University of Michigan
Geological Sciences

Geoscience News

For Alumni and Friends of the Department of Geological Sciences

Fall 2009

Chair's Corner

Dear Alumni and Friends,

Greetings once again from beautiful Ann Arbor! As I write this, the trees are awash in autumn colors and the football team has nearly doubled its number of wins over last season. Within our Department, it has been a year of accomplishments, accompanied by challenges that will have a lasting impact on the geology program. If you have been listening to the news about the Michigan economy, you already know the budgetary challenges we face, though my preference is to spare you the details until later on in this letter. In the meantime, it is a lot more fun for me to tell you about all the exciting news from the Department over the past year or so.

First, a College-appointed External Review Committee of five distinguished earth scientists visited us just after last year's Newsletter was published and declared our Department "strong and healthy, consistent with [our] traditionally strong showing in national rankings." They regard the scholarly output of the faculty, research scientists and students to be strong and to be published in high-impact journals. Consistent with this assessment, several of our colleagues were honored for their scientific accomplishments. Kudos for Rod Ewing who has been named a Distinguished University Professor, the highest honor conferred upon a faculty member at the University of Michigan. He has selected the name Edward H. Kraus for this professorship in honor of the founding chair of the Department of Mineralogy. Kudos also for Ben van der Pluijm who has been named a Collegiate Professor; he has chosen to honor Bruce R. Clark, a past member of our faculty and former chair of our Alumni Advisory Board. Last but not least, kudos to Tom Baumiller for receiving a Fulbright Fellowship which will allow him to pursue scholarly work at the University of Otago in New Zealand during his sabbatical leave.

In other news, Youxue Zhang published a book on *Geochemical Kinetics* which fills a long-neglected niche. Emeritus Professor Henry Pollack wrote a book entitled a *World Without Ice* which is garnering world-wide attention. Emeritus Professor Eric Essene, whose "retirement" went into effect January 1, 2009, is continuing as Director of the Electron Microbeam Analytical Laboratory. Eric still dispenses much-welcome advice to everyone who comes to use the facility .

We have continued to attract and hire excellent new faculty. This year, we are being joined by Dr. Jackie Li, a mineral physicist most recently on the faculty at the University of Illinois. Please join me in welcoming Jackie to the Department, and read about her academic background elsewhere in this newsletter. In addition, this fall we are searching for two faculty members in the general area of global change, and have submitted hiring requests in the areas of carbon management and water resources. Sadly, I must also report that Todd Ehlers left the Department this past summer. Todd did most of the heavy lifting in the redesigning of our undergraduate curriculum while he served as Associate Chair. These changes were accepted recently by the College of LS&A. We thank Todd for his dedicated service to the Department and wish him well in his new position.

Finally, I don't need to tell you that we have one of the most supportive and engaged alumni bases of any geology department in the country, or any other unit on campus, for that matter. The support and generosity you extend toward our Department has had a tremendous impact on our ability to maintain a competitive program in times of diminishing support from the College, the University and the State. Our Department was incredibly successful in raising funds during the recently completed Michigan Difference capital campaign. Phase 1 of the construction project at Camp Davis is nearly complete, revitalizing basic infrastructure and replacing twenty cabins. With the anticipated alumni support, we can begin to contemplate Phase 2 of the project, replacing the remaining 30 cabins. Nevertheless, with 25% of our departmental endowment disappearing during the on-going economic downturn, our ability to support graduate fellowships has been severely eroded. As President Mary Sue Coleman observed recently, losses in the endowment have been compounded by private giving declining significantly over the last year. State support to U-M has gone down by 10% over the past seven years, and an additional 20% cut is anticipated in the next fiscal year.

In closing, thanks to your support, the Department continues to thrive in these difficult times. Our undergraduate student population has doubled in the last few years to nearly 80 students, and our graduate program grew by 21 new students this year. A recent article in Science reported that business is booming in the geosciences, and we continue to place our graduates in good jobs. Yet, our field is being marginalized, judging from the geological sciences programs across the country which have been targeted for severe downsizing or complete elimination. One of those programs is our sister department at Michigan State. We have written letters of support and advocated against these proposals, and we hope that you will as well.

Here is to wishing you a happy holiday season, and as always we hope to hear from you.

Warmest regards,

Samuel B Mukasa

EVERYWHERE YOU LOOK – EVERYTHING YOU HEAR……IT'S JUST BAD NEWS

Investments are down, the State revenues are down, the University budget is down, the unemployment rate is the only thing that is up.

Despite all of this bad news, the Department of Geological Sciences continues to survive because of your continuing generosity. Your annual giving to our endowments, to our student fellowship funds, and to our capital campaign targets has established a solid foundation that helps us maintain, allows us to sustain, and keeps us productive in our teaching and research endeavors. While it is true that our endowments have also decreased substantially, conservative investment strategies and measured spending ensures that we can fund the essential functions of our Department.

Let us share with you the many ways your support has helped our students. Through our Turner research grants (~$30,000 per year), students can complete their field work or laboratory analyses. Through our tuition assistance program for Camp Davis (~$31,000 per year), students can learn directly through field studies. The Graduate Fellowship Program (~$60,000 per fellowship) helps us attract and retain the best of the next generation of geoscientists. Here are a few examples:

"The Turner program has been essential to the development of my PhD work at the University of Michigan. Funding from this program has afforded me the opportunity to pursue research avenues that may not have originally been the focus of my research work, but so often turn out to become an integral part of the thesis framework. In particular, Turner funding has supported fieldwork and the cost for laboratory analyses."
Alex Lechler is a fourth year PhD student in Tectonics

"The fellowship helped me embrace both the academics and the geologic community at Michigan….adjust to the rigors of Geology….and jump start my research."
Laura Waters is a second year PhD student in the field of Igneous Petrology

"Camp Davis was a great experience, but it would have been difficult for me to go without financial aid from the Department."
Josh Soble is a senior concentrating in Geological Sciences

All of the students of the Department thank you for your continuing support

GIVE WHEN YOU CAN AND WHATEVER YOU CAN AND GO BLUE!

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Cover Photograph:
Students walking along the beach in New Zealand during the Department's 2009 International Field Trip. (K. Knudsen).

Back Cover:
Serpentinized peridotite, formerly exposed at the Tethyan seafloor, 60 million years ago. The peridotite is serpentinized and veined and replaced by carbonate, and has been mined for marble since Roman times. Red material at top is the famous Rosso Levanto marble. (Cava di Marmi, near Levanto, Italy). Serpentinization reactions generate hydrogen and support microbial activity (sulfate reducers) at the seafloor, and are important for recycling of volatiles in subduction zones. (J. Alt)

Geoscience News is compiled periodically for alumni and friends of the Department of Geological Sciences at the University of Michigan, Ann Arbor, MI 48109-1005

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Honors and Awards

Departmental Graduate Awards 2009

John Dorr Graduate Academic Achievement Awards

Jason Barnes (PhD '08) received the Department's Dorr Graduate Award for his dissertation on the evolution of the Andes Mountains. Jason is currently an NSF Postdoctoral Fellow at Durham University, and will join the faculty in the Department of Geological Sciences at the University of North Carolina, Chapel Hill in 2010.

Lin Ma (PhD '08), received the Dorr Graduate Award for his dissertation on noble gas geochemistry of groundwaters in the Michigan basin. He is currently a postdoctoral researcher at Pennsylvania State University.

Outstanding Graduate Student Instructor Award

Rackham Outstanding Student Instructor Award

Dan Horton (PhD cand.) was recognized by the department and the Rackham Graduate School for his contributions to undergraduate education as a Graduate Student Instructor. Dan has taught numerous courses on campus and at the Camp David field station.

Christopher Stefano (PhD '10) recently won an award for "Most Educational Exhibit" for a display entitled "Historical Mineral Specimens from the Collection of the Philadelphia Academy of Natural Sciences" that he entered at the Southeastern Michigan Gem and Mineral Show in May, 2009. The display consisted of sixteen of Chris's specimens that were part of the recently deaccessioned mineral collection of the Philadelphia Academy of Natural Sciences. The Philadelphia Academy had one of the oldest institutional mineral collections in the United States, started in 1812, and many of the specimens were of great historical value. The Academy had kept notes as to the donors of each specimen, and Chris was able to find biographical information on many of the donors, who were often important mineralogists or geologists of the day. The specimens were displayed with biographical sketches of their respective donors, resulting in a display focused on the history of mineralogy in the United States and the people involved.

Departmental Undergraduate Awards
2009

The department recognizes the excellence of its undergraduates with three awards each year. The Academic Excellence award recognizes achievements in the classroom through the course of an undergraduate's education. The Alumni Undergraduate Award recipient is selected by GeoClub as an individual who has made outstanding contributions to the Department through spirit and service. The Camp Davis Field Geologist Award is given to the student with the strongest performance in the GeoSci 440 Field Course. Awarded for the first time this year was the Eugene and Elizabeth Singer Award for Academic Excellence in Geology, which is awarded annually to a student of junior standing who has demonstrated the highest level of academic achievement.

Mary Peterson (BS '09)
Academic Excellence Award

Jessica Zinger (BS '09)
Academic Excellence Award

Lauren Miller
Alumni Undergraduate Award

David Azzolini (BS '09)
Camp Davis Field Geologist Award

Alexandra Costakis (BS '10))
Eugene and Elizabeth Singer
Junior Achievement Award

Yong Keun Hwang, a 5th year graduate student in Geophysics, was awarded the Outstanding Student Paper Award of the Seismology Section during the Fall 2008 meeting of the American Geophysical Meeting, in San Francisco, California. Yong Keun presented a poster entitled "Global seismic wave attenuation" and demonstrated how the attenuation of seismic waves generated by deep earthquakes can be used to constrain the temperature structure of the continental upper mantle.

GeoClub and SGE Awards

GeoClub continued its tradition of providing awards to outstanding students to help defray the costs of textbooks and field equipment. Eight recipients this year received a total of $675 from GeoClub.

Book Awards

Athena Eyster (BS '10)
Eleanor Ferguson (BS '10)
Semechah Lui (BS '10)
Jonathon Syrek (BS '10)
Jessica Zinger (BS '09)

Field Gear Awards

Patrick Hastings (BS '10)
Mastura Johari (BS '10)
Caitlin Rushlow (BS '10)

In addition to the GeoClub awards, the Department's honor society, SGE, selected **Ada Dominguez (BS '10)** as recipient of the SGE Iota Chapter W. A. Tarr Award.

GeoClub is generously supported by the John and Jean Greene Student Activities Fund and Shell Oil Company

Carlton Brett (MS '75, PhD '78) was presented the IUGS Digby McLaren Prize in recognition of his outstanding career of significant contributions toward advancing the discipline of stratigraphy.

Bruce R. Clark (Professor '68-'78) has been elected to the Board of Trustees of the Geological Society of America Foundation.

Rod Ewing (Professor) was selected as a 2009 Fellow of the Geochemical Society based on a sustained record of significant scientific contributions. He joins current and past department members **Bob Garrels**, **Jim Walker**, **Alex Halliday**, **Klaus Mezger**, **Jim O'Neil**, **Phil Meyers**, and **Lynn Walter** in receiving this honor.

Rod Ewing (Professor) has been named the Edward H. Kraus Distinguished University Professor of Geological Sciences. *Distinguished University Professorships, which recognize exceptional scholarly and/or creative achievement, national and international reputation, and superior teaching skills, are the top recognition for a faculty member at the University of Michigan.* Ewing earned the award for his leadership in developing innovative, science-based approaches to solving the difficult technical challenges of nuclear waste management. He has been a leading figure internationally in the quest to understand radiation damage in both natural and man-made materials, and an important force behind the use and application of natural mineral analogs to develop new nuclear waste forms and understand the behavior of waste repositories over geologic time. His research, which encompasses nuclear materials and radiation effects in ceramics and natural analogs, combines techniques of materials and glass science, solid state methods, ceramic science, nuclear materials and materials chemistry within the broader context of environmental interactions and geological science. Ewing also holds appointments in the Departments of Materials Science & Engineering, and Nuclear Engineering & Radiological Sciences.

Edward H. Kraus was the first professor of mineralogy at the University of Michigan, a Dean of the College of Literature, Science, and the Arts and of Pharmacy, and held the Henry Russell Lectureship in 1945. He played a key role in the founding of the Mineralogical Society of America, and in creating the premier journal in mineralogy, *American Mineralogist*. Kraus was the fourth recipient of the Roebling Medal, which is the highest honor bestowed by the Mineralogical Society of America.

Todd Ehlers (Assoc. Professor) and **Chris Poulsen's (Assoc. Professor)** recent article on the uplift of the Andes and paleoclimate of South America was selected as Editor's Choice in *Science*.

Tracy Frank (MS '93, PhD '95) received the J. B. Coffman Excellence Award from the University of Nebraska, Lincoln for her outstanding record of teaching and research.

Nadja Insel (PhD Candidate) published an article in *Climate Dynamics* (*http://dx.doi.org/10.1007/s00382-009-0637-1*) that was highlighted recently in *Nature Geoscience News and Views*.

Edward Landing (MS '75, PhD '79) was elected a Fellow of the American Association for the Advancement of Sciences.

Roberto S. Molina-Garza (PhD '91), currently at the Universidad Nacional Autónoma de México–Juriquilla is a new 2009 fellow of the Geological Society of America

Sam Mukasa (Professor and Chair) is the incoming president of the Geochemical Society in 2010.

Shanan Peters (Michigan Fellow '05-'07) has been awarded the 2010 Wilson Award, which is awarded to someone at an early stage in their career for having a significant impact in the science of sedimentary geology.

Martin Reich (PhD '06) received the *Mineralium Deposita* Best Paper Award for 2009 for his journal article entitled "Atacamite formation by deep saline waters in copper deposits from the Atacama Desert, Chile: Evidence from fluid inclusions, groundwater geochemistry, TEM, and ^{36}Cl data". *Reich M, Palacios C, Parada MA, Fehn U, Cameron EM, Leybourne MI, Zuniga A (2008), Mineralium Deposita, 43, 663-675*.

James M. Robertson (MS '68, PhD '72) was a recipient of the GSA Distinguished Service Award.

Joaquin Ruiz (MS '80, PhD '83) was elected Vice President of the Geological Society of America.

Zach Sharp (MS '84, PhD '87) was named a Regents Professor at the University of New Mexico.

Josh Soble (BS '10) was recognized for his efforts to support elementary education in Iraq. Josh collected school supplies from fellow students and department members and sent boxes of supplies to schools in need.

Ben A. van der Pluijm (Professor) has been named the Bruce R. Clark Collegiate Professor of Geology, College of Literature, Science, and the Arts. Collegiate Professorships are awarded to members of the faculty in recognition of their leadership in research, teaching and service. The award to Professor van der Pluijm recognizes his outstanding contributions in both research and teaching. Professor van der Pluijm's research focuses on the deep architecture of Earth's crust, especially major fractures and faults that are the locus of earthquakes and crustal deformation. He uses a wide variety of approaches in his research ranging from traditional field mapping to innovative laboratory-based geophysical and geochemical studies and has worked on fault-related problems on five continents. His most recent efforts focus on the first-ever effort to drill into an active fault, the San Andreas Fault in California, at a depth of several kilometers. Professor van der Pluijm has been involved with this project from the start and was one of the first researchers to be funded by the National Science Foundation to work on samples recovered from the drilling. The award also recognizes his numerous contributions to University teaching and administration, including his pivotal role in developing and encouraging growth of the highly popular Global Change Program.

Bruce R. Clark was a faculty member at the University of Michigan from 1968 until he resigned in 1978. He received his Bachelor of Science from Yale University (1963) and Doctorate from Stanford University (1967). Professor Clark was appointed Assistant Professor at the University of Michigan (1968) and promoted to Associate Professor, with tenure (1973). He resigned to accept a position at Leighton and Associates, Inc., a Southern California-based consulting firm specializing in geological, seismic, and geotechnical hazards and their solutions. He retired after seventeen years as President and CEO. After his resignation from the University, he served as an influential member and Chair of the Department of Geological Sciences' Alumni Advisory Board.

Peter van Keken (Professor) has received a Faculty Recognition Award for his dramatic impact on research in his field and in fields around him through his own research and that of his students, his highly influential editorial work on journals, and his participation in workshops and research meetings.

Sara Worsham (BS '07) received a graduate fellowship from the German Academic Exchange Service.

Transitions

Eric Essene *with former graduate students* ***Larry Anovitz (MS '82, PhD '87)***, ***John Bowman (PhD '78)***, ***Phil Brown (Ms '76, PhD '80)***, ***Steve Bohlen (MS '77, PhD '79)***, ***Larry Allard (former EMAL staff)***, ***John Valley (MS '77, PhD '80)*** *and* ***Bob Shedlock (MS '75)*** *at his retirement party. (S. Mukasa)*

Eric Essene (Professor) retired this year after 39 years on the faculty at the University of Michigan. His career was celebrated with a dinner at the University of Michigan's Matthaei Botanical Gardens. A number of Eric's former students returned to celebrate his career.

Todd Ehlers (Assoc. Professor) has resigned his position at the University of Michigan to become Chair of Geology and Geodynamics at Universitat Tuebingen, Germany.

Postdoctoral fellows **Amy Bengston** (van Keken), **Jason Demers** (Blum), **Sharon Hoffman** (Mukasa and Lund), **Mike Hren** (Sheldon), **Adam Rountrey** (PhD '09, Fisher), **Charlie Verdel** (van der Pluijm), **Aaron Wood** (PhD '09, Gingerich) and **Brian Yanites** (Ehlers) have joined the Department in the past year.

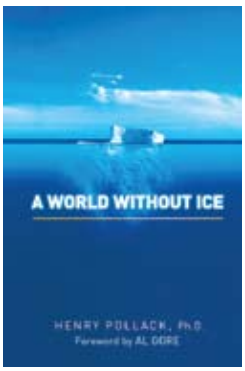
Selena Smith has been appointed as Assistant Research Scientist in the Department. Her interests are in using modern and fossil plants, principally monocots, to understand evolution of plants and the environment.

The Department welcomed 18 new graduate students for Fall 2009, four of whom are Masters students.

Faculty News

Henry Pollack's new book *A World Without Ice* appeared in bookstores in October, and is quickly rising to the top of the best-seller lists.

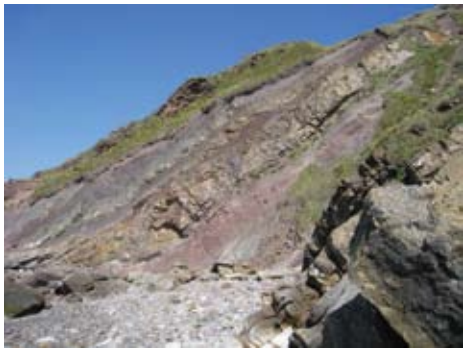
The book is fundamentally a tale of climate change and people, told through the prism of ice. For those who may have been in Henry's mini-course "Climate and Human History", you will recognize the similarity between the framework of that course and the new book.



The book, published by Penguin and with a foreword by Al Gore, describes the role ice has played in the development of Earth's landscape, climate, and human civilization, and the reciprocal impact of people on the planet's ice. It paints a compelling portrait of the delicate geological balance between ice and climate, and why the rapid disappearance of ice portends serious consequences in our not-so-distant future. It provides insight into why ice matters, and how we humans are dramatically changing this critical component of our global environment.

You can learn more about the book at http://www.worldwithoutice.com.

Nathan Sheldon and Master's student **Karen Gutierrez** were joined by Alberto Perez-Huerta of the University of Glasgow for fieldwork in Asturias, Spain in early May. Over 100 meters of Jurassic-aged section were logged and 18 paleosols corresponding to three distinct paleosol types, entislos, inceptisols, and vertisols, were identified. The region the group visited is known as the "Coast of the Dinosaurs" because of the numerous footprint sites created by ornithopods, sauropods, and theropods found throughout the area. The goal of this project is to reconstruct the paleoenvironment in which these dinosaurs lived.



*Continuous exposed section logged at the Playa de Vega, Asturias, Spain, by **Nathan Sheldon (Asst. Professor)** and Karen Gutierez **(Graduate Student)**.*

Assistant Professor **Jeff Wilson** and his lab spent much of their Spring and Summer studying fossils in museum collections. Wilson and PhD candidate **Mike D'Emic** spent two months in museums in Argentina, Chile, and Brazil as part of an NSF-supported project to reconstruct the evolutionary relationships of the large, long-necked dinosaurs known as sauropods. D'Emic also spent part of the Spring in Germany and France studying dwarfed members of that group as part of his dissertation research, which was supported by a Rackham grant. He also spent part of the summer in museums in the American southwest and at Camp Davis as a GSI. PhD candidate **John Whitlock** continued his research into the evolution of feeding behavior in giant herbivorous dinosaurs with visits to museum collections in Pittsburgh, Philadelphia, and Cleveland. With the assistance of Dr. **Tomasz Baumiller**, he also began a study using a robotic dinosaur jaw to examine bite

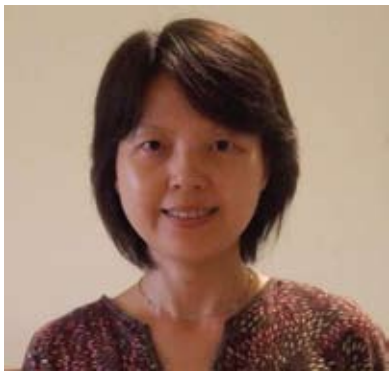
***Jeff Wilson's (Asst. Professor)** graduate students hard at work. Clockwise from top **Mike D'Emic (PhD Candidate)**, **Emile Moacdieh (Graduate Student)**, **John Whitlock (PhD Candidate)** and **Takehito Ikejiri (PhD Candidate)**.*

mechanics and tooth wear patterns. **Takehito Ikejiri** spent much of his summer measuring bones in a variety of museums in South Africa to continue his research on the skeletal growth in early sauropod dinosaurs and their immediate ancestors. Both Whitlock's and Ikejiri's research were supported by the Scott Turner Fund. This Fall, we were joined by graduate student **Emile Moacdieh**. Emile joins us from American University in Beirut, Lebanon, and he is interested in the evolution of the sauropod body plan.

This past summer started with a bang for **Dan Fisher**, with an opportunity to observe present-day elephants in Samburu Nature Reserve in Kenya. This chance arose through his collaboration with Thure Cerling, from the University of Utah, to test methods of tusk analysis with material from African elephants. Dan stayed in Iain Douglas-Hamilton's research camp and participated in surveys, checked on cases of elephant mortality to determine cause of death, and had dramatic "close encounters" with elephants of all ages and sexes. Dan was particularly excited to compare the skeletons of two old males that had differed in status within the local population; the anatomical location and number of healed injuries on these elephants showed interesting parallels to patterns Dan had already observed on mastodons, but for the elephants the social context was known. Returning to Ann Arbor, Dan worked with graduate students **Adam Rountrey** and **Katy Smith** on various proboscidean ventures. By July, all celebrated Adam's successful defense of his dissertation on juvenile mammoths, and Katy was making great progress on her analysis of the Bothwell mastodon site, one of the few multi-individual mastodon death sites in North America. Dan and Adam joined **David Fox (PhD '99)**, now an associate professor at University of Minnesota, for fieldwork in Chukotka, on the Arctic coast of Siberia. Here they met with Russian colleagues and had wonderful luck prospecting for mammoth remains and sampling specimens collected by collaborators in previous years. They shipped almost 500 kg of cargo, mostly mammoth, back to Saint-Petersburg. They still have to work out the details of exporting some of this back to the US for analysis, but hopefully that bridge, only one of many, will be crossed in due course.

Jeff Alt returned to Italy last summer to sample high-P serpentinites in the southern Alps, and to start a project on ultramafic-hosted hydrothermal systems in Ligurian ophiolites. This fall Jeff follows in the footsteps of **Ted Moore**, **Phil Meyers**, and **Kacey Lohmann** as a Distinguished Lecturer for the Coalition for Ocean Leadership (formerly JOI). Graduate student **Susan Alford** finished her MS thesis about microbial sulfate reduction in plutonic oceanic rocks, and now has a laboratory position at UC Merced.

New Faculty



Jie (Jackie) Li

Earth and planetary materials, thermal and chemical evolution of Earth, planets, and moons

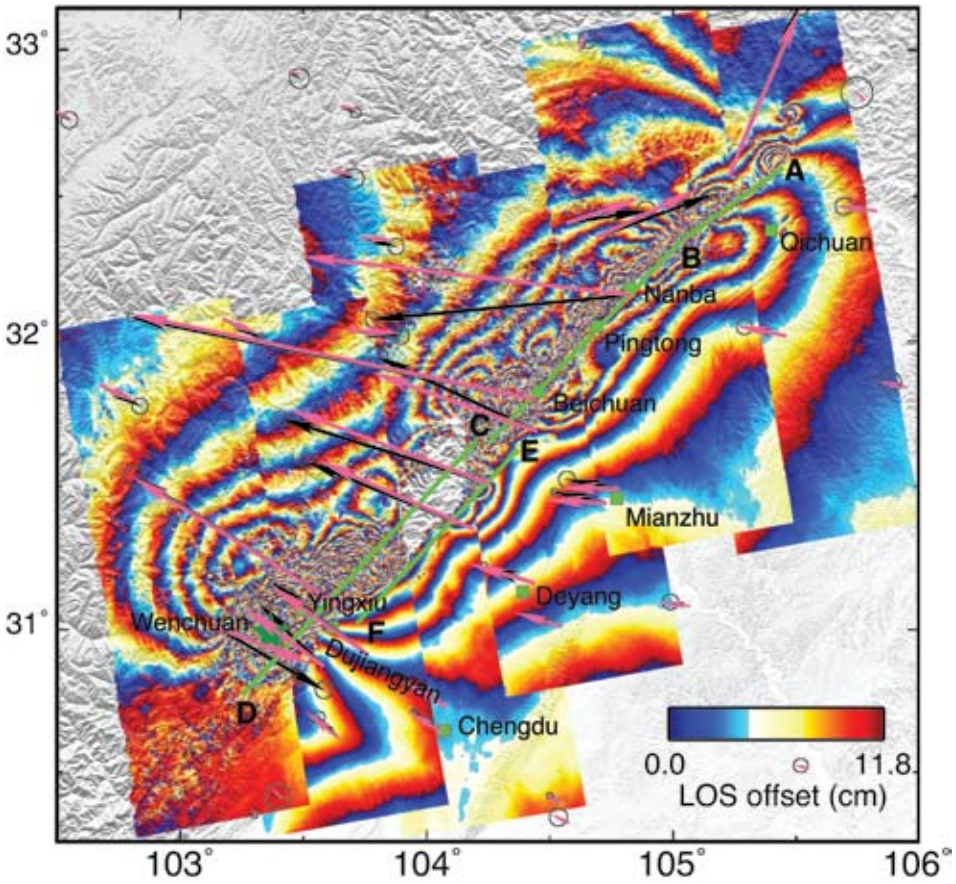
PhD Harvard University

I am interested in how the properties and behavior of Earth and planetary materials influence the thermal and chemical evolution history of planetary bodies in the solar system.

We use multi-anvil press and diamond-anvil cells to simulate the high-pressure conditions of planetary interiors, and employ a wide range of analytical tools to investigate how the physical properties and chemical behavior of materials respond to compression and heating. These tools include various diffraction and spectroscopic methods involving x-rays, lasers, and electrons. They are available on campus or at national synchrotron facilities such as the Advanced Photon Source in the US and Spring-8 in Japan.

Below are examples of recent and ongoing research projects:

- Study the effects of pressure on the melting behavior of the iron-sulfur binary system in order to understand the state and dynamics of Mercury's core, and to explain its weak global magnetic field
- Measure the density of iron-carbides to multi-megabar pressures, to test the hypothesis that the Earth's inner core is made of Fe_3C
- Detect pressure-induced transitions in the spin state of iron in perovskite and post-perovskite and explore the implications for the nature and dynamics of the Earth's lower mantle
- Determine the thermal conductivities of high-pressure water ices and apply the results to understand the presence of an internal ocean in Jupiter's major moon Callisto and its poorly differentiated interior



Deformation due to the 2008 7.9 Wenchuan earthquake measured by the ALOS satellite and GPS surveys. The color scale shows the changes in the distance between the ground and the satellite along line of sight (each fringe represents an accumulation of 11.8 cm), and measures mostly vertical ground deformation. Horizontal ground deformation is measured by GPS (black vectors), and green lines are the surface traces of the earthquake rupture. Also shown is the predicted horizontal deformation in our preferred earthquake fault slip model (pink vectors). (From Feng, Hetland, Ding, Li, and Zhang, 2009, submitted to GRL.

Eric Hetland's new cluster computer came online this spring, and was ready for a productive summer. Eric and two undergraduate research assistants (**Ka Yan Lui** and **Samantha Moore**) kept the cluster busy calculating models of the process of stress build-up and release on continental faults. Ka Yan continues to work with Eric's research group, helping on a project on inferences of lithosphere rheology on different time scales. Samantha continues work on models of continental faults, and will also be working on models of subsidence due to removal of fluids from the crust. Eric is hosting a visiting PhD student from Hong Kong Polytechnic University, **Guangcai Feng**, who is a specialist in processing satellite based observations of ground deformation. Gaungcai is working on models of the fault slip in the M 7.9 Wenchaun earthquake, which devastated Sichuan province, China, on 12 May 2008. Eric also continues collaboration with Prof. **Marin Clark** and graduate student **Nora Lewandowski**, on developing a new understanding of the forces that shaped the Tibetan plateau.

◄ ***Nathan Niemi (Asst. Professor)***, *and GSIs* ***Alex Lechler (PhD Candidate)*** *and* ***Alison Duvall (PhD Candidate)*** *on top of Sunset Peak, Utah, during the Alta mapping project, GEOSCI 440, summer 2009. (P. Hastings)*

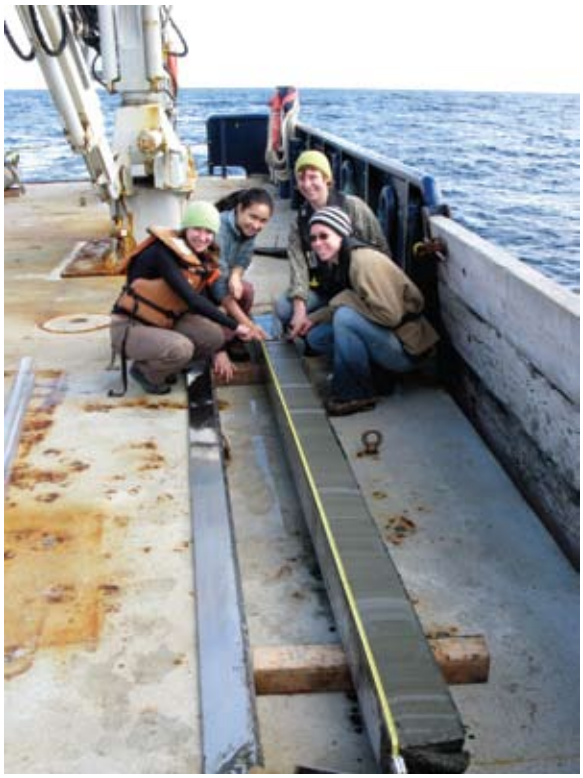
Mike D'Emic (PhD Candidate) *extracting sauropod bones from the Early Cretaceous Cloverly Formation in the Bighorn Basin. Mike's work is aimed at understanding the paleobiogeography and extinction of sauropods in North America.* ►

Old Mud Tells Many Tales: Studying Climate Change During the Last 2000 Years

Knowledge of the past can help predict the future. A good deal is known about Europe and its climate variations over the past 2000 years. For example, studies have revealed that from 900 to 1300 AD, during The Medieval Climate Anomaly, Europe, Greenland and Asia were warmer than they are today.

In contrast, during the Little Ice Age, from 1400 to 1850 AD, the average temperatures were colder than they are today. In the American Southwest, drought related to this short-term climate change has been implied in the collapse of ancestral Pueblo (Anasazi) culture around 1200 AD. Understanding how the environment responded to climate change in the past provides valuable guidance in predicting the extent and effects of future climate change. Despite extensive knowledge about past climate conditions in Europe, little is known about changes on the west coast of North America. Therefore it is more difficult to predict how the climate will change and how it will affect marine and water resources in the American West.

I was invited to accompany Professor **Ingrid Hendy**, and graduate students **Karla Knudson** and **Meghan Wagner** from The University of Michigan as well as teams from the University of California Santa Barbara and University of Indiana Bloomington on a research cruise in Santa Barbara Basin in Southern California. Our goal was to collect large volume cores containing sediment from the bottom of Santa Barbara Basin. Samples from these cores will be analyzed for the chemical composition of annually layered mud and the different species of floating plants and animals. We fled the snow and ice of a Michigan winter in January 2009 to live on the Research Vehicle *Robert Sproul* for five days. Our workday started early around 6 am and we worked under the floodlights until breakfast. After breakfast, which was always delicious, we continued working on the deck operating the winch until dusk. In between collecting cores and after dark, we worked in the wet lab sampling the core material.



Athena Eyster (BS '10), Karla Knudsen (PhD Candidate), Ingrid Hendy (Asst. Professor) and Meghan Wagner (Grad. Student) examining core.

In addition to seeing many dolphins, seals and the enchantingly beautiful bioluminescent plankton, I was able to participate in the collection of data first hand, collecting box and kasten cores; the kasten cores were each approximately 3 meters long when removed from the sea. I helped to cut the kasten cores into 5 mm and 10 mm sections to acquire samples for high resolution data. Now that we have returned to the lab, I am helping prepare these samples for analysis of planktonic floraminifers, radiolarians, diatoms and dinoflagellates that will provide information on seasonal temperature variations and changes in nutrients and upwelling conditions at 5 year intervals for the last 2 thousand years.

This nautical adventure provided first hand exposure on how researchers gain valuable knowledge from humble sea mud.

Rainbow above the Channel Islands, Santa Barbara Channel, California.

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*Article provided by **Athena Eyster** who is an undergraduate concentrator in Physics with a minor in Earth Sciences.*

Camp Davis Gazette

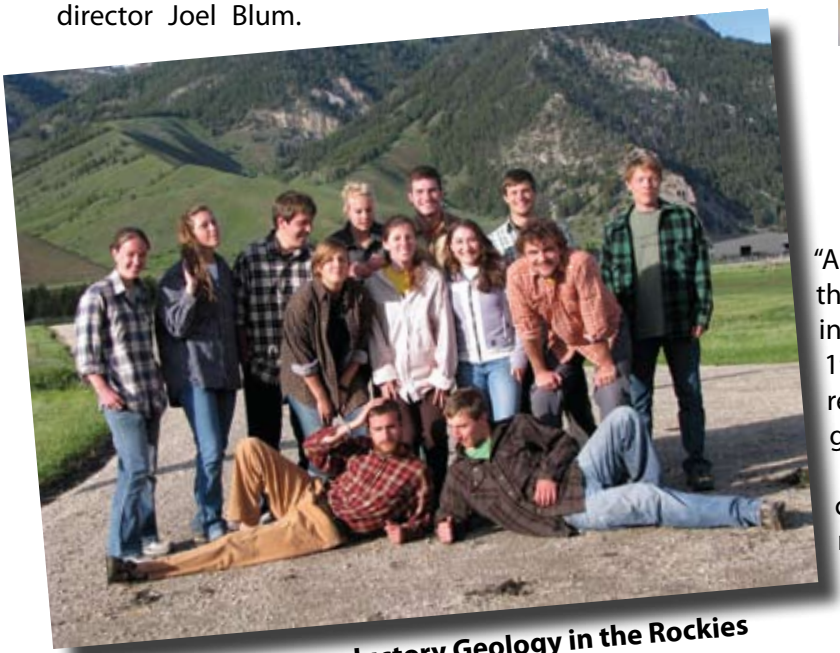
An abandoned ranch in a sheltered Wyoming valley with mountain vistas and clear streams seemed an ideal spot for U-M's summer surveying camp back in 1929, when it became necessary to relocate the facility from northern Michigan.

The Board of Regents approved the purchase of 120 acres for $2,500, crude cabins were erected, and the Camp Davis Rocky Mountain Field Station was born.

This summer the camp — now a teaching and research facility offering courses in geology, ecology, renewable and fossil energy, and humanities — celebrates its 80th anniversary with the grand opening of a block of new cabins, the first major construction since the camp was built.

"The upgrade was overdue", says Camp Davis director Joel Blum.

Interior of one of the new cabins built at Camp Davis. Each of the 16 new cabins has a bathroom, sink, refrigerator, and electric heat, as well as superb insulation, extending the use of these new cabins from May to October.



GEOSCI 116-1: Introductory Geology in the Rockies
Chris Poulsen, Joel Blum, Jamie Gleason

"Although the facility has had some improvements — the most notable of which was a new classroom building in 2001 — the cabins and bathrooms were original to 1929 and were in desperate need of renovation. We're replacing 16 of the 50 cabins this year, with the ultimate goal of replacing all the housing."

The new facilities not only will make camp life more comfortable for students and faculty during the usual midsummer sessions, but also will allow the camp to be used earlier and later in the season. As course offerings and student enrollment have grown in recent years, faculty have considered offering courses May

GEOSCI 116-2: Introductory Geology in the Rockies
Skip Simmons (UNO; PhD '73), Karen Webber (UNO)

GEOSCI116-3: Introductory Geology in the Rockies
Marin Clark, David Lund

through September instead of mid-June through mid-August. But the spartan living conditions in the old cabins were no match for Wyoming weather extremes.

"There's an old saying in the Yellowstone area, which is not far from Camp Davis, that in this part of the country there are only two seasons: July and winter," says Blum, who also is the John D. MacArthur Professor of Geological Sciences and a professor of ecology and evolutionary biology. "In the past, we've had freezing pipes and other problems due to lack of heat, but the new cabins are well heated and insulated and have water systems that won't freeze."

The new cabins, some of which are named for memorable faculty mentors, former Camp Davis students and family members of alumni, were celebrated at a ceremony during the annual Alumni Getaway in August.

Also new this year is a course titled "Sustainable and Fossil Energy: Options and Consequences", which Blum added to accommodate students' interests.

"Wyoming is one of the most energy-intensive states," he says. "It has enormous coal and gas resources, and it's a perfect place for wind farms, photovoltaic generation and hydroelectric dams.

GEOSCI 344: Sustainable and Fossil Energy: Options and Consequences
Joel Blum, Rod Ewing

"Over the years, as I was teaching the geology and ecosystem courses, we would travel around the state and pass these facilities, and I noticed the students becoming more and more interested in issues and science related to energy. We were able to work little bits of energy content into some of the other courses, but taking a hint from the students, I decided to launch a new course that was entirely devoted to the topic."

GEOSCI 341: Ecosystem Science in the Rockies
Joel Blum, Don Zak (SNRE), Tom Baumiller, Brian Kennedy (U. Idaho)

AMCULT 301: History and Literature of the Rockies
Philip Deloria (History and Program in American Culture, Gregg Crane (English Language & Literature)

With partial funding from the Graham Environmental Sustainability Institute and the Office of the Provost, Camp Davis also is installing renewable energy systems that will serve as a demonstration project for students in the course.

The energy course is the latest addition to a curriculum that includes classes in the history, literature and ecosystems of the Rockies, in addition to introductory and advanced geology field courses. Hiking, camping and exploring are all part of the educational package, and the typical student to instructor ratio of 10:1 fosters a close-knit, collegial learning community.

Nestled in the mountains just south of Jackson Hole and tucked between the Hoback River and Bridger Teton National Forest, Camp Davis offers access to some of North America's most scenic and interesting geological, ecological and historic sites.

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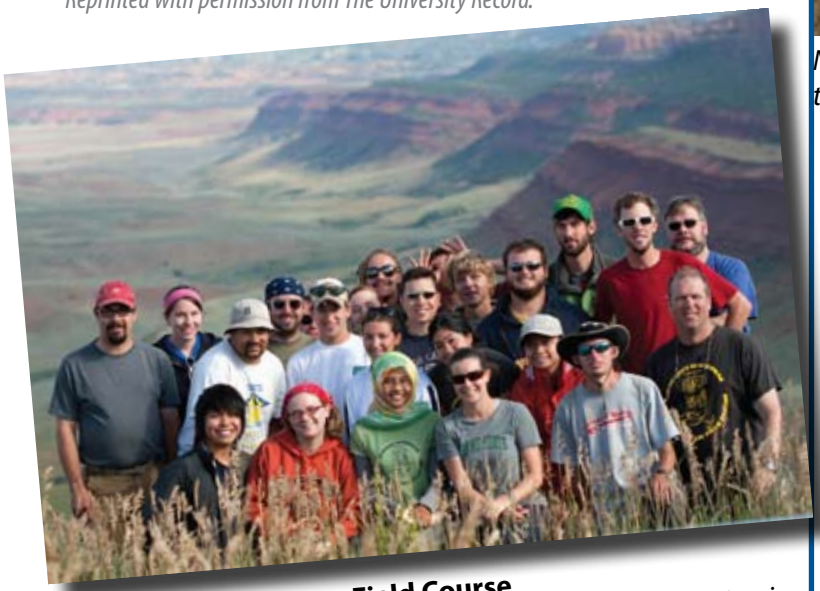


GEOSCI 440: Geology Field Course
John Geissman (UNM; BS '73, MS '76, PhD '80), Nathan Niemi, Nathan Sheldon, Peter van Keken

Spotlight: Chef's special: Project coordinating with a dash of cooking

Pecan crusted salmon with a maple syrup mustard glaze is not the typical dining hall fare found at camps. But Chris Malvica, the project coordinator at Camp Davis, has tried to make sure the food served at the academic camp for U-M students in Jackson Hole, Wyo., is anything but ordinary.

Malvica worked as a temporary chef at Camp Davis in the summer of 2000. With his culinary expertise honed at the Ritz-Carlton, he quickly raised the caliber of the Camp Davis dining experience.

He returned to Ann Arbor in the fall to resume his full-time profession of being an electrician. When he was asked to become Camp Davis' project coordinator the next year, he gladly accepted the position and has helped run the camp ever since.

U-M students attend each summer to obtain natural science credits using the Rocky Mountains as an

Niel Steinberg tying the shoe of his son, Avery, during the fun times at this year's Alumni Getaway.

Nothing like a summer vacation at Camp Davis to rebuild one's energy for the upcoming year and to renew one's memories of the great times as a student at Michigan's Camp Davis. Eight families joined **Peter van Keken**, Colleen Currie and **Kacey Lohmann** for 5 days of great weather and great fun. This was an exceptionally special year as we celebrated the replacement of the cabins on the faculty side of Camp. Unlike the earlier rustic accommodations that reminded folks what it was like for both faculty and students for the eighty years that Camp has been in operation, this year we had "civilized" accommodations. We were definitely spoiled this year with lots of activities: horseback riding, white water rafting, long

outdoor classroom, and it falls upon Malvica to ensure that everything runs smoothly.

He takes a certain pride in exposing the students to the breathtaking scenery and exciting experiences Camp Davis has to offer.

"It's beautiful — incredibly so — he says. "I love watching kids who have never seen the mountains experience the Rockies. When the students are getting ready to depart they often realize they have not only had fun and learned a lot, but they have also had a life changing experience here"

As his role has progressed and he finds himself spending less time in the kitchen, Malvica still helps out in that domain daily, whether it's covering for a chef on his or her day off or helping to order and inventory food.

"The food here is amazing, but organizing three meals a day for more than a hundred people can be chaotic sometimes," Malvica says. The camp also tries to "never serve the same meal twice," which inevitably adds to the hectic mood in the kitchen.

The camp staff strives to use local ingredients while cooking. Regional treats such as buffalo, huckleberries and sage "picked right from the ground" are incorporated into meals. "It can be a daunting task, good food keeps the students' spirits high," says Malvica of his roles in the kitchen.

Malvica's other duties encompass "anything it takes to run a small camp." Ranging from maintenance, washing dishes, recruiting students and advertising to name a few, work is "never the same from day to day."

Malvica also can be found mending fences and chasing bears and badgers off the camp's secluded property.

While his job features a plethora of nontraditional tasks, he still spends a large part of his day behind a desk.

With such a wide array of duties both in and out of the kitchen, Malvica has picked up more than few new skills during his nine-year stint at camp.

"Although I'm trained as an electrician I've become a decent plumber now and I can fix just about anything," Malvica says.

Reprinted with permission from The University Record.

For a video about the Camp renovation, go to http://www.ns.umich.edu/podcast/video.php?id=881

Alumni Getaway 2009

hikes into the Tetons, evening socials, geologic field trips with lectures, and evenings with beautiful Camp Davis sunsets. What made it particularly nice this year was the return of several families for their second or third visit. However, with the kids getting a little older each year, and a lot faster in their hiking and climbing, it is hard to keep up with their boundless energy on the steep and long hikes. It might be that we all are getting a slight bit older as well, but there is clearly a big difference in the arrival times of the kids and adults on hikes like Cream Puff and Garnet Canyon.

Well.....if you haven't been back for several years, start planning for our next alumni camp and get the family convinced that 2011 will be the time to make their visit to Camp Davis.

CAMP DAVIS ALUMNI GETAWAY -- THE CAST OF STARS

With Beaver Mountain in the background this year's alumni participants include (from left to right): Kacey Lohmann, Giselle Brabb, Joanna Lyle, Matthew Rector, John Rector, Robin Brabb, Lou Rector, Carol Rector, Earl Brabb, Peter van Keken, Al Geiger, Annette Olivarez Lyle, Colleen Currie, Nicholas Lyle, Ellie Geiger, Mitch Lyle, Hella Lange, Matthew Lyle, Avery Steinberg, Jim Barnes, Dave Barnes, Niel, SeAnne, and Shana Steinberg, Allan Lange, Simon and Margaret Klein, and Jack Barnes.

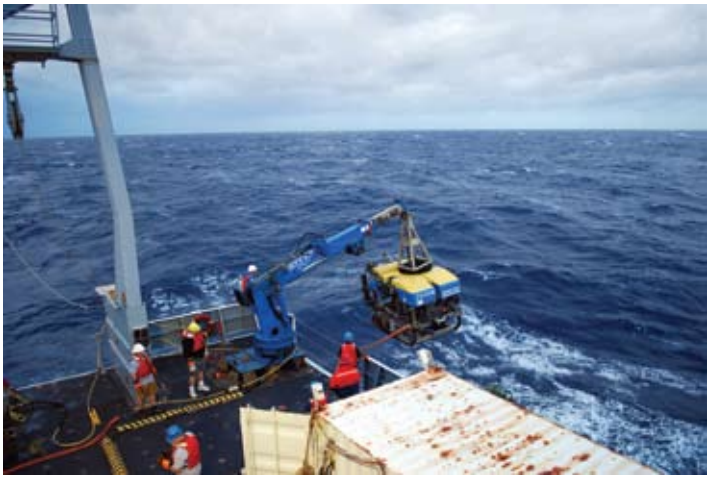
ALUMNI GETAWAY 2011

More photos:
http://www.picasaweb.google.com/UmichGeosci/

Microbes and Minerals in Deep-Sea Hydrothermal Plumes

The R/V Thomas Thompson, home to graduate student Karthik Anantharaman for 30 days this summer.

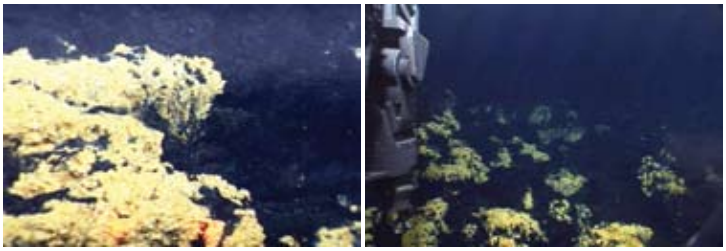
32 summers ago, deep-sea hydrothermal vents were discovered not far from Galapagos, forever changing our understanding of Earth and life. This summer, graduate student **Karthik Anantharaman** spent a month at sea aboard the *R/V Thomas Thompson* in the southwestern Pacific and had his own first up-close encounter with vents. Karthik, a 1st year student in **Greg Dick's** new geomicrobiology lab, joined 21 other scientists from around the world to sample deep-sea hydrothermal vents along the Eastern Lau Spreading Center (ELSC) and the Valu Fa ridge in Lau Basin. He recently completed a masters degree in Environmental Engineering at U-M, so life on an oceanographic expedition was quite a change of pace: there was the excitement of exploring the seafloor and discovering new vent sites, the gruel of midnight to 4 am watches, and even a medical emergency involving a ship crew member (who is now OK). But all the travel and effort was well worth it. Karthik returned to Ann Arbor with a rich array of samples that he will use to investigate how microorganisms mediate the flux of elements from the subsurface through deep-sea hydrothermal vents and into the oceans.



ROV Jason II being deployed for a dive.

Deep-sea hydrothermal vents are renowned for fueling dense ecosystems where microorganisms serve as the primary producers, translating energy held within hydrogen, sulfur, iron, manganese, and methane into biomass. However, a large portion of hydrothermal energy and elements injected by vents into the deep-sea it is dispersed beyond these near-vent oases of life. Hydrothermal plumes rise hundreds of meters off the seafloor and travel thousands of kilometers away from mid-ocean ridges, thus distributing elements that have profound impacts on ocean chemistry and life. It is within these plumes that the ultimate fate of hydrothermal inputs is determined; hydrogen and sulfur are oxidized; methane and ammonia are consumed; dissolved iron and manganese are transformed into particulate minerals. All of these reactions are mediated by microorganisms, and microbial precipitation of minerals is particularly important. The products, iron and manganese oxides, have earned the nickname "scavengers of the sea" because they sequester many biologically important nutrients and geologically relevant trace elements and deposit them on the seafloor as metalliferous sediments. Biogenic iron and manganese oxides are even more reactive than their abiotic counterparts, and their impact is underscored by the fact that the entire volume of the world's oceans is cycled through deep-sea hydrothermal plumes on relatively short time scales.

At Lau Basin, the gradients in host rock geology and hydrothermal fluid chemistry that occur along the ELSC ridge present a unique opportunity to better understand how hydrothermal venting shapes biological communities, and in turn how biology influences the impact of deep-sea vents on ocean chemistry. The goal of the cruise was to sample a wide range of vents and characterize the microbes and minerals present at different locations within rising plumes. But how do we get samples from 2000 meters deep and study organisms that appear as anony-



Extensive microbial mats, encrusted in Mn oxide (black) and elemental sulfur (yellow), covered the seafloor in some areas.

mous blobs under even the most powerful microscopes? With a lot of help from remotely operated vehicles (ROVs) and the information encoded within DNA.

The *ROV Jason II* was used to sample deep-sea hydrothermal plumes as never before. Despite being piloted remotely from the surface thousands of meters above, Jason is quite nimble and can be maneuvered to hover just above a vent chimney spewing hydrothermal fluid. Using a robotic arm coupled to the SUPR sampler, a filtration device built by collaborator John Breier of Woods Hole Oceanographic Institution, numerous discrete samples can be taken from precise locations within a rising plume. SUPR sits on Jason with a rosette that rapidly filters fluids from up to 24 samples in situ. This allowed vertical profiles of the rising plume and a horizontal profiles of the neutrally buoyant plume. In total, 81 plume samples were collected from 5 different sites in the Lau Basin. This will allow spatial and temporal characterization of plume microbial communities and mineralogical composition.

Jason's robotic arm using the SUPR to sample rising hydrothermal fluids from a black smoker at the Mariner site in Lau Basin.

A variety of approaches are being used to reveal interactions between microbes and minerals in the plume, including the traditional method of determining what microorganisms are present in a sample: growing the "bugs" in lab culture, the same way you would test a sore throat for the presence of strep. However, the recent recognition that most microorganisms refuse to grow on petri dishes has ushered in a new era of molecular geomicrobiology that hinges on genetic techniques. Thus samples will be analyzed by sequencing DNA extracted directly from plume waters to provide genetic insights into what organisms are present and what they are doing. At the very cutting-edge, this molecular approach involves extracting RNA and gaining glimpses into what genes are being expressed, yielding genetic biomarkers of microbially-mediated geochemical reactions occurring at any given time or place.

After a short delay being stranded in Samoa (which conveniently led to several days of snorkeling), Karthik is back in the geomicrobiology lab at C. C. Little, extracting and sequencing DNA and carefully cultivating his new friends from the deep. As these new methods are pieced together with microscopic, spectroscopic and geochemical data, the aim is to gain a more complete picture of plume processes such as biomineralization.

Greg Dick *is an Assistant Professor in the Department of Geological Sciences, an Affiliate Faculty Member in the Center for Computational Medicine and Bioinformatics, and a Faculty Associate in the Program in the Environment at the University of Michigan.*

U-MTV

Phil Gingerich's work on the evolution of whales has been turned into an episode of National Geographic Channels show *Morphed* called *When Whales Had Legs*. This episode is available on-line.

In the Fall 2007 issue of Geoscience News, **Dan Fisher** reported on his work on a baby mammoth found in Siberia. This research graced the cover of National Geographic earlier this year, and the discovery and study of this amazingly well-preserved mammoth specimen has been documented in a National Geographic Channel television special entitled *Waking the Baby Mammoth*. Check your local listings for air times. Dan will be presenting a public lecture on this research at the Field Museum in Chicago on March 9, 2010, as part of the opening of a new exhibit on mammoths and mastadons *(http://www.fieldmuseum.org)*.

Waking the Baby Mammoth *http://channel.nationalgeographic.com/episode/waking-the-baby-mammoth-3630*

Morphed *http://channel.nationalgeographic.com/series/morphed/3001/Overview*

Tectonic Evolution of the Greater Caucasus Mountains

Although the Greater Caucasus are primarily known as a locus of political upheaval, **Nathan Niemi (Asst. Professor)** and **Boris Avdeev (PhD Candidate)** are interested in a different type of unrest within this mountain range. The Greater Caucasus lie along the borders of Russia, Georgia, and Azerbaijan and form the northernmost tectonic element of the Arabia-Eurabia collision zone. The peaks of the Greater Caucasus, capped with stratovolcanoes, such as Mt. Elbrus and Kazbek, exceed 5000 meters, making this the highest mountain range in Europe.

Unlike many actively deforming mountain ranges, however, the highest portions of the Greater Caucasus are underlain by remarkably little seismicity, and recent surveys using high-precision Global Positioning System receivers show little present-day shortening across the range, perhaps only 5 mm/yr, as compared to shortening rates across mountain ranges such as the Andes, Taiwan or the Himalaya which typically exceed 20 mm/yr.

Boris Avdeev (PhD Candidate) *collecting samples on Mt. Ushba (4690 m) in the Georgian-controlled portion of the Greater Caucasus.*

Nonetheless, large earthquakes still occur beneath the Caucasus, with the 1991 M7 Racha earthquake in Georgia leaving hundreds dead and tens of thousands homeless, and the medieval Shamakhi earthquake in 1667 resulting in the death of 80,000 people in Azerbaijan.

These observations lead to a number of interesting scientific questions such as Why is the tallest mountain range in the Arabia-Eurasia collision located the furthest from the plate boundary? How do you build a large mountain range with relatively minimal shortening and accompanying seismicity? And what is the seismic hazard associated with this range? Is the historic record of infrequent, but large, earthquakes representative of the long-term evolution of the range, or has this record under-represented the seismic risk?

In collaboration with geoscientists from the University of California at Davis, St. Petersburg State University, the Azerbaijan Academy of Sciences and the Seismic Monitoring Center of Georgia, Niemi and Avdeev are attempting to address these issues. Their work to date focuses on constraining the rate and timing of exhumation of the Greater Caucasus using low-temperature thermochronology. This technique relies on thermochronometers that are sensitive to cooling below temperatures found near the Earth's surface (<180°C, or roughly the upper 5 km of crust). As deformation uplifts the mountain range, erosion removes material from the surface, bringing deeper rocks to the surface. As theses deeper rocks cool, a suite of thermochronometers records when, and how quickly, these rocks traveled to the surface of the Earth.

Although this approach is an indirect way to measuring crustal shortening, and does not explicitly account for geological structures, such as faults, it is an excellent means to establish a regional picture of the timing, rates

and magnitude of deformational events. In a region as remote, large, and difficult to access as the Greater Caucasus, these studies provide valuable new constraints on the evolution of the range, and supply a framework around which to plan future detailed structural and stratigraphic studies.

Results so far have been surprising. The timing of Arabia-Eurasia continental collision is debated, with various workers preferring dates ranging from Late Eocene (~40 Ma) to Middle Miocene (~12 Ma), based on a variety of stratigraphic structural, and geophysical data. We observe slow cooling of the Greater Caucasus beginning in Oligocene time, perhaps related to onset of Arabia-Eurasia collision, but the rates of exhumation are much lower than those observed in large, active mountain ranges today. At 5 Ma, however, a dramatic increase in the exhumation rate is observed, consistent with those rates observed in large, active orogenic systems.

Nathan Niemi (Asst. Professor) *examining Cretaceous sedimentary rocks on the northern slope of the Greater Caucasus in Russia.*

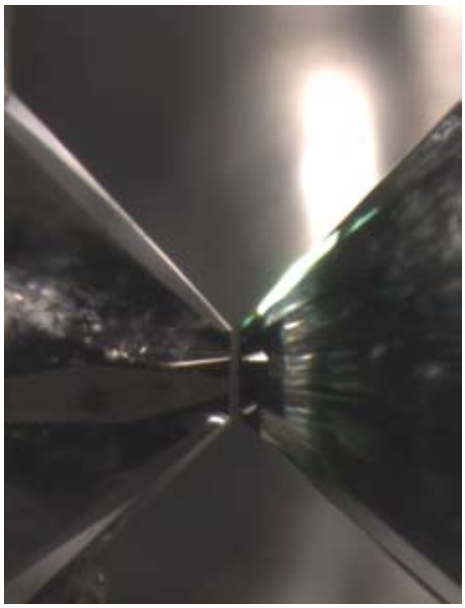
Mt. Şahdağ (3982 m) in the eastern Greater Caucasus of Azerbaijan. Jurassic strata are uplifted and deformed over a north-vergent thrust system on the north side of the range.

The observed change from slow to rapid exhumation coincides with a variety of other changes within the Arabia-Eurasia collision zone, suggesting that the Greater Caucasus have grown as mountain range since Pliocene time, and have done so as the result of a reorganization of the Arabia-Eurasia collision zone, rather than as a result of driving forces at the plate boundary.

Work in the coming year along strike in the range will help to determine if the conclusions drawn to date are accurate for the evolution of the range as a whole, or if the Greater Caucasus have a more complex temporal and spatial evolution.

Nathan Niemi is an Assistant Professor in the Department of Geological Sciences at the University of Michigan.

This photograph shows two diamond anvils (thickness: ~2 mm) after their bombardment with high energy, heavy ions accelerated to relativistic velocities. These two natural diamonds were previously used in high-pressure experiments to apply 40 GPa by squeezing against a sample embedded in a chamber filled with pressure medium. The intense uranium beam completely traversed the left diamond (from left to right) as indicated by the dark green coloration. The projectiles were stopped in the right diamond and the range in this anvil is indicated by the sharp line of contrast within about 2/3 of the total diamond thickness. The band of enhanced transparency in the right diamond is due to shielding effect of the metallic sample chamber. The green color might be related to modifications associated with impurities such as nitrogen. (R. Ewing) ►



Response of Pyrochlore to Extreme Conditions

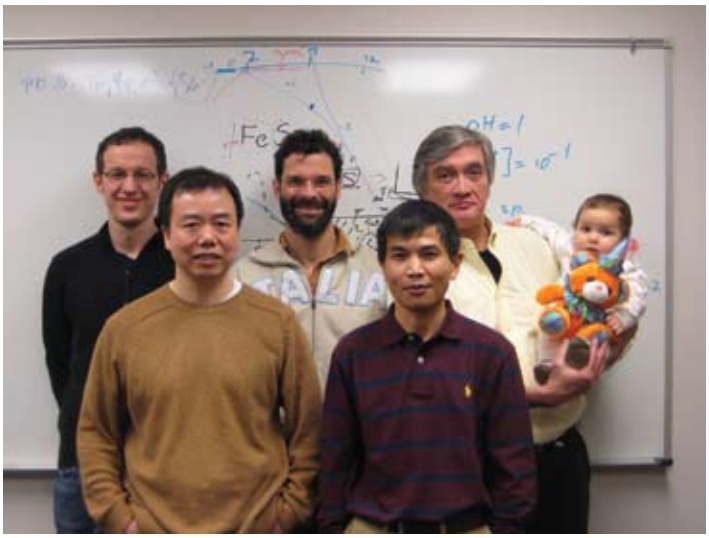
At the National Synchrotron Light Source, a team of researchers from the University of Michigan and Rensselaer Polytechnic Institute led by **Rod Ewing** has demonstrated the effect of composition on the stability and response of the pyrochlore structure under high pressure and in a high radiation field. This study lays the foundation for understanding how complex ceramics will respond to the extreme environments, such as those in advanced nuclear reactors.

Pyrochlore has a flexible structure, which can exist in more than 500 compositions that have a wide variety of chemical and electronic properties with many technological applications. Some pyrochlores can also incorporate actinides, such as plutonium, so there is great interest in their use as nuclear waste forms or as inert matrix fuels.

In order to investigate the effects of high pressures and irradiation on pyrochlore, two closely related compositions, a gadolinium titanate oxide and a gadolinium zirconate oxide, were compressed with up to 45 gigapascals (GPa) of pressure, roughly more than six million pounds per square inch. That, by comparison, is almost 200,000 times the pressure in a car tire and more than the weight of a space shuttle on one's fingertip.

The structure of gadolinium titanate oxide remained relatively stable under the highest pressures tested (45 GPa), but the gadolinium zirconate oxide only maintained stability up to 23 GPa, above which it structurally distorted. When the pressure was released, the zirconate pyrochlore further disordered into a very stable defect-fluorite structure, which held up when irradiated to high doses.

Under ion-beam radiation, however, the behaviors of the two pyrochlores changed. The zirconium pyrochlore was more resistant to radiation damage, and therefore remained crystalline. In contrast, the titanate pyrochlore transformed into disordered structure at low doses and finally became stable at higher doses.



From left, Maik Lang, Jianwei Wang, Udo Becker, Fuxiang Zhang and Rod Ewing (holding Sofia Becker). Not pictured: Jie Lian (faculty member at Rensselaer Polytechnic Institute)

After using Raman scattering, calculations, and angle dispersive x-ray diffraction at NSLS beamline X17C, the researchers concluded that subtle changes in their structures significantly influence the response of pyrochlore to elevated pressure and irradiation fields. The performance of these materials in extreme environments is directly related to the energetics of the disordering process. Their results were reported in the February 1, 2008 edition of Physical Review Letters.

Now, Ewing's team is further studying titanium and zirconium composition under very high-energy irradiations, finding that the materials have consistent susceptibility to radiation damage. A single uranium atom fired through pyrochlore material leaves a damaged zone, which exists as a linear track. Using high-resolution electron microscopy, the researchers have found every type of structural stage within this trail of damage.

"The research team is now actively involved in studies that investigate the simultaneous effects of high pressure and a high radiation field using very high-energy, swift, and heavy ions passing through a diamond anvil pressure cell," said research group leader and University of Michigan Geological Sciences Professor Rod Ewing. "The next year should provide new and exciting results under a pressure and irradiation regime that have never been investigated," Ewing said.

Researchers involved included **Fuxiang Zhang**, **Jianwei Wang**, **Maik Lang**, **Udo Becker**, and Rod Ewing of the University of Michigan, and Jie Lian of Rensselaer Polytechnic Institute.

This research was supported by the Office of Basic Energy Sciences within the U.S. Department of Energy and the National Science Foundation (NSF). Use of beamline X17C was supported by the Consortium for Materials Properties Research in Earth Sciences (COMPRES), funded by the National Science Foundation.

Rod Ewing is the Edward H. Kraus Distinguished University Professor in the Department of Geological Sciences, a Professor in the Department of Nuclear Engineering & Radiological Sciences, and a professor in the Department of Materials Science and Engineering at the University of Michigan.

The results of this research were published in F. X. Zhang, J. W. Wang, J. Lian, M. K. Lang, U. Becker, and R. C. Ewing, 2008, Phase stability and pressure dependence of defect formation in $Gd_2Ti_2O_7$ and $Gd_2Zr_2O_7$ pyrochlore, Phys. Rev. Lett., **100(4)***: 045503.*

Freshwater in the Galapagos – a Resource in Peril

Last June, Associate Professor **Clara Castro** headed to the Galapagos Islands for a three week field trip aimed at collecting groundwater samples for analyses of noble gases in two of the inhabited islands, Santa Cruz and Isabela (the other inhabited islands are San Cristobal, Floreana and Baltra). Because noble gases incorporate and preserve signatures of distinct sources, specifically, the mantle, crust, and atmosphere, they provide a unique insight into groundwater mixing, flow patterns and recharge locations of complex volcanic structures.

Because of their complex internal structure and challenging access, volcanic areas are often poorly characterized with respect to groundwater resources and frequently suffer from water scarcity. The Galapagos Archipelago, a UNESCO World Heritage site famous for its unique fauna and flora, is one example of such a region, and has historically been regarded as an inhospitable land due to a lack of this vital resource. However, in the last few decades, economic development supported by a booming tourism industry has led to exponential population growth without regard for the preservation and limitation of natural resources in the inhabited islands of Santa Cruz, San Cristobal, Isabela and Floreana. As a result of the overwhelming pressure which is currently being placed on both natural ecosystems and resources of the archipelago, the islands were placed on the UNESCO World Heritage "In Danger" list in June 2007.

One of the main goals of Castro's work is to obtain an in-depth and overall understanding of the groundwater flow system of these islands in order to better manage the resources for human consumption and improve conservation of the ecosystems dependent on these resources. This noble gas study is part of a multidisciplinary collaborative international project in the archipelago - GIIWS: "Galapagos Islands: Integrated Water Study", led by the University of Paris VI and involving multiple European universities and French schools of engineering, as well as local institutions, in particular, the Galapagos National Park and the Charles Darwin Foundation. The first phase of this ambitious project, which involved generation of a digital elevation model for Santa Cruz, as well as extensive coverage of Santa Cruz and San Cristobal Islands by helicopter-borne transient electromagnetic prospecting, identified major basal and perched aquifers on the southern portions of both islands. Direct access to the basal aquifer is possible on Santa Cruz through "grietas" (open vertical fractures) in the vicinity of the coast line. This is not the case for San Cristobal Island where access to the basal aquifer is non-existent. On the other hand, the presence of a perennial hydrographic system is unique to San Cristobal. The remainder of the archipelago is considered hydrologically dry and arid. In addition to stored rain water, poor-quality brackish water extracted from the "grietas" accounts for most of the water supply to Santa Cruz and Isabela, while San Cristobal (and occasionally Floreana) rely mostly on spring water. Such water supply is heavily contaminated at multiple locations by fecal coliform bacteria and pesticides.

The specific goal of this field trip was to sample the basal aquifer in Santa Cruz and Isabela. This was a first hydrological reconnaissance in Isabela where the basal aquifer is accessible through shallow wells near the coastline. Neither of these two islands have perennial rivers, but animal life is well adapted to living within these harsh conditions. It is interesting to witness the relationship between the native fauna and water resources when they do exist. Giant tortoises are often found loitering around muddy pools and ponds in the humid highlands of Santa Cruz, while flamingos can be found around lagunas in Isabela.

Construction growth appears to be impossible to contain on Santa Cruz Island, as evidenced by the major, busy population center, Puerto Ayora, and increasing to urbanism along the road leading to the smaller town

"Las Grietas", Santa Cruz - view toward the ocean.

of Bellavista. On the other hand, Isabela remains for the moment a much more pristine area where all sorts of wildlife are still encountered near its major (but much smaller) population center, Puerto Villamil.

With such goals in mind and the prospect of an exciting sampling season, Clara headed to Quito, Ecuador, on June 1st. The flight was uneventful, aside from a late, midnight arrival, and an astounding and unexpected landing right in town among the tall buildings of this high altitude city surrounded by spectacular, beautiful high volcanos reaching altitudes of ~6000 m. In Ecuador, she was joined by Sophie Violette, Assistant Professor in Hydrogeology and Principal Investigator of the GIIWS project, and her PhD student Alexandre Pyret, who had just flown from Paris to be her trip companions in this sampling campaign. The field trip had been planned well in advance and all the sampling equipment sent a month earlier to Santa Cruz through FedEx to Noemi d'Ozouville, coordinator of the overall project and already on site. No complications were thus expected with their trip and beginning of the sampling campaign. Unfortunately, all the noble gas sampling equipment was unexpectedly retained by customs in Guayaquil, from where flights depart directly to Baltra/Santa Cruz, forcing the sampling team to a sudden change of plans and an additional three-day stay in Guayaquil, the time to secure the release of the equipment. Once the equipment was released, they headed to Santa Cruz on June 5th, where Noemi and Godfrey Merlen, another project collaborator were awaiting them. They proceeded shortly afterward to start what became an intense, and at times unexpectedly challenging sampling season!

In Santa Cruz, access to groundwater from the basal aquifer is primarily through "grietas" which are natural fractures in the volcanic rocks which comprise the island. While some of these "grietas" are open and access to the water table is not difficult, most are actually quite deep and sampling proved to be very challenging. The water is brackish as it is a mixture of saltwater intrusion from the ocean and of freshwater lenses fed by rainfall infiltration in the highlands. Barranco and Ingala were among the most challenging "grietas". Water at Ingala is found at ~15m depth, and while some stairs are available in the shallowest portion of the "grieta", the team was left to use their own skills to approach the water through tortuous and narrow openings in the rock – it certainly paid off that all the team members were relatively slim and in decent shape! Collection of samples in this "grieta", which is used to provide "freshwater" (the water is actually brackish and highly contaminated due to lack of sewage system) to the municipality of Santa Cruz was actually very precarious. In this instance, water samples were collected by Alexandre with the help of a local worker. Both had to stand on suspended cables connected to a water pump in

Sampling "grieta" Ingala, Santa Cruz, a concerted effort among Clara Castro, Sophie Violette, Alexandre Pyret and a local worker. Sophie's feet, view from below.

yet another narrow fracture. Sampling at Barranco proved to be no less challenging, the entrance to the shallowest portion of the grieta being achieved through placement of a movable staircase. The walls of this "grieta" appeared to be very unstable, and made of a mixture of volcanic rock and soil and put in place by landslides that have occurred in the past. As Clara and Alexandre were sampling below, small rocks kept falling, a reminder that it might be better not too stay too long onsite… In addition to the unstable walls and ceilings of the "grieta", all surfaces were very slippery due to the high humidity – all of which made sampling extremely challenging.

Isabela was the team's next stop, where they arrived after an intensive two-hour ride in one of their fast "lanchas" (boat) in a somewhat agitated ocean. Five nights were spent on this island, four of which were in the astoundingly beautiful Marita hotel which had an unbeatable low season offer ($25/night!) and which is owned by a very pleasant Italian woman who apparently decided to make Isabela her home. In Isabela, groundwater is typically much closer to the surface and the four sites that were sampled were in fact shallow "wells". To be more specific, these are not exactly wells because they are also natural fractures in the rock, but resemble regular wells from the surface. These wells actually supply all of the "freshwater" (in fact brackish water) to Puerto Villamil, the main population center in Isabela. Given their importance, these wells are thus well known by the Galapagos National Park staff. In addition to these well known well locations, Clara and her co-workers were interested in checking one additional potential sampling location in the Galapagos National Park not too far from Puerto Villamil, prior to their departure. Unfortunately, no paths accessing this location exist through the densely vegetated jungle. Here, the vegetation is so dense that it required one staff member from the Park to guide Clara and her collaborators to this

Clara Castro emerging from Barranco "grieta" on Santa Cruz island.

location through a path cut by a large machete. They had to move slowly to avoid contact not only with gigantic cactus plants but also bee's nests that were suspended in the trees. The trip back turned into a slightly more challenging one as our guide (likely in the absence of GPS) became slightly "disoriented" leading to a longer return and hardly bearable walk under a very hot mid-day sun. They were able, at some point though, to finally find the road where a National Park car was awaiting them.

Back to Santa Cruz in the very early morning of June 16, Clara and Noemi dedicated the two remaining days to obtaining all the necessary permits from the Galapagos National Park as well as the Charles Darwin Station to export all the samples to the USA for analyses of noble gases in Ann Arbor. Results from these samples collected in Santa Cruz and Isabela will be analyzed together with results from samples collected in a previous sampling campaign in San Cristobal by Noemi and Sophie. Helium, which is expected to present a strong mantle signature on these islands will be particularly useful in providing information on deep versus shallow water mixing, flow patterns and connectivity between the different aquifers. The deeper the flow path and absence of contact with recharge water, the stronger the He mantle signature, as this mantle component will accumulate over time. Similar mantle signatures within different reservoirs will point to a high degree of connectivity. Concentrations of all noble gases (He, Ne, Ar, Kr, and Xe) and simultaneous consideration of He isotopic ratios, He concentrations, and mixing of He components will allow us to quantify groundwater mixing and to identify flow patterns when strong dilution by recharge water has occurred. All these results will be subsequently incorporated into numerical groundwater flow models being developed by Clara's French co-workers, in particular for Santa Cruz and San Cristobal. Information on recharge locations will be provided by the atmospheric component of all noble gases which is primarily dependent on the mean local atmospheric pressure (altitude of the recharge area) and temperature of the recharge water. These results will be published next year, so stay tuned as they are expect to be very interesting!

Clara Castro is an Associate Professor in the Department of Geological Sciences at the University of Michigan.

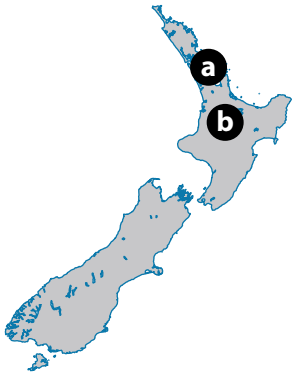
A Travel Guide to the Department's 2009 International Field Trip to New Zealand

Travelogue by Meghan Wagner (Graduate Student)
Photos by Karla Knudsen (PhD Candidate)

Sunday, August 23

We arrived safely, and without much sleep, in New Zealand at approximately 7:30am and successfully met up with Chris and Vivian Hendy, Peter Knoop, Annie (a colleague of Chris's at the University of Waikato), and Lisa (a graduate student working with Chris Hendy). We loaded up into two mini buses and headed off to One Tree Hill (also of U2 fame). At One Tree Hill we were able to view the entire city of Auckland and survey the Auckland volcanic field, a series of basalt volcanoes. The historical significance of One Tree Hill as a Maori pa, or settlement, was also noted. Man-made terraces surround the hill. From there we headed to the Miranda coast, where we stopped to walk along the chernier shell beds and mangroves that line the shore. The area attracts many migrating birds, and so down the road we made our third stop at the Miranda Shorebird Center. This was also our lunch stop, which was very welcome at this point, especially because it included coffee and tea. This was the beginning of the consumption of copious amounts of hot drinks to stave off the damp New Zealand chill. One of the employees at the Shorebird Center is a friend of Chris's, and we were treated to a discussion of the birds seen along the Miranda shoreline and their migration patterns, which cover almost the entire Pacific Ocean from north to south. After lunch we moved on to the Martha Hill and Waihi gold mines, where we were met by Jake Croall, a former student of Chris's. He described for us current operations at the gold mines and the innovative cyanide process that is used to extract the gold. By this time we were all pretty wet from the rain and very sleepy, so we drove to the Hendy residence in Hamilton for dinner. Vivian and Annie made a great dinner for us while we sat as close to the fire as we could and petted the nice cat we found.

a



b

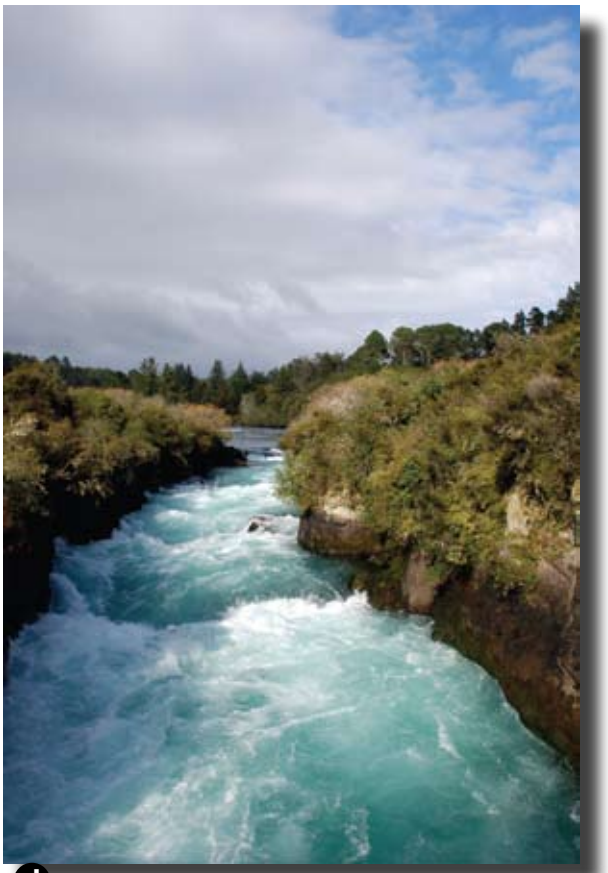
Monday, August 24

We made our first stop at the Waitomo caves, also known as the "glowworm caves." After hiking through some beautiful native New Zealand forest, we came to the cave entrance and toured the caves. We discussed cave formation and the role of the glowworms in the cave ecosystem. After lunch, we took another hike through the native forest to a natural tunnel that has been carved out of the landscape. Our second stop that day was at Maungatautari Ecological Island. The peak of an eroded andesitic volcano has been enclosed by a fence and all non-native New Zealand "pests" have been removed from inside the fenced area, making a haven for native New Zealand wildlife. We were met by one of Maungatautari's guides, a local Maori named Wiki. She described the creation of the island for us, its inhabitants, and ongoing projects. Along our walk inside the island, we were followed by some noisy kaka, which are native New Zealand parrots. We also climbed to the top of the viewing platform to see the forest canopy. After leaving the island we headed to Powhiri Marae, where we stayed the night. A marae is a Maori gathering place. At the marae, we were welcomed by a traditional Maori greeting ceremony, ending with a hongi (pressing noses together). We had the opportunity to speak with several of the people living at the marae about Maori history and culture. Later we ate a fantastic dinner which included the kumara, a sweet potato. This was also our best chance for viewing the Southern night skies.

c

Tuesday, August 25

In the morning we had to wait for our rides to arrive and in the meantime some clever games of apple-tossing and duck-duck-goose ensued. Our first stop was at a dam that was constructed between two walls of ignimbrite rocks. Then we continued further south into the Taupo Volcanic Zone. Outside Rotorua we stopped to view some fossil fumaroles. We continued through Rotorua, which smelled of sulfur, to Orakei Korako. Orakei Korako is an active geothermal area known for its fault-stepped sinter terraces. We reached it by taking a ferry across the Waikato River. Visitors are warned not to step off the wooden path, but Chris Hendy ignored this and crossed the sinter multiple times to collect water samples from the geysers. The samples were measured for temperature and pH. We also visited Ruatapu Cave and the pool at the bottom of the cave known for its ability to clean jewelry. The pH of this water is around 2. Chris also knew of a smaller, very warm cave off to one side of the main cave where Al salt deposits have been precipitated. After leaving Orakei Korako, we stopped at another geothermal field which is currently being exploited for energy production. We spent that night in Taupo. A few people braved the cold to go down to Lake Taupo, where they attempted to dig a hole in the beach which would subsequently be filled with warm water.



d

Wednesday, August 26

Our first stop of the day was at the de Bretts hotel where a nice road cut exposed an eruption sequence from the AD 186 Taupo eruption. We then headed to Tongariro National Park, where we got to view Mt. Tongariro, Mt. Ruapehu, and Mt. Ngauruhoe, the last of these being also known as Mt. Doom to Tolkien fans. We stopped to take a short walk through a lahar field before moving on to the visitors center. Unfortunately we were unable to hike up any of the volcanoes. We then drove a short distance to the site of the 1953 Tangiwai disaster, when a lahar flow damaged a bridge just minutes before a passenger train arrived. After that it was on to Wanganui, where en route we were able to view some marine transgression/regression sequences.

e

Thursday, August 27

The theme for the day was terraces. We started at Kai-iwi, where the beach has magnetite in the sand which has been sourced from Mt. Ruapehu. We walked around the bluff to examine the cliffs. The soft siltstone cliffs proved to be very unstable because a few people saw and we all heard a massive chunk of the cliff fall to the beach. At this point the tide was coming in rather quickly so we decided to leave. Driving away from Kai-iwi, we noted Quaternary-age terraces cut into the landscape, a result of sea level changes during glacial-interglacial cycles. A beach walk following lunch turned up many shells, including an intact one with a rotting animal inside. We then drove toward Wellington but first made a stop at Turakirae Head. The beaches in this area have been uplifted successively by earthquakes. A long-ish walk brought us out to the fur seal colony, this one inhabited by male fur seals. Many in the group enjoyed climbing on the rocks and getting as close as they could to the seals for some photographs. We spent the night in Wellington. Most of the group went to the fancy steak restaurant next door to the hostel, where we said good-bye to Chris, Annie, and Lisa. Overnight, we woke up to an earthquake, although as we discovered in the morning, it is possible to sleep through a 5.2 magnitude quake.

Friday, August 28

Today was a free day in Wellington. Places visited by students included Te Papa, the national museum; Parliament House; the botanical gardens, NIWA, and a cable car ride up the mountain. We also had some time to do laundry and relax a bit.

If you have a free day, you can read more about the New Zealand field trip, and see additional photos on-line. Check out the article on the field trip in the University Record (http://www.ur.umich.edu/0910/Oct26_09/17.php), see the associated on-line slideshow (http://www.umich.edu/news/slideshows/NZTRIP/) or browse the blog the students created during the trip (http://um2009nz.blogspot.com/).

Saturday, August 29

We took the ferry across Cook Strait in the morning. In Picton we were met by our new driver, Carl. Our first stop was at Woodside Creek to look at the K-T boundary section exposed there. The site is on a farm, and the farmer who owned the property graciously took us down there. Half of the group rode in the back of the farmer's truck, while the other half walked—not easy since the winding creek we had to cross was very full. A number of us got very wet feet. After that we drove on to Kaikoura. The rocky beaches lining the road to Kaikoura were full of New Zealand fur seals. We stayed in Kaikoura for the night, a favorite stop on the trip: ocean and mountains and fur seals and R. Kelly all in one place.

Sunday, August 30

A few people had a chilly early morning swim in the ocean. Later we left Kaikoura and made our first crossing over the Southern Alps. At a quick stop along the South Island's winding roads, Alison and Boris described the pull-apart basin in front of us; the basin was between two right lateral strike-slip faults. We had a picnic lunch at Evison's wall, a small concrete wall constructed to prove that the Alpine fault does not creep, but jumps. A few enterprising students even managed to be on both the Australian and Pacific plates at the same time. Moving on, we began to drive out of the rain shadow and the buckets of rain that the west coast receives started. We made a brief stop at the information center in Reefton. Reefton has active gold mines and coal mines, the latter of which are currently burning but are being worked. Our next stop was in Inangahua, the site of a major earthquake in 1968. The town museum was quite strange. There were newspaper clippings and historical information about the earthquake, but also information about other aspects of the town's colorful past. One example is an article about the headless body murder that occurred there. Finally, we drove to Punakaiki to see the blowholes. The walk along the cliff edge was short, but between the driving rain and the wind, we were all soaked when we returned to the bus. We stayed the night at Te Nikau Retreat, which was arguably the best accommodation we had in New Zealand. The cabins were immaculate. A group of us cooked together to make dinner for all and we had fun all hanging out for the evening. There was a game of euchre and a record player with some old records. Ingrid dejayed.

Monday, August 31

We left Punakaiki early and stopped at a beach to discuss the basement rock of New Zealand (greywacke) and the Greenland Group. Our next stop was at the Franz Josef Glacier. Unfortunately, due to the rainy conditions, we couldn't get closer than about 750 m to the glacier. But we did get some great photo opportunities. We also drove over to the Fox Glacier. Ingrid pointed out moraines and other glacial formations of New Zealand's west coast as we drove along. We stayed the night in Haast.

Tuesday, September 1

We made two quick stops first off to see waterfalls (Fantail Falls and Thunder Creek Falls). We also then stopped at the Gates of Haast to see the Haast River rushing over large boulders. The river bed was carved by glaciers about 10,000 years ago. Today we discussed more of New Zealand's glacial landscape as we also passed Lakes Wanaka and Hawea, both glacial lakes. Because we crossed over the Alpine fault again to the other side of the Southern Alps, we were able to compare the glacial features we had seen on each side of the mountains. Just before lunch we took a hike up Mt. Iron for some exercise. It was nice to be warm for a change! After lunch we headed on to Te Anau for the night.

Wednesday, September 2

Fifty centimeters of snow overnight and a rock slide in Milford Sound cancelled our trip there, but the professors quickly organized Plan B. Driving along the road east out of Te Anau was quite a sight since the road we had driven the day before was now covered in snow! Just outside Queenstown we made our first stop to see a roadcut that had exposed some metamorphic rocks (Otago Schist?) that had been intruded by mafics. In Cromwell we stopped to see the old town and the dam that was constructed there without proper assessment of the land. Due to problems with the adjacent rock, the project cost overran the budget by almost 50%. Next we stopped at Mitchells' Cottage, a dwelling constructed during the goldmining heyday of the 1800s, and an excellent example of highly skilled stonemasonry. Then it was on to Gabriel's Gully to view a fault scarp and finally some fossil whale bones outside Milton. We spent the night in Dunedin.

l

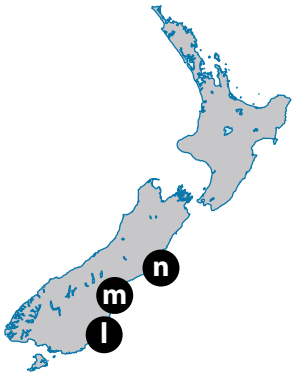
Thursday, September 3

We made our first stop at the Royal Albatross Center and got to view some albatross chicks that were almost ready to fledge. Then we moved on to the aquarium, where the staff was kind enough to let us use their meeting room as a place to have lunch. We had a guided tour of the aquarium and especially liked the touch pool. We then drove on to see the Moeraki boulders—large concretions that have now been placed just at the water's edge along the beach. We were also met by Megan Ortega, who then took us to a penguin colony. All of us saw fur seals and yellow-eyed penguins, but only a few spotted the little blue penguins, who had already burrowed into their holes for the night. That night we stayed in Oamaru.

m

Friday, September 4

Our first stop this morning was at the beach with **Megan Ortega ('BS 07, MS '08)**, now a student at the University of Otaga, to see a marine transgression/regression sequence. Unfortunately, we also found a dead blue penguin on the beach on the way out to the site. While fascinating, it was also a bit sad. We then moved down the beach to look for moa bones, but we only found paleosols instead. Our next stop was at a roadcut that once had exposed some pillow lavas, but they have now weathered almost completely away. Then we drove to Anatini to view some fossil whale bones. Lunch was at the elephant rocks, which everyone enjoyed climbing on. A few people even held races across the plain. Next we drove to Christchurch and continued up to Banks Peninsula, which sits on top of an extinct (?) cinder cone. Sam led a discussion which helped us to pull together all of our experiences in New Zealand into a more coherent picture. That night we stayed in Christchurch in a creepy hostel that had once been a jail.



n

This 14 day field trip to New Zealand was led by Ingrid Hendy and Sam Mukasa. Special thanks go to an anonymous donor whose generous donations have established the Field Excursion Endowment and to the International Institute of the University of Michigan for their partial support. Without these funds, students would not have been able to afford such a trip. Indeed, student costs were limited to only $800 each.

SOFT ROCK SPRING TRIP
THE GREAT SOUTHWEST

White Sands National Monument, New Mexico

Each year as classes wind down, as exams are finished and the campus begins to empty for the long summer months, the graduate and undergraduate students of the Geology Department hit the road for the Spring Field Trip. Traditionally, this trip had been run by **Bruce Wilkinson** and **Kacey Lohmann**, but with the retirement of Bruce, Kacey has maintained this yearly trip with the help of either **Peter Knoop** or **Nathan Niemi**. This year, Peter and Kacey were joined by a group of 20 students on a two week excursion from Ann Arbor to the Great Southwest.

Following a long first day of driving, the trip began its geological stops in the area of Rolla, Missouri examining Pennsylvanian-aged fluvial deltaic sequences of sands shed from the southerly sources of the Abruckle and Ouachita Mountains. Westward through southeast Kansas, we were able to focus on the transitions into shallow marine cyclothem sequences. Phyloid algae bioherms, aragonitic marine cements and bimineralic oolitic units were among the highlights at our variety of stops. Then, off to Palo Duro Canyon and Triassic Dockum Group to work on some of the best fluvial sequences in the region. Moving westward we decended on Carlsbad to explore the classic Permian Reef Complex. What would be better than to have the opportunity to climb 3,000 feet through a perfectly exposed sequence from Shelf to Basin. Although few have ever trekked these trails at temperatures exceeding 103 degrees, we are the "Leaders and the Best". Everyone survived the adventure: all experienced the Permian Reef.

From the heat of west Texas and the long climb to the summit, we all had a rest as we descended into the depths of Carlsbad Caverns. "It was really cool." In contrast to seeing the reef from the trail, we touched the reef from the inside, seeing the same features, but these were ornamented with cave calcite.

One of the best things about working in New Mexico is the food. We all learn to crave the spicy flavors of chiles with frequent dinners at Lucy's in Carlsbad or the El Camino in Alamogordo — Chile Rellenos followed by Huevos Rancheros, the perfect food group.

The Sacramento Mountains remain one of the key areas of study on this trip. In addition to examining the mudmounds of the Mississippian, or the phylloid algae bioherms of the Pennsylvanian, coastal marine cycles present in the Permian Holder Fm. serve as the perfect student exercise to practice their field skills of section measuring and rock description.

The group this year was quite diverse, comprising a few sophomores, a couple of graduate students and a majority of seniors and students completing their final semester at U-M.

How can any trip to this region be considered complete without a visit to White Sands National Monument. This park is the perfect venue for teaching eolian processes and sedimentary bedforms. Blowout, barchan and transverse dunes — avalanche and grain flow deposits—we saw them all and felt the fine gypsum sands between our toes, and in our ears. White Sands is always one of our best localities.

This year's trip was constrained by many factors that we normally do not have to consider — H1N1 outbreaks in Texas and the violent drug war along the border with Mexico. As a result, our typical visits to El Paso and to Big Bend were replaced by more extensive visits to the Davis Mountains, the Caballos Novaculite, and Marathon uplift region. This area always has the potential encounters with wild boar, havolina, as the campfire dies down in the evening and folks begin to drift into sleepfulness.

Students describing and drawing up sections in clastic-carbonate cycles of the Holder Fm. For many, this was their first experience in hands-on field exercises.

No trip is complete without a visit to the Llano Uplift with its array of lower Paleozoic formations -- the Hickory Sandstone, the bright green glauconites of the Lion Mountain Sandstone, and the algal bioherms characteristic of these Cambrian-aged limestones.

This year was our first return to the Gulf Coast since the widespread devastation of this area by hurricanes. We were fortunate to have one of our distinguished alumni, **Egon Weber (PhD '98)**, who now heads a coastal studies program at Texas A&M University in Corpus Christi, provided us with an extensive lecture and field demonstration of the evolution of the Texas coastline. This new knowledge was reinforced through our camping on the barrier of Mustang Island and the late evening swims in the Gulf of Mexico. We could tell we were moving eastward, not only by the scenery, but the progression of food from Mexican to barbecued and smoked meats.

Carrying on the tradition started by Bruce Wilkinson, as the trip turns back toward the Ann Arbor, we always find a way to celebrate the culinary specialties of the region. This year as the caravan passed through Louisiana just north of New Orleans, we had one

The trail was long, the temperature 103, the group unrelenting in their quest to reach the top -- OH! From Basin to Reef to Shelf.....the classic geologic locality.

of the finest Crawfish Boils with its combination of shrimp, potatoes, corn and boudin. This banquet will be hard to match in our future adventures.

Finally after two weeks of travel, we finally arrived safely back in Ann Arbor. For next year's trip, the Grand Canyon, Death Valley and California are on call .

SHELL OIL COMPANY deserves our special thanks for providing the funding that made this trip possible. Such field excursions represent significant opportunities for students and faculty to work together in field settings to share their knowledge and experiences, and importantly, to look at rocks. THANKS SHELL.

Photos: Courtesy of Peter Knoop

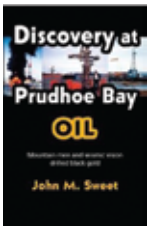
Ian Winklestein, Catlin Rushlow, Becky Povilus and Jessica Zinger sketching out the stratigraphic sequence in the Holder Formation, Permian at Dry Canyon.

This would normally be funny, but Lohmann actually stopped smoking this summer, and "CRUSHED THE SMOKES". We are concerned, however, that he may not be able to lecture as effectively in the field without the aid of the ever-dangling cigarette.

More photos are available at:
http://picasaweb.google.com/knoopwww/2009UMTexasGeologyFieldTripSelected#
http://umgeotexas2009.blogspot.com/

◄ *GeoClub members **Laura Sherman (PhD Candidate)**, **Julia Giddy (BS '10)** and **Lauren Miller (Graduate Student)** teach children about the Earth during the "Solar System Walk". This event, held last April, was organized by the Exhibit Museum. The museum made to-scale models of each planet and set them up from the center of the Diag all of the way to the Rackham building at to-scale distances. Different groups organized tables for each of the planets and GeoClub was asked to run the Earth table. Department graduate and undergraduate students taught the visiting children and their parents about plate tectonics and the history of life on earth using a variety of fossils, models, and home-made props.*

Alumni News



Discovery at Prudhoe Bay, by **John Sweet (BA '48, BS '49, MS '50)**, has been published and is available at bookstores everywhere.

Gene Singer (BS '51) writes about his experiences living in California for 50 years, and his share of earthquakes. When he lived in Los Angeles, the San Fernando and Northridge earthquakes, while locally severe, were just minor shakes at his house on the other side of town. Swimming pool slopping over the coping and minor glassware breakage was all he got from a little rocking and rolling.

Gene then lived in Palm Springs for 10 years, about 5 miles from the main strand of the San Andreas. There, he went through the Palm Springs earthquake of 1986. Eventually, Gene and his wife settled down in Huntington Beach, directly above the Newport-Inglewood fault. On May 17, they were watching a movie when an earthquake hit. There were 5 or 6 very sharp jolts that scared them both, followed by about ten seconds of noticeable rocking and sounds of glassware falling and breaking. The jolts were so severe the thought flashed through Gene's mind that this was not only the strongest quake he had ever felt, but maybe it could be the Big One!

The first USGS report was a M 5.0, soon changed to 4.7, with the epicenter on the Newport-Inglewood fault. There were 4 or 5 aftershocks in the next 48 hours, but Gene didn't feel any of them.

That's Gene's experience as a Californian living in earthquake country!

Bob Blair (MS '60) visited Ann Arbor with his wife, Mary Ann, on Wednesday, October 25. Bob was in the area for the 55th reunion of his high school class in Maumee, Ohio. He is currently Vice President for Exploration with Avanti Mining in Denver, where he is in charge of exploration of the Kitsault molybdenum deposit in northern British Columbia, one of the largest such deposits in the world. Bob has a well earned reputation as one of the most experienced and knowledgeable field-based exploration geologists in the business. According to Bob, his secret for climbing the hills in BC and elsewhere is to work out at least three days a week starting at 5 AM.

A new diorama at the Illinois State Museum portraying Rock Island County in the Pennsylvanian.

Richard Leary (MS '61) spent 35½ years working as the curator of geology at the Illinois State Museum. He undertook research on geology and paleobotany of western Illinois and discovered and named several fossils, that led to a series of proposals for the evolutionary relationships between several groups of fossil plants. Soon after his retirement, the museum renovated the entire first floor natural history exhibit area. One of the major new dioramas is based on Richard's research in Rock Island County, Illinois. It portrays an area as it appeared at the beginning of the Pennsylvanian Period, 310 million years ago. Richard and his wife, **Eleanor Riehl (BS '60 in Zoology)**, have traveled widely, and continue to do so, having camped in all 50 states (all but Alaska in a tent), and visited 55 countries and all seven continents.

David J. Krause (BS '62, PhD '86) writes, "I was sorry to read of Don Eschman's death in Geoscience News. Don was chairman of my dissertation committee at the time of his aneurysm, and my dedication to him of the book that resulted from that work was the least I could do in thanks for his many years of encouragement of my geological efforts. He had a major effect on the course of my life, and I continue to be thankful for his influence."

Bob Vincent (PhD '73) was awarded a U.S. patent for an algorithm that uses LANDSAT TM satellite data to map cyanobacteria blooms in lakes and streams. He and BGSU negotiated an agreement that involved the start-up of a new company called Blue Water Satellite, Inc., with offices in Bowling Green, OH. The new company (BWSI), which has an exclusive license to market and use the BGSU patent, began operations on February 17, 2009, and has already produced its first royalty check to BGSU. BWSI has twice raised venture capital and its sales are increasing, expecting to reach profitability near its 1-year anniversary. BWSI offers monitoring of drinking water reservoirs around the world via satellite and also provides historical

images back to 1982, when the LANDSAT TM sensor was first orbited. Bob Vincent is currently the Chief Technical Officer of BWSI, while still active in research and teaching as a tenured Professor in the Department of Geology at BGSU.

Donna Jurdy (PhD '74) taught a course in June at the Graduate School of the Chinese Academy of Sciences in Beijing. The course, "Exploration of the Solar System" had c. 35 graduate students from all over China. Donna was one of 25 "Visiting Professors" in the College of Earth Sciences. A very interesting experience!

Bill Williams, undergrad 1991-5, finally finished up his degree requirements! Post-college work has mainly been with small software companies, the last eight years with an employment-focused ASP/MSP.

Karen Boven (BS SNRE '95, MS '98) bought her first home, with private vineyard, in July 2009 within the unincorporated town of Penngrove, Sonoma County, California. She continues to support Chevron as a project manager on a variety of projects ranging from the design and construction of a new medium-voltage electrical substation to regulatory compliance for the Richmond Refinery's Long Wharf marine oil terminal in San Francisco Bay. She's looking forward to experimenting with her Cabernet and Zinfandel grapes...results to be released in 2011.

Ruth Blake (PhD '98) was awarded tenure at Yale. At the present time Ruth is on sabbatical at Stanford with the aid of a Stanford Fellowship. Ruth has some exciting ongoing research, including a project on phosphate extracted from Barberton sediments. There are two textural varieties of phosphate in these old rocks, one present as veins with characteristically low $\delta^{18}O$ values, and the other is present in tiny amounts and presumed to have been adsorbed on Fe oxide hydroxide particles. This latter phosphate has the same range of high $\delta^{18}O$ values as similar phosphate forming on the ocean floor today. With this publication Ruth puts another nail in the coffin of those who promote a hot Archean ocean (up to 80°C) and provides "unambiguous" evidence for an active phosphorous cycle operating in that Archean ocean.

Sarah Smalheer (MS '00) reports that in the fall of 2006, as part of a massive lifestyle overhaul, she returned to distance running after a fifteen-year hiatus. Since October 2007 she has run three half marathons and two full marathons, most recently the Cleveland Marathon in May 2009. At the race in Cleveland she qualified to run the Boston Marathon in 2010. Not bad for someone who used to consider the walk from the parking lot to her office building her daily dose of exercise.

Josh Trapani (PhD '03) is currently working for the National Commission on Energy Policy, part of the Bipartisan Policy Center, a D.C. think tank, as the Associate Director for Research for the National Commission on Energy Policy.

Karen Kimm (BS '05) and **Brian Ellis (BS '05)** were married on August 22nd in Kalamazoo. Karen will be starting her PhD work in the Geosciences department at Princeton in the fall, so they will be in New Jersey for 5 more years.

Matt Wasson (MS '05) and his wife Naomi welcomed Abbie Caitlyn Wasson to the world on Wednesday, Oct. 7th, 2009, at 2:56 pm, weighing in at 6 pounds, 9 oz, and 19 inches long.

Jason Barnes (PhD '08) is starting a faculty position in Earth Surface Processes at the University of North Carolina, Chapel Hill, in January 2010 and will finish up his current NSF postdoc the following summer, in Durham UK.

Matt Manon (PhD 08) is now a Postdoctoral Fellow at Syracuse University in New York.

Wenjun Yong (PhD 08) is currently a Postdoctoral Fellow at the University of Western Ontario, in London, Ontario.

Jeff Bartels (BS '09) was commissioned into the U.S. Navy as an Ensign and was selected to be a pilot. He is currently in the beginning of his training and has logged a total of 8.8 flight hours in a Cessna 172 (a very small civilian single prop plane that has less horsepower than a car!). He is in Pensacola, Florida and enjoying the nice warm weather. Unfortunately, there are very few outcrops and the only geology he gets to see are from his old textbooks and news about earthquakes, volcanoes, and other geological events on the TV or internet. After Florida, Jeff will get sent to Texas to complete the second phase of training in Corpus Christi.

Joe Murphy (BS '09) is currently at Fort Benning completing IBOLC (Infantry Basic Officer Course), after which he will be assigned to Fort Drum, NY with the 10th Mountain Division.

In Memoriam

Barbara Barksdale (BS '44) passed away May 16, 2009 at the age of 84. Born in 1923 in Youngstown, Ohio, Barbara graduated with a degree in petroleum geology from the University of Michigan. Preceded in death by her husband, **William Leigh Barksdale (BS '43)**, they enjoyed a wonderful life together, both in Colorado and Arizona. A world traveler, blessed with many circles of good friends, gardening, golf, bridge, and her family were her passion. She lived an exceptional, fulfilled life up until the end. She is survived by her son John (Kathy), daughters Elizabeth and Laura, 4 grandchildren and 5 great-grandchildren.

Catherine Dawson Belknap passed away earlier this summer at the age of 101. Born Catherine Cecilia Dawson in Custer, WI, she moved west with her family at an early age, settling in Washington State. She returned east for college, receiving a degree in geology from the University of Michigan, where she met and later married Ralph L. Belknap, a professor of geology, with whom she had two sons, Charles Lewis and John Edward. Catherine worked in the Geology department until she married, and returned to work at the University of Michigan after her husband's death. In the Ann Arbor community, Catherine initiated the magazine exchange at the public library and was a proponent of recycling long before it was commonplace. She was also a frequent volunteer at Matthaei Botanical Gardens where she made pressed flower cards and gifts. She is survived by her son, John Edward and two grandsons.

K. Jeffrey Bickart (MS '86) of Craftsbury, VT, died of melanoma, three years after the initial diagnosis, at his home on October 17, 2008. He was born in Baltimore, MD, on October 1, 1960, the son of Carol and Theodore A. Bickart. He was also the loving stepson of Frani Bickart. He grew up in Syracuse, NY, where he graduated from William Nottingham High School in 1978. He became a resident of northern Vermont in 1998, when he joined the faculty of Sterling College in Craftsbury Common. Jeff loved both learning and teaching. He earned a B.A. in earth and planetary sciences from Johns Hopkins University (Baltimore) in 1982 and an M.S. in geology from the University of Michigan (Ann Arbor) in 1986. He taught high school biology and Spanish at Hyde School (Bath, ME) from 1987 to 1994, and Spanish and outdoor skills at Hebron Acacemy (Hebron, ME) from 1994 to 1997. At Sterling College since 1998, Jeff taught geology, ecology, ornitholigy, botany, fiber arts, organic crop production and traditional outdoor living skills. In recent years. He gave hands-on workshops at local middle schools on primitive skills. Jeff's intense curiosity and his wide and deep knowledge, as well as his sense of humor, made the subjects he taught come alive to his students. An avid reader, he was also a published poet and essayist. He made numerous articles of clothing from local plant and animal materials, spinning and dyeing his own yarns and weaving, knitting and felting fabrics, as well as tanning hides. He built his own wood and canvas canoe, as well as paddles, snow-shoes, bows, arrows and atlatls. With his family, he created a homestead farm, with extensive vegetable gardens and a large orchard. He had a particularly strong interest in the preservation of heirloom varieties of vegetables and fruits and was for 10 years an active member of Seed Savers Exchange. A competitive long distance runner in high school, college, and later, Jeff continued to enjoy running until his illness prevented it. Jeff is survived by his cherished wife of 14 years, Jennifer (Brown); and their two beloved children, Alexander (age 9) and Laura (age 7) of Craftsbury, as well as his mother, Carol of Syracuse, NY; his father and stepmother, Theodore and Frani, of Golden, CO; his sister, Lauren (David Zhang) of San Jose, CA; his stepsister, Jennifer Cumming of Palo Alto, CA; his parents-in-law, D. Halbe and Jane Brown of South Barre, VT; and many nieces and nephews.

William T. Smith (BS '47, MS '48) passed away on January 11, 2009 at age 85. His passing was in Fort Worth, Texas, his home for many years. Bill was a distinguished alumnus, a founding member of the Geological Sciences Alumni Advisory Board, and a great friend of the Department. In 2005 he made a gift of $2.6M to the Department to endow a faculty position in honor of Professor Henry N. Pollack and to endow the Department's weekly visiting lecture series, now called the William T. Smith Lectures in Geological Sciences.

Bill, a native of Kalamazoo, was born October 2, 1923. He enrolled at U-M in the 1940s, but his studies were interrupted for military service in World War II. After the war he returned to Ann Arbor to complete his undergraduate and graduate degrees. His Masters thesis, completed in 1948, was titled *Geology of Part of the Tendoy Medicine Lodge Area, Beaverhead County, Montana*. It involved field mapping in the rugged terrain along the continental divide in the far southwest of Montana. He was also a graduate of the Harvard Business School of Advanced Management Program.

After completing his studies at U-M, Bill joined Stanolind Oil & Gas Company, the exploration and production subsidiary of Standard Oil of Indiana (later known as Amoco). In 27 years at Stanolind he advanced through a number of exploration and management positions to become the Executive Vice President of Amoco Production Company.

In 1975 Bill joined Champlin Petroleum, a subsidiary of the Union Pacific Corporation, and was elected Chairman of Champlin in 1982. He served on Champlin's Board of Directors until 1987. At that time he was also Vice Chairman and Director of Union Pacific. During this time with Union Pacific, Bill was instrumental in securing a substantial grant for the Department from the Union Pacific Foundation. Following Bill's retirement from Champlin in 1987, his first "retirement", he started his own independent enterprise, appropriately called Wolverine Exploration Company, which he led as Chairman and Chief Executive Officer until his second retirement in early 1992.

Bill served as Chairman of the Natural Gas Supply Association, whose members account for almost 90 percent of all domestic natural gas supplies. He was also the National Chairman of the 8,500 member Mid-Continent Oil & Gas Association, and a Director of the American Petroleum Institute (API). At the API he served as a member of the Committee on Public Issues, as chairman of its Major Issues Task Force on Land Use, and on its Budget Committee. Bill also has served as a member of the Texas Energy Advisory Council and was a member of the All-American Wildcatters Association. He served on the National Petroleum Council, and as a Director of the Texas Research League. He was also a Director of Tandy Corporation and of First Republic Bank Corporation.

Bill's formal ties to U-M's Geological Sciences Department were renewed in 1982 when he was asked to serve on the Department's first Alumni Advisory Board. His participation on the Board in its early formative years, from 1982-88, set a firm foundation for the later activities of this Board in guiding the Department up to the present day. Bill continued to play an important advisory role in the years subsequent to his time on the Board, and always welcomed students and faculty from the Department who were passing through Fort Worth.

Stewart Raynor Wallace (MS '48, PhD '53) died on March 12, 2009 at the Frasier Meadows Health Care Center in Boulder, CO, at the age of 89. He was born in Freeport, NY, was educated in the public schools there, and later graduated from Dartmouth College. He served in the U. S. Army in Britain, France and the Yukon during World War II. He then returned to graduate school at the University of Michigan, and was later employed by the U. S. Geological Survey.

From 1955 to 1969 Stewart led the geology department of the Climax Molybdenum Company. Achievements included clarifying the geology of the Climax Mine and discovering two new ore bodies. In 1969 he became the President of Mine Finders, Inc., a mineral exploration company, and in 1976 he became in independent consultant working for mining corporations across the globe.

Stewart was a Distinguished Member of the Society of Mining Engineers, and President of the Society of Economic Geologists from 1992-1993. He was a recipient of the Daniel C. Jackling Award for discovery of the Henderson ore body. In 2001 he was inducted into the National Mining Hall of Fame.

Corporate Connections

2009 Interns

BP
Devapriya Chattopadhyay (PhD '09)

Shell
G. Alex Janevski (PhD. Cand.)
Jessica Malone (MS '09)
Aaron Wood (PhD '09)

HighMount
Jessica Malone (MS '09)

Recent Hires

ExxonMobil
Franek Hasiuk (PhD '08)

Shell
Matt Densmore (PhD '08)
James Hnat (PhD '08)
Sarah Rilling (PhD '09)

It's been a busy fall in the Department for alumni now employed in the petroleum industry. Both Shell and BP held on-campus interviews and recruiting events. **Brett Peppard (MS '02)**, **Steve Ownby (PhD '05)** and **Katie Keller (PhD '06)** led the Shell recruiting team, which included informational sessions for both graduate and undergraduate students, and seminars on careers in the petroleum industry by **Steve Glass (MS '78)**, recently retired from Shell, and Sustainable Fuels by Jose Brave, Chief Scientist for Shell Exploration and Production.

In early October, the BP Campus Team for the University of Michigan presented the 2009-2010 scholarship and programs check of $250,000 to university officials, including **Sam Mukasa**, at a reception in Ann Arbor, Michigan. The University of Michigan Campus Team includes **Adam Collins**

Sam Mukasa *helps accept a check from BP to the University of Michigan at a dinner held at the Gandy Dancer Restaurant in October.*

(MS '02)(Geosciences Lead), who was joined by **Andrea Cicero (MS '00)** and **Bob Klein (MS '93, PhD '96)** for on-campus recruiting. Many of the students that were invited to the reception participated in BP's interview process for Full Time, Intern, and Co-Op opportunities for summer 2010.

Gifts from both of these corporations have been instrumental in continuing the Department's history of guaranteed graduate student support, financial aid to undergraduate students to attend Camp Davis, and regional and national field trips to expose our students to world-class geology. Due to generous endowment support and current gifts we were able to award tuition and stipend fellowships to 9 of our 18 incoming graduate students for Fall term this year. These included the Pollack fellowship and the Slawson fellowship, as well as graduate fellowships funded by Shell, BP, and Chevron.

Getting Ready for Game Time: *Bob Klein,* ***Tracy Frank (MS '93, PhD '95)*** *, Adam Collins, Nadalia Henry, and Andrea Cicero.*

Rod Who? Chris Palenik (MS '01, PhD '04) *is currently working at Microtrace LLC.*

Recent Doctoral Dissertations

Devapriya Chattopadhyay	Predation in Mollusks: A Multi-taxon Approach Using Neontological and Paleontological Data
Elizabeth Ferriss	Corrosion and Substitution Processes of Actinide Oxides and Orthosilicates
James Hnat	Kinematic and Temporal Evolution of the Southern Appalachian Foreland Fold-thrust Belt: Constraints from Structural, Magnetic, and Radiometric Analyses
Sarah Rilling	Geochronological and Geochemical Assessment of Cenozoic Volcanism from the Terror Rift Region of the West Antarctic Rift System
Adam Rountrey	Life Histories of Juvenile Woolly Mammoths: Stable Isotope and Elemental Analyses of Tooth Dentin
Lindsey Waddell	Cenozoic High Latitude Paleooceanography: New Perspectives from the Arctic and Subantarctic Pacific
Aaron Wood	Paleobiological Studies on the Early Eocene Equid Hyracotherium (Perissodactyla, Mammalia) from the Clarks Fork and Northwestern Bighorn Basins, Wyoming

Recent Masters Theses

Susan Alford	Microbial Sulfate Reduction During Low-Temperature Alteration of the Lower Oceanic Crust: Insights from ODP Hole 735B
Darius Dixon	Thermodynamic Mixing Properties of $Gd_2Ti_2O_7$-$Gd_2Zr_2O_7$ Pyrochlore Using First-Principles and Monte-Carlo Simulation
Jessica Malone	New Insights into the Origin and Evolution of Lake Vida, McMurdo Dry Valleys, Antarctica: A Noble Gas Study in Ice and Brines

Laura Sherman (PhD candidate) *setting up tripods to collect precipitation for research on mercury deposition in central Florida.*

Alison Duvall (PhD candidate) *and* ***Nora Lewandowski (Graduate Student)*** *take a tea break while working on the Tibetan Plateau.*

Gretchen Gehrke (PhD candidate) *slicing sediment core on a cruise in the Baltic Sea.*

Recent Bachelors Degree Graduates

Concentration Majors

David Azzolini	*Geological Sciences*
Jeffrey Bartels Jr	*Geological Sciences*
Matthew Burdey	*Earth Sciences*
Sarah Crane	*Environmental Geosciences*
Kristen Davis	*Earth Sciences*
William Frank	*Earth System Science*
Paul Hojnacki	*Environmental Geosciences*
Andrew Little	*Geological Sciences*
Steven Louis-Prescott	*Environmental Geosciences*
Omari McCord	*Earth Sciences*
Brian Mulvihill	*Geological Sciences*
Joseph Murphy	*Geological Sciences*
Rudy Novak	*Earth Sciences*
Suzanne Panetta	*Earth Sciences*
Mary Peterson	*Geological Sciences*
Rebecca Povilus	*Earth Sciences*
Joseph Ramirez	*Earth Sciences*
Rachel Sortor	*Environmental Geosciences*
Arron Stroud	*Earth Sciences*
Krista Tenney	*Environmental Geosciences*
Christopher Trepky	*Earth Sciences*
Ariel Wheelock	*Earth Sciences*
William Williams	*Earth Sciences*
Jessica Zinger	*Earth Sciences*

Concentration Minors

Samina Bhumbra	*Minor -Paleontology*
Sarah Cook	*Minor -Earth Sciences*
Jessica Darga	*Minor -Oceanography*
Brian Downing	*Minor -Earth Sciences*
Adam Foley	*Minor -Environment Geology*
Max Heitner	*Minor -Earth Sciences*
Whitney Johnson	*Minor -Oceanography*
Lauren Kemink	*Minor -Oceanography*
Darshana Shapiro	*Minor -Paleontology*
Sean Southard	*Minor -Earth Sciences*

Chair: Samuel B. Mukasa

Faculty: T. Baumiller, U. Becker, J. D. Blum, R. Burnham, M. A. Carroll, M. C. Castro, M. K. Clark, G. Dick, R. C. Ewing, D. C. Fisher, P. D. Gingerich, I. Hendy, E. Hetland, G. Keeler, S. E. Kesler, R. A. Lange, J. Li, K. C. Lohmann, D. Lund, S. B. Mukasa, N. A. Niemi, R. M. Owen, C. Poulsen, J. Ritsema, L. J. Ruff, N. Sheldon, B. A. van der Pluijm, R. Van der Voo, P. van Keken, L. M. Walter, J. Wilson, Y. Zhang.

Visiting Faculty, Research Scientists and Post-doctoral Scholars: J. C. Alt, C. Badgley, A. Bengston, J. Demers, T. Ehlers, G. Feng, J. Finarelli, J. D. Gleason, C. M. Hall, F. Hankard, S. Hoffman, S. Huang, M. Hren, M. Lang, C. Lithgow-Bertollini, A. Roundtrey, A. Schleicher, S. Smith, C. Verdel, L. Wadddell, J. W. Wang, B. Yanites, A. Wood, I. Zalmout, F. Zhang, J. Zhang.

Lecturers and Adjunct Faculty: M. Arnaboldi, J. W. Geissman, G. Gunnell, W. M. McElhinny, W. Sanders, W. B. Simmons, K. Webber.

Emeritus Faculty: C. B. Beck, P. L. Cloke, E. J. Essene, W. R. Farrand, W. C. Kelly, P. A. Meyers, T. C. Moore, J. R. O'Neil, S. I. Outcalt, D. R. Peacor, H. N. Pollack, D. K. Rea, G. R. Smith, J. C. G. Walker, B. H. Wilkinson.

Support Staff: A. Andronikov, B. Apsitis, D. Austin, D. Dault, C. Henderson, J. Hinchcliff, A. Hudon, T. Huston, M. Johnson, N. Kingsbury, C. Lambert, J. Magiera, C. Malvica, T. Merline, M. Messina, B. Paulsen, J. Taylor, W. Wilcox, S. Wilkin, L. Wingate, Z. Xu.

Alumni Advisory Board: John Geissman (Chair), Aboud Afifi, Larry Davis, Steve Glass, Steve Henry, George Ireland, Bob Klein, Chad McCabe, Eva Moldovanyi, Cary Mrozowski, Chris Palenik, Dexter Perkins, Scott Tinker, William Zempolich.

Alumni Capital Campaign Committee: John Greene, Larry Davis and Steve Henry (Co-Chairs), John Geissman, Steve Glass, George Ireland, Curt Lundy, Chad McCabe, Fred Metzger, Cary Mrozowski, Chris Palenik, Ed Poindexter, Scott Tinker, and William Zempolich.

The Regents of the University: Julia D. Darlow, Ann Arbor; Laurence B. Deitch, Bingham Farms; Denise Ilitch, Birmingham; Olivia P. Maynard, Goodrich; Andrea F. Newman, Ann Arbor; Andrew C. Richner, Grosse Pointe Park; S. Martin Taylor, Grosse Pointe Farms; Katherine E. White, Ann Arbor; Mary Sue Coleman (ex officio).

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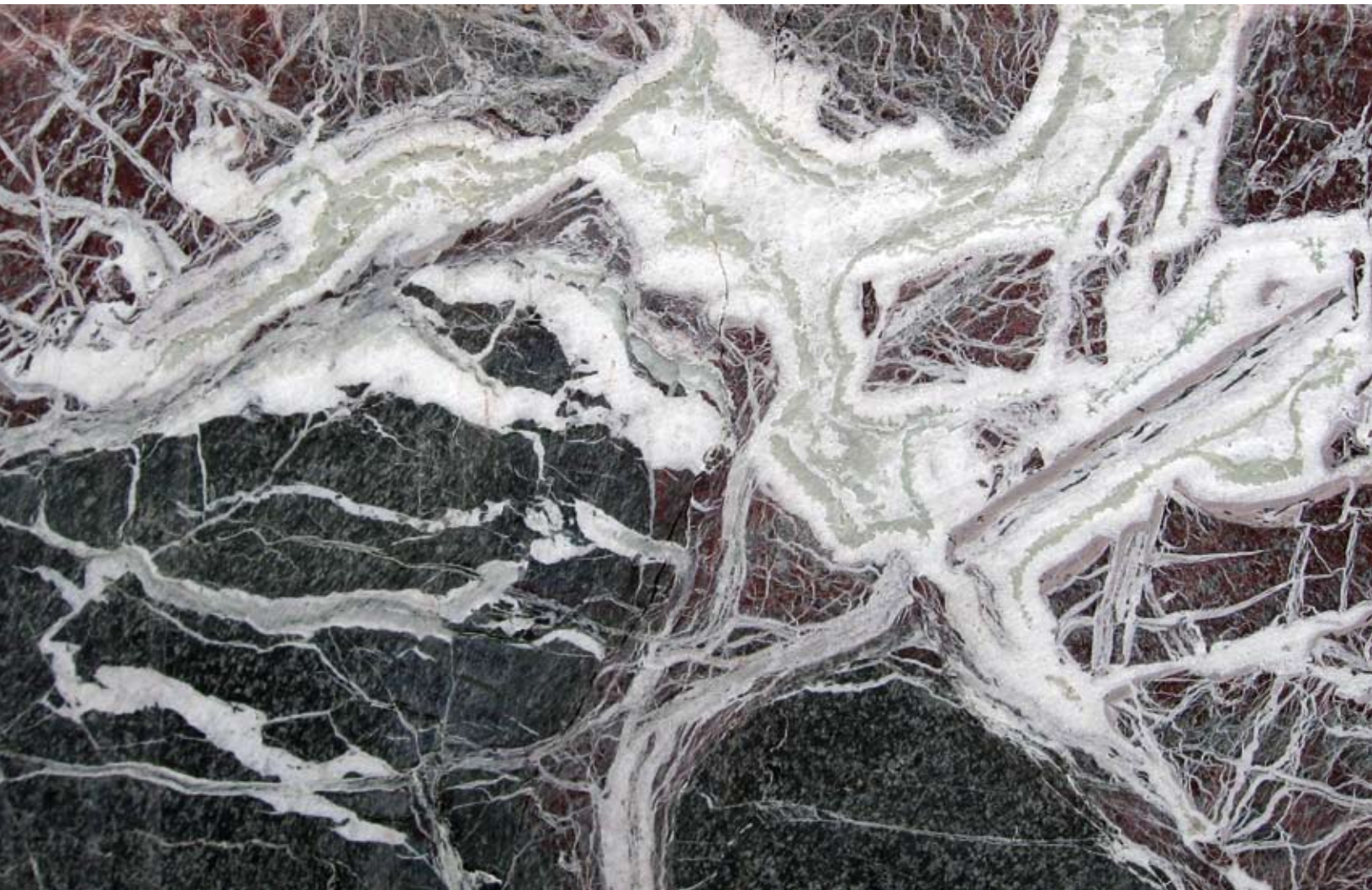

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