THE FIELD

Graduate Student Sails Western Pacific

By Robby Valentine

Robby Valentine set sail with an international team of 27 scientists on the *RV Resolution* during the Ocean Drilling Program (ODP) Leg 185. They departed from Hong Kong on April 17, 1999, and arrived at port in Tokyo two months later. This marked the 185th consecutive two-month leg since the inception of ODP in 1986, following the successful Deep Sea Drilling Program (1971-1985).

ODP Leg 185 drilled two sites (see Figure 1) in some of the deepest waters of the Pacific Ocean, the first east of the Mariana trench (Site 801),5.7 km below sea level, and the second east of Izu-Bonin trench (Site 1149) 6 km below sea level. Hole 801C intersects the oldest (~167Ma) crust in the Pacific Ocean and was first drilled during ODP Leg 129 in 1990, penetrating 100 m into basement. Leg 185 deepened Hole 801C by nearly 400 m, making it the sixth deepest site drilled into normal oceanic crust (>900 m). ODP Hole 801C is a reference site for old super-fast-spreading (160 mm/yr) crust. At Site 1149, the only site drilled in the Nadeshda basin, the entire pelagic sequence (400 m) and 133 m of basement were cored.

ODP Leg 185 is the first ODP leg specifically dedicated to the determination of the geochemical composition of sediment and altered oceanic crust (AOC) entering a subduction zone. Subduction zones are the locus of many important geological processes. They represent the main regions where crustal recycling takes place, and through time they have provided a setting for the formation of continents and mantle evolution. The material recovered by ODP Leg 185 will be used to make comparisons with material exiting the IBM subduction zone at the forearc, volcanic arc and backarc, in order to calculate the geochemical flux mass balance. A well constrained flux mass balance will allow for evaluation of what degree along strike variation in arc lava geochemistry is controlled by subducting

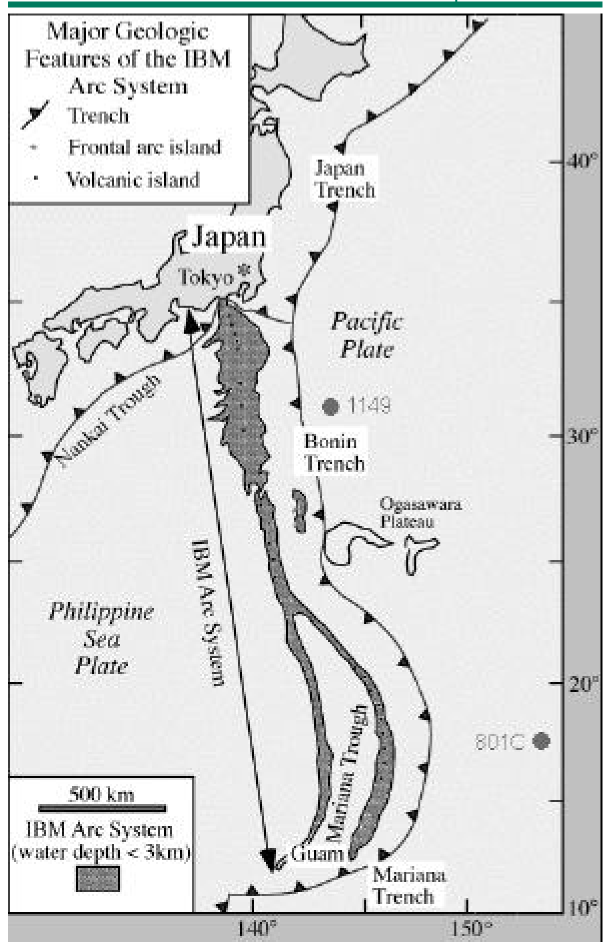


Figure 1 Map showing location of two sites drilled during ODP Leg 185

sediment and AOC composition and what role forcing functions (e.g., slab geometry, slab temperature and convergence vectors) play. Prior to Leg 185, with the arc, backarc and forearc well studied, the only component missing for a geochemical mass flux calculation at the IBM convergent margin was the composition sediments and basaltic crust entering the subduction zone. Core description is essential to the success of the leg and requires a coordinated effort of the scientific party. This task requires the expertise of

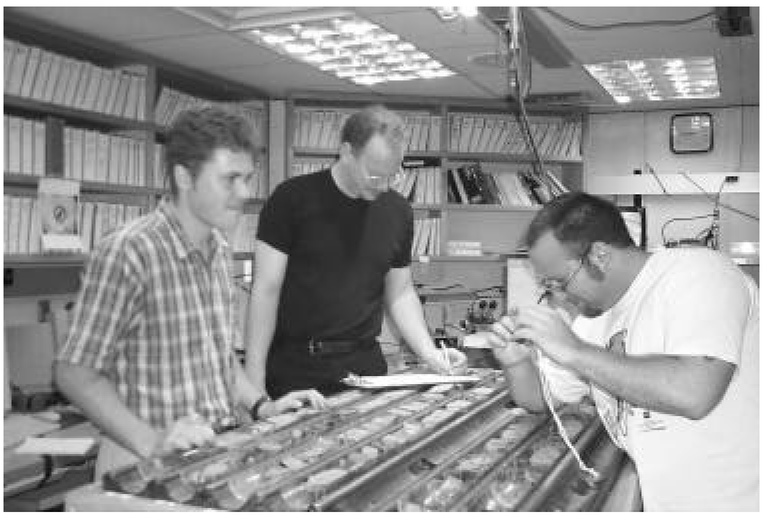


Figure 2 Robby (right) and fellow students, Olivier and Robin, inspecting igneous basement cored at ODP Site 801C

paleontologists, physical property specialists, geophysicists, sedimentologists, igneous petrologists, and micro biologists. Robby served as coredescriber in the capacity of both a sedimentologist and an igneous petrologist. On the catwalk, the paleontologist has first crack at the sediments, taking the contents of the core-catcher. A 10-cm whole- round is taken for interstitial water analysis and voids within the core are sought for gas sampling. The biologists also get a first crack at the core, taking a section off to the bio-van to excavate biological samples for culturing in an anoxic chamber. The cores are then allowed to equilibrate to room temperature before anything else is done to it. After warming, a battery of tests are made, ranging from magnetic susceptibility to gamma ray attenuation porosity evaluation.

Next the core must be split or cut, with one half archived. The core describers examine the core, bit by bit, for texture, structural features, sedimentary features, mineralogy and vein distribution. Onboard geochemical analyses include x-ray fluorescence, x-ray diffraction and atomic adsorption spectrometry. After the core has been examined and described in excruciating detail cores are laid out wherever there is room and scientists can pick, choose and fret over individual samples to take home for shore-based research.

A major component of ongoing research from Leg 185 results from a coordinated shipboard sampling and analytical effort in order to develop a common set of samples for all geochemical investigators. This is a novel approach which will lead to an unprecedented geochemical data set (major elements, trace elements, REE and Pb, Nd, Sr, Os, Hf, Li, B, Be, Cl, S, Se, C, N, O and H isotopes) for these two reference sites, that represent the crustal input to the IBM subduction system.

Robby, working closely with research professor Julie Morris, will determine boron, lithium, and beryllium concentrations and isotopic ratios in material recovered during Leg 185. Cosmogenic and radioactive ^{10}Be provides a geochemical tag for the upper portion of the sediment column. The utility of ^{10}Be stems from the fact that it is detectable in marine sediments up to 10 Ma and is absent or below analytical detection limits in mantle rocks that have not undergone recent subduction modification. Concentrations of B and Li in altered oceanic crust and sediments are much higher than in the mantle. The processes that enrich B and Li in sediment and AOC occur at low temperatures and cause significant isotopic fractionation. Recent experimental work suggests that B and Li have much greater affinities for aqueous fluids than other element with similar mantle-melt incompatibilities. Thus B and Li have the potential to provide a high fidelity fingerprint of slab derived fluid contribution to arc magma generation.

Overall ODP Leg 185 was a glowing success. Good recovery yields and detailed hole logging will provide high resolution documentation of materials entering the IBM trench. The surprising recovery of fresh glass at both sites provides pristine samples of igneous liquid that forms Mesozoic Pacific crust. These are valuable samples that record mid-ocean ridge processes, mantle composition and mantle temperatures at a time preceding the Cretaceous superplume event in the Pacific. Microbial contamination tests of cores demonstrate that biological contamination can be assessed and surmounted, thus paving the way to establish ODP as a new platform for microbiological studies.

GEOPIG in Yellowstone

By Everett Shock

Members of GEOPIG, led by Everett Shock, together with several other researchers, undertook a second expedition to Yellowstone to study the geochemistry of hot spring ecosystems. This year's research built on the field work from the previous summer. Before the trip in 1999, Gavin Chan endeavored to predict the compositions of springs in the Lower Geyser Basin and in the Mud Volcano area. He and Brian Kristall assembled the published geochemical analyses from these springs, and everything known about the metabolism of microorganisms that survive in these locations. D'Arcy Meyer designed growth media for high-temperature microorganisms taking into account a wide variety of expected microbial life styles. Loaded with hundreds of sample bottles, analytical equipment, meters, and hundreds of microbial growth tubes, the team (Everett, Gavin, Brian, D'Arcy, Panjai Prapaipong, Bob Osburn, Maggie Osburn, Mitch Schulte, Karyn Rogers, Barb Winston, Bill Winston and Jan Amend) descended on Yellowstone to explore, map and sample the geochemistry and microbiology of hot spring systems. After the trip, dozens of samples were analyzed, microorganisms were isolated and cultured, and preliminary results were presented at the Fall AGU, Astrobiology, and American Society of Microbiology meetings.

This year, armed with our data and fresh perspectives, the team departed in early June on the three-day trek to Yellowstone. Everett. Bob, Maggie, and D'Arcy were joined by first year graduate students Larry Marcus and Samantha Fernandes. Jan, Mitch, and Karyn arrived in Yellowstone from various directions, as did Toby Fischer from New Mexico, Melanie and Steve Summit from Seattle, and Mike Singleton from Wash U. As in 1999, Bob led the mapping team, and applied his considerable skills in fine-scale mapping to making extremely accurate and detailed maps of hot springs with the aid of Mitch, Maggie, Mike, Steve, a laser theodolite and two-way radios. Jan spear headed the effort to collect a comprehensive suite of samples for major, minor and trace element analysis, stable isotopes, and dissolved organic compounds (including carbohydrates and amino acids), with help from Karyn, Mel and Samantha. Toby was in charge of sampling gases, and introduced several new techniques to the rest of us, including tasting the gas sample to see if it is 'right'. D'Arcy inoculated and incubated hundreds of microbial growth experiments, and undertook a whole new series of sampling techniques that introduced molecular methods into the mix. We used portable spectrophotometers and a battery of other meters and devices to make field measurements that cannot be made in the lab.

Bob Osburn mapping Octgrus Spring in the Lower Geyser Basin. Look closely and you can see Barb, Bill and Maggie.

Again we discovered young male bison have a interest in mapping and sampling of hot springs. This year we learned elk like to charge theodolites and tall people with tall poles sporting reflectors. We also discovered just how cold it can be in Yellowstone mid-June, as we scraped ice off the table in the campground to fix breakfast, or off our notebooks in the field.

We focused on hot springs in the area around Obsidian Pool near Mud Volcano, Sylvan Springs southwest of the Norris Geyser Basin, and large alkaline hot springs in the Sentinel Meadows areas. The geochemical contrasts between these areas are remarkable, including pH variations from less than 2 to greater than 9. Ongoing analytical work using gas chromatography, ion chromatography, X-ray diffraction, petrography, stable isotope mass spectrometry and inductively-coupled plasma mass spectrometry is revealing the full component of mineralogical and aqueous geochemical variables that characterize these hydrothermal habitats. These data are the starting point for quantitative assessments of the availability of geochemical energy through thermodynamic modeling.

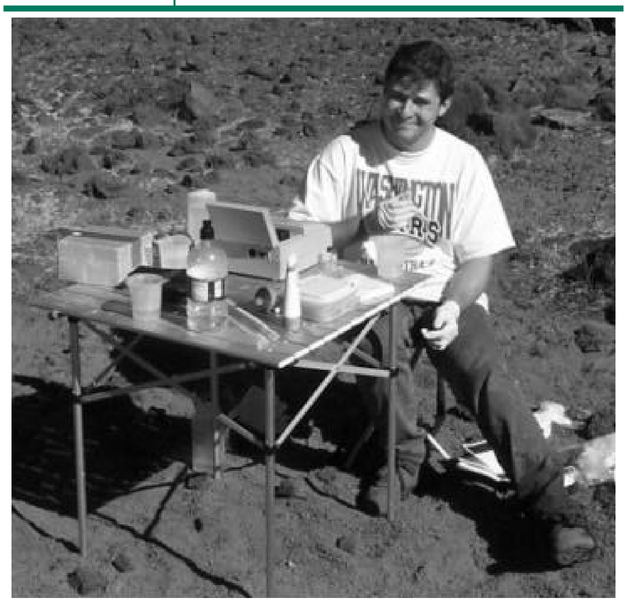
Meanwhile, microbial growth experiments have confirmed that designing growth media based on geochemical data helps to isolate novel strains of high-temperature microbes. D'Arcy, working in Jan's new Microbial Geochemistry lab, has isolated two high temperature bacteria, which appear to be previously unknown. Once these organisms' metabolic strategies are understood we can make explicit links with the geochemical measurements and calculations. Comparative studies across Yellowstone will permit us to understand the biogeochemical effects of magmatic gas input, water/rock reactions, and the underlying hydrology of the hot spring areas. We have already documented changes, especially in the most acidic hot springs, and now have a foundation for exploring the effects of future changes in water supply, direction of fluid movement, shifts in geochemical composition, and structure of microbial communities, as well as major disruptions that might be caused by earthquakes or steam explosions. Plans are underway for a third Yellowstone trek, and for comparative studies in the hot springs of Iceland and New Zealand.

Environmental Sustainability on Hawaii

By Velma Gentzsch

Seven Hewlett undergraduate seniors with various majors participated in a senior capstone experience in environmental studies led by Professor Ray Arvidson and Research Associate Professor Julie Morris. In August 1999 the group went to Lake Waiau and surrounding areas of Mauna Kea, Hawaii where they conducted field work and subsequently did water and rock analyses in the labs at Washington University. The project started four years ago when as freshman the students began studying environmental sustainability issues through the Hewlett Program. The previous field trips were so successful that these enterprising students formulated a plan to study Mauna Kea for senior honors. Their results are a coordinated as a set of undergraduate honors theses that includes a GIS database that supports conclusions, and predictive models that replicate key aspects of the hydrology of the Mauna Kea summit and southwestern slopes. In all cases, the research questions encompassed the central theme of environmental sustainability.

The students began seriously planning the capstone project in the fall of 1998. With the help of Ray Arvidson they determined that Mauna Kea provided the widest range of opportunities for study and application. The group met weekly to discern their study topics and discuss field logistics, travel logistics and terrain peculiarities noting that the area around the lake is considered sacred by native Hawaiians and would require special state permission to collect samples. The students spent August 12 to August 19, 1999 on Mauna Kea collecting data, samples and making observations along the Saddle Road, Mauna Kea Observatory Road, around Lake Waiau and the Pohakuloa Gulch.


Jeff Byers testing water sample from Lake Waiau on Mauna Kea, HI

The Mauna Kea research activities ranged from determination of hydrologic, geologic, and biologic systems to examination of the land use planning systems. Elena Arensman researched the effects of increased agricultural development, particularly associated with coffee, on the flanks of Mauna Kea. Elizabeth Dolan studied the environmental impact of the development of the summit observatory facilities. Velma Gentzsch analyzed the development of the Saddle Road from a "Smart Growth" perspective.

Jeffery Byers and Nathan Snider examined the hydrology and hydrogeology of Lake Waiau and the surrounding springs in Pohakuloa gulch. A basic understanding of the hydrologic systems and the hydrologic budget was obtained from stable isotope ratios of the various waters in the system and electrical resistivity measurements on the shores of Lake Waiau. They also analyzed the waters' chemical composition in order to determine the mobility of the chemical species in the system. By measuring mobility, they were able to determine the relationships between naturally occurring and manmade systems of Mauna Kea.

Brian Kristall looked at the chemical weathering of Mauna Kea. His goal was to understand the reactions involved in weathering using water-rock interaction modeling. To do this, he analyzed the mineral and chemical composition of the base rock and the weathering products. Margaret Yu examined the distribution and composition of the vascular plant community at the transition from the inversion layer to the next higher layer. She compared ground truth data with remote sensing data taken during the trip.

The theses were completed in March of 2000. A research article is now in draft form.

EPSC FACULTY

Jan Amend
Assistant Professor, University of California-Berkeley, 1995, Microbial geochemistry.

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James S. McDonnell Distinguished University Professor and Chairman, Brown University, 1974, Remote sensing, surficial geology.

Robert Criss
Professor, California Institute of Technology, 1981, Stable isotope geochemistry, fluid-rock interactions, groundwater hydrology.

Ghislaine Crozaz
Professor, University of Brussels, 1967, Trace elements in extraterrestrial and terrestrial rocks.

Robert F. Dymek
Professor, California Institute of Technology, 1977, Igneous and metamorphic processes, Pre-Cambrian geology.

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Professor, Massachusetts Institute of Technology, 1977, Chemical processes on planetary surfaces, in planetary atmospheres, and in the early solar system.

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Ralph E. Morrow Distinguished University Professor, University of Kansas, 1960, Trace-element geochemistry, terrestrial and lunar materials.

Anne Hofmeister
Research Professor, California Institute of Technology, 1984, Physical and thermodynamic properties of minerals, infrared spectroscopy.

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Research Associate Professor, University of Wisconsin-Madison, 1976, Lunar geochemistry

Harold L. Levin
Professor, Washington University, 1956, Invertebrate paleontology; micropaleontology, stratigraphy.

William B. McKinnon
Professor, California Institute of Technology, 1981, Origins of icy satellites of the outer solar system, Pluto, and impact craters.

Julie Morris
Research Associate Professor, Massachusetts Institute of Technology, 1984, Isotope geochemistry, magmatism and tectonics.

Jill Dill Pasteris
Professor, Yale University, 1980, Ore deposits associated with igneous rocks, geological applications of Raman spectroscopy.

Roger J. Phillips
Professor, University of California-Berkeley, 1968, Interior evolution of the terrestrial planets and relationship to tectonic deformation.

Frank A. Podosek
Professor, University of California-Berkeley, 1969, Isotopic compositions and elemental abundances in terrestrial, lunar, and meteoritic materials.

Everett Shock
Professor, University of California-Berkeley, 1987, Geochemical processes involving fluids throughout the crust and upper mantle of the Earth, other planets, and meteorites.

William Hayden Smith
Professor, Princeton, 1966, Development and application of high-reliability instruments for space, airborne, and ground-based environmental remote sensing.

Robert D. Tucker
Associate Professor, Yale, 1985, High-precision U-Pb dating techniques and their application to the study of Pre-Cambrian and Phanerozoic orogenic belts.

Douglas A. Wiens
Professor, Northwestern University, 1985, Earthquake source processes, structure of the mantle and crust, plate tectonic processes.

Michael E. Wysession
Associate Professor, Northwestern University, 1991, Seismology and geophysics, structure of the Earth from the inner core, core-mantle boundary.

Ernst Zinner
Research Professor, Washington University, 1972, Astrophysics, cosmochemistry, extraterrestrial materials.

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ALUMNI UPDATE

- **Carolyn (Briggs) Sorvoja** (BS 86) is currently a grad student (M.S.) in Environmental Quality Science at the University of Alaska-Anchorage. Her email address is csorvoja@gci.net
- **Juliet E. Remley** (BS 87) is now Dr. Juliet E. Morrow, Station Archeologist for Arkansas Archeological Survey, Jonesboro. She was featured in the April 2000 edition of National Geographic. Email address: jmorrow@ choctaw.astate.edu.
- **Jeremy Voligny** (BS 96) is a mudlogging geologist for oil and gas wells in the WV, PA, and OH regions of the Appalachian Basin. Wants to hear from anyone interested in mudlogging. Address: 714 Walnut Hills Drive, Chillicothe, OH 45601-2037
- **Douglas Kilmer** (AM 90) is part owner of Millennium Environmental & Remediation Services, Inc., specializing in petroleum consulting and geophysical/remote sensing applications to environmental consulting. Married in 1996 (Diane) and had a son in 1998 (Andrew). Also consulting in geophysical surveys for archeological assessments. Address: 2200 Green Island Drive, Columbus, OH 43228-9432. Tel.: 614-279-5087
- **Deborah S. Snavely Lumia** (BA 72, AM 75) recently completed 24 years with the U.S. Geological Survey. Married fellow hydrologist 10 years ago. Still misses Washington University! Address: 5 May Apple Way, Ballston Spa, NY 12020. Tel.: 518-899-5219 (h), 518-285-5668 (w)
- **Bruce Stinchcomb** (AM 63) is finishing a paleontological paper on Ozark Cambrian monoplacophorans. One species, *Gayneoconus echolsi*, is named in memory of Dorothy J. Echols (Mrs. E. 1916–97), professor of Paleontology. Mrs. E. took great interest in cultivating budding paleontologists and this ornate Cambrian mollusk should be a fitting tribute to her enthusiasm. Address: Department of Geology, St. Louis Community College, Pershall Rd., St. Louis, MO 63135. Tel.: 314-595-2380.

Continued on next page

Andrew Dombard (PHD 2000) finished his orals and took a post-doc position at Carnegie Institute (DTM) in Washington D.C. His successful oral defense was June 20 and the title of his paper was "Modeling of Geodynamics Processes on Ganymede and Callisto: Insight into Thermal and Tectonic Histories". He and D'Arcy Meyer, current EPSc grad student, are engaged to be married.

Jeff Plaut (PHD 91) and **Ellen O'Leary** (AM 88) recently exchanged marriage vows. Jeff is a staff scientist at JPL in Pasadena where Ellen is a systems analyst.

Mary Katherine (Kate) Crombie (PHD 97) is the director of government programs for an Arizona-based company called Computer Access, Inc. Recently her paper "Application of Remotely Derived Climatological Fields, etc." won the third place prize for the 2000 ERDAS Award for Best Scientific Paper in Remote Sensing.

DEPARTMENT WELCOMES NEW EMPLOYEES

Seth Michael Davis, Business Manager for the Geochemical Society

Originally, Seth is from small-town Kearney, Nebraska, but he slowly migrated east, first to Lincoln, NE, and then to St. Louis, MO in December 1999. He attended both the University of Nebraska at Kearney and the University of Nebraska at Lincoln ("Go Huskers!"). His academic pursuits are scattered across a wide spectrum of studies (mostly in illustration, literature, and music). Currently, he is attending Missouri College in the evenings pursuing certification as a Massage Therapist. Seth enjoys playing the violin, riding his bicycle, traveling, and surfing the net, especially eBay. He and his girlfriend, Kathy, live with her cat, Hablo. He loves the WU campus and the great work environment in the Department, and looks forward to handling all the challenges of his new job.

Molly Dubberke – EPSc Assistant Librarian

Molly began working for the Earth and Planetary Sciences Library in July of 1999 after moving from the Chicago area to St. Louis. She graduated from Augustana College in Rock Island, Illinois with a degree in Geology with a concentration in Environmental Studies. After graduation, Molly worked as an Environmental Specialist for a consulting company in Chicago and an engineering company in Rockford. She has enjoyed getting to know the people in the Earth and Planetary Sciences department, learning about the library, and assisting library users with their needs. In her free time, Molly enjoys exploring the St. Louis area, cooking, and working on her new home with her husband.

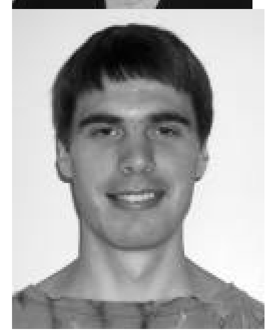
Lisa Klein - Accounting Clerk

Lisa began working in the EPSC accounting department in October 1999. Formerly a finance manager for an advertising agency in Clayton and has enjoyed working in an academic setting after spending so much time in the corporate world. Working here will also give her the chance to pursue a bachelor's degree in Industrial and Organizational Psychology through University College. Beyond working full time for the department and studying for her degree, Lisa also keeps busy with her two children, a son, age 11, and a daughter, age 5, both of whom love soccer, and her husband, Kevin, an inspector at Boeing. Lisa has been riding horses since she was 12 or 13 years old on her father's farm. She has continued riding and training Paso Fino horses and plans to start showing them again in the near future.

Karen Pollard – Editorial Assistant, *Geochemica et Cosmochimica Acta*

Karen has lived in Florissant all her life, but only recently came to work in the EPSC Department as an editorial assistant in the GCA Editorial Department. Karen has three daughters, Kristal, Danielle, and Niki, ranging from 3 to 14 years old, who keep her and her husband, Paul, busy. In her free time, she enjoys a range of activities including macramé, crocheting, bowling, and working in the yard. Her favorite thing to do is spend time with her family, playing games. In spite of her early employment status, Karen believes she has found a place she can enjoy working and could not have asked for better people with which to work. She thanks everyone for making her feel welcome at the University.

Nathan Snider - Systems Analyst



Nathan graduated from Washington University in St. Louis this past May with a degree in Environmental Studies. Home was Bonners Ferry, Idaho until he came to work for Ray Arvidson and now he lives in the city, close to the University. When he is not working on the remote sensing laboratory computers, he is taking part in his favorite hobby, composing electronic music. Other pastimes include reading, running playing African hand drums and making frequent stops at Al Tarboush restaurant and deli.

Linda Trower - Editorial Manager, *Geochimica et Cosmochimica Acta*

Linda is not new to Washington University, only to the EPSC. She came from the Physics department in September 1999 to help Frank Podosek with his editorial tasks for the journal *Geochimica et Cosmochimica Acta*. Frank and Linda have devised an electronic system to speed the process. Most correspondence is accomplished through email and a special web page which Linda is responsible for maintaining. In her free time, Linda is an avid golfer, and still delights in her crowning achievement of a hole-in-one 3 years ago. She and her sister are regulars in the Staff Day golf tournament, and have won the "Best Female Team Golfer Award" since the competition started in 1998. Linda volunteers for the American Red Cross, the American Cancer Society and Southpointe Hospital.

Natasha Zolotova - Laboratory Technician

Natasha started working in Jan Amend's group as a volunteer in early 1999 while waiting for her work visa, and was hired in November of the same year. Trained in geochemistry, she received her masters from Moscow State University and worked for the Institute of Experimental Mineralogy. She came to St. Louis with her family three years ago and worked at the City Museum for a Russian Dinosaur exhibit before coming to work for the Department. Here she works on ion and gas chromatography analysis. She does analytical work for models and projects, focusing on the Aeolian hot springs in Sicily and the microbial experiments. On the weekends, Natasha likes to explore state parks in the area with her husband and two children. When the weather is nice they hike and camp in Missouri and southern Illinois.

CREDITS

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ALUMNI UPDATE CARD

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