

THE EPOCH

Summer/Fall 2012 No.42



Letter from the Chair

Dr. Richelle Allen-King, Professor and Chair



Dr. Allen-King at Lake O'Hara in Yoho National Park, British Columbia, Canada.

Greetings Alumni and Friends!

I hope that 2012 has treated you well so far. I have completed my third year as Department Chair after taking a year-long temporary position as a Program Officer with the National Science Foundation, and am glad to be back home at UB! I would like to take this time to thank you all for your ongoing dedication to the department of Geology, and to our mission.

Our students have received numerous awards last year to support in support of their ongoing research and recognition of their accomplishments. The following are only a few of many examples. Both **Lauren Fortson** and **Kyle Jones** received Bernold M. Hanson Memorial Environmental Grants from the American Association of Petroleum Geologists' Grants-in-Aid Program, and Kyle also received a Fellowship from the Society of Sedimentary Geology. **Zackary Munger** was named the 2012 Northeastern Section Outstanding Poster Award Winner by the Geological Society of America. Our newest

scholarship fund, the Duane Champion Summer Travel Award, provided awards to **Laura Best**, **Simon Pendleton**, and **Dawn Ruth** for their fieldwork and summer research (read more on page 16). Graduating senior **Rachel Kolenko** was awarded this year's College of Arts & Sciences Outstanding Senior Award in the Geology Department, based on her academic excellence, research participation, and other academic achievements. **Justin Miceli** was the recipient of a CURCA Undergraduate Research Grant. For more information on student awards, please see page 12. Congratulations to all of our students!

In this edition of the EPOCH, you will learn about the progress of our **Natural Hazards Field Station**, headed by **Dr. Greg Valentine** in his role as Director of the Center for Geohazards Studies (page 8). The Field Station is one of sixteen projects that have been funded through the University's competitive 3E program, designed to invest in collaborative initiatives to advance UB's stature and student experience.

The 3Es - excellence, engagement, and efficiency - serve as the guiding principles of President Satish Tripathi's vision for UB.

The Geology Department has had a successful and productive year, thanks in part to the support of our alumni and friends. We are grateful for all of your kindness and generosity, and we hope you enjoy reading this year's issue of the EPOCH!

Dr. Richelle Allen-King
Professor and Chair

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Remember When Page

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Eliza Calder Promoted

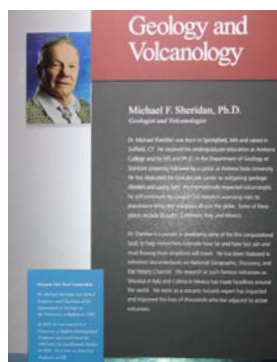
The Department is pleased to announce that **Dr. Eliza Calder** was promoted to Associate Professor with tenure effective for the Fall 2012 semester. Dr. Calder received her PhD in Geology from the University of Bristol in 1999, and is a member of the Advisory Board for the Center for Geohazards Studies housed here at UB. Her research focuses on the processes associated with explosive volcanism including

the generation and emplacement of volcanic plumes and pyroclastic density currents, through the application of multi-disciplinary approaches and techniques. Dr. Calder teaches upper-level courses in Volcanology, and Advanced Volcanology, and is currently lead PI on the International Geological Master in Volcanology and Geotechniques (INVOGE) grant, supported through the U.S. Department of Education.

She is also currently working on two National Science Foundation grants, entitled Lava Dome Collapses: Their Mechanisms and Short-Term Forecasting, and Statistical and Computational Models and Methods for Extracting Knowledge from Massive Disparate Data for Quantifying Uncertain Hazards. Congratulations Dr. Calder!

Dr. Michael Sheridan Honored

Dr. Michael Sheridan, Professor Emeritus, was honored as a recipient of the Hauptman-Woodward Medical Research Institute's Pioneers of Science Award, which honors individuals from Western NY who have contributed significantly to their fields. You might spy Dr. Sheridan's award recognition while strolling through the Buffalo airport. Congratulations, Dr. Sheridan!



Dr. Tracy Gregg Elected to GSA Fellowship

Dr. Gregg was elected to a GSA Fellowship on April 28th, 2012. Fellowship is an honor that is bestowed on the best of the geological sciences profession once per year at the GSA Spring Council meeting. GSA members are elected to fellowship in recognition of distinguished contributions to the geosciences, and

nominations may be made only by a Fellow of the Society. In addition to the minimum of eight years of professional experience in Geology or related fields, the nominee must have significant contributions to science in several of the following areas: publication of the results of geologic research, applied research, teaching

or training of geologists, administration of geological programs, public awareness in geology, professional organization leadership, or editorial responsibilities. Dr. Gregg and the other newly elected Fellows will be recognized at the 2012 GSA Annual Meeting in Charlotte, NC on Monday, November 5th, 2012.

Every Day is an Adventure - 2012 Field Camp

Travis A. Nelson, Field Camp Operations Coordinator, Geologist, Grad/Dept. Support Tech.

2012 Field Camp Cast and Crew:

Dr. Greg Valentine and **Dr. Marcus Bursik** – Summer Coon Mountain map site.

Dr. Jason Briner and **Dr. Marcus Bursik** – Davis Canyon map site.

Dr. Chuck Mitchell and **Dr. Marcus Bursik** – Rainbow Valley Ranch map site.

Dr. Marcus Bursik - Q Creek Ranch map site.

Our fantastic group of students this year consisted of 16 gals and 22 guys: 15 students from UB, 3 from University of Pittsburgh, and 5 from Edinboro University. We also had 1 each from the following schools: Appalachian

State University, Bloomsburg University of Pennsylvania, Buffalo State, Cedarville University, Macalester College, Montclair State University, Murray State University, Rutgers University, SUNY Binghamton, SUNY at Potsdam, Syracuse University, University of Northern Iowa, and University of Wisconsin at



Travis and Marcus

Milwaukee. Our wonderful teaching assistants this year were: **Michelle Gilmore** (3rd yr), **Solene Pouget** (1st yr), **Simon Pendleton** (1st yr) and our incredible cooks: **Phil Stokes** (10th yr), **Anna Hrywnak** (3rd yr) and **Matt Wendt** (2nd yr).

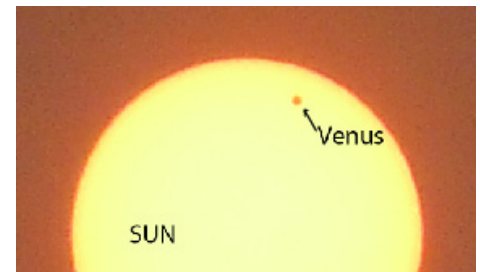
Thanks to Ron Ufford and family for another terrific barbecue at the Rainbow Valley Ranch.

We had a really great field camp this year. Every day seemed to have its own uniqueness and surprises. Early in the camp we had a run-in with a rattlesnake - too close of a run-in. If you get two puncture holes in your pant leg, yup, you're too close! We were also treated to a rare celestial event, the transit of Venus

across the face of the Sun. Very cool to witness and some great pictures! Now we just need to wait 105 years for it to happen again. Cooke truck 3.0 came on the scene after a shattered rear axle in Davis canyon. Yea, that was fun, and it happened to be a holiday....again. But just a few days later our caravan was at full strength. Nice work to all!!! We also crushed our record for the most water purchased from the Gearheads outdoor store in Moab. We also crushed and took back our water record at Gearheads outdoor store in Moab. UB field camp made history that day..... yet again... and this new record should last forever. For more info, check out Gearheads on Facebook. The "Dino wall" finally opened this year after 5 years of renovations at Dinosaur National



Split Mountain Campsite



Venus Transect

Monument. It's a site to see, them bones... them bones....them... crazy bones. OK, now toss in a dust storm, amazing nightly jam sessions (Thanks Phil!!!) and not one, but two Hollywood movies being produced near camp (Will Smith/Johnny Depp), great geology, great students, great faculty, great staff....WOW!

Good times, many thanks for this year!
See you on the trails!

Please visit:

<http://www.geology.buffalo.edu/fieldwork/fieldCamp.shtml>

for more information, highlights and pictures.



Brian MacDowell, Simon Pendleton, and Nicholas Fiesler.



The Group at Goose Neck

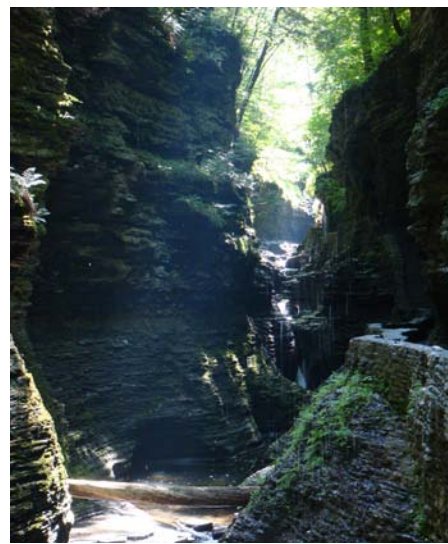
Advanced Field Camp

Dr. Robert Jacobi

Dr. Jacobi again taught the joint AAPG/UB field short course entitled “Northern Appalachian Basin Faults, Fractures and Tectonics and Their Effects on the Utica, Genesee, and Marcellus Black Shales” in June, 2012. The course headquarters was at the 4-star Harbor Hotel at Watkins Glen, NY. The course continued the successful format of the previous years with lectures in the morning, followed by field work in the afternoon that illustrated the elements of the morning lecture. In response to requests for a review of Appalachian plate tectonics, Dr. Jacobi added a section that put the faulting history of the Appalachian Basin in the context of the plate tectonic history of the Appalachian Orogen, with illustrations of the rocks in the orogen that were the building blocks for the plate tectonic theories. The balance of the course remained the same—the course looked at fractures and faults in the Utica, Genesee and Marcellus black shales—really great. The unofficial TA was **Anna Hrywnak**, who

is studying fractures in Utica cores as part of Jacobi’s NYSERDA/DOE study for CO₂ sequestration in black shales. UB geology students who attended the course included undergrads Nicole Fenton, Matthew McClellan, Michael Polaacco, and Kazi Saif; grad students included: Laura Best, Jeffrey Folger, Nicholle Griffith, Kevin Kersten, Timothy O’Brien and Patrick Staub. The professional registrants worked at such corporations as Saudi Aramco, Petrobras Colombia, Talisman, Weatherford, Environmental Resources Management, and independent consultants, and came from as far away as Dhahran and Bogota. The weather, fractures, faults, restaurants and wineries were all fine yet again. Early in the course, the professionals (including Dr. J) each drew a student’s name out of a hat and mentored that student during and after a blow-out dinner—it really did seem to better integrate the students with the professionals—giving the students a chance to hear lots of “war stories”. Dr. Jacobi

will be offering a one day course on faults and fractures in the northern Appalachian Basin at the International AAPG annual meeting to be held in Pittsburgh in May 2013.



Advanced Field Camp - Watkins Glen



Advanced Field Camp - The Class

Paleoclimate Lab Update

Dr. Jason Briner

The Paleoclimate Lab proceeded on course without me this past year while I was on sabbatical leave. I was in awe of my students as they stayed the course during my absence. Following a second field season in the Brooks Range, **Mike Badding** spent the year dissolving quartz for cosmogenic ^{10}Be exposure dating. His productivity in the lab led to an impressive dataset, which Mike wrote up as part of his MS thesis, defended in April; Mike has recently accepted a job in Chicago. Mike wasn't the only student to finish; **Nicolás Young**, following six years with us in UB Geology (MS, 2008, PhD 2012), successfully defended his PhD in April. As I stated during his defense, if the currency of a PhD student is publications, then he'd be rich! Nicolás' dissertation was composed of five manuscript chapters, three of which are published, one is in review, and one is soon-to-be submitted; this doesn't count an additional paper in Geology unrelated to his dissertation. Nicolás' work profoundly moved forward our knowledge of

Greenland and Laurentide ice sheet change during the Holocene (in my biased opinion...); he has accepted a Post-Doc Fellowship at Lamont-Doherty Earth Observatory that will start in September, 2012. **Sam Kelley**, 2nd year PhD student, completed his third field season in western Greenland last summer, 2012. Sam's first dissertation manuscript was recently submitted and is currently under review. **Simon Pendleton**, who just completed the first year of his MS degree, joined me in the Brooks Range this past summer. Simon is working on Holocene glaciation of the Brooks Range, and was awarded a National Park Service grant to study glaciers in the spectacular Arrigetch Peaks area of Gates of the Arctic National Park. Undergraduates **Sarah Lavin** and **Stefan Truex** dominated as lab technicians! Both graduated this past year; Sarah is joining the graduate program at University of Pittsburgh and Stefan is looking for a consulting or oil industry job. Personally and professionally, I had a great sabbatical year. I spent August-November at

the University of Bergen, Norway, following a couple weeks of fieldwork in southern Norway with Jan Mangerud and John-Inge Svendsen studying the history of the southern Fennoscandian Ice Sheet. I'll never forget those months in Norway, and I look forward to seeing those fjords again! Also, this past year, I had extended stays at the University Center of Svalbard, Brown University, the University of Colorado, and Lamont-Doherty Earth Observatory at Columbia University. The visits with colleagues - both established and new - were priceless, and I'm optimistic that some at least will lead to future collaborations. As for now, following this past summer's fieldwork in Alaska and Greenland, I am excited to be back in Buffalo to work more closely with graduate students and to other good times in the UB Department of Geology.

El Salvador Project Update

By Jorge Bajo, PhD Candidate

A group of UB and Buffalo State College faculty and students appeared on the Periodico Grafico of El Salvador this past March, while accompanying members of the Direccion General del Observatorio Ambiental during their monitoring of water quality and control of the San Salvador region (photo below). This trip was part of an ongoing project led by Research Assistant Professor **Dr. Bettina Martinez-Hackert**, and PhD candidate **Jorge V. Bajo**, funded by the Pan-American Institute of Geography and History (PAIGH) titled "Creating Pyroclastic Density Currents Hazard Map for the Santa Ana Volcano in El Salvador". This project is being done in collaboration with the Direccion General del Observatorio Ambiental (DGOA), the former Servicio Nacional de Estudios Territoriales (SNET) of El Salvador.



From left to right: Dr. Marcus Bursik, Jorge V. Bajo, Solene Pouget, and Mark Tate (Buffalo State).

Lava Lab Update

Dr. Tracy Gregg

In a new record, 4 M.S. theses have been successfully defended by members of the Lava Lab this year! These investigations covered the inner solar system, including research on the Moon, Mars, Venus, and Earth.

M.S. student **Diana Miller** defended her research into the characteristics of, and differences between, shield fields and shield plains on Venus. Venus has a geologically young surface (less than 1000 impact craters on the entire planet gives a global average surface age of <1 billion years). A debate rages over whether Venus was resurfaced catastrophically 1 Ga ago ("catastrophic resurfacing"), or whether it has been resurfaced in bits and pieces over geologic time ("equilibrium resurfacing"). Ms. Miller's investigations strongly support the equilibrium resurfacing hypothesis, making Venus geologically more similar to Mars than to Earth.

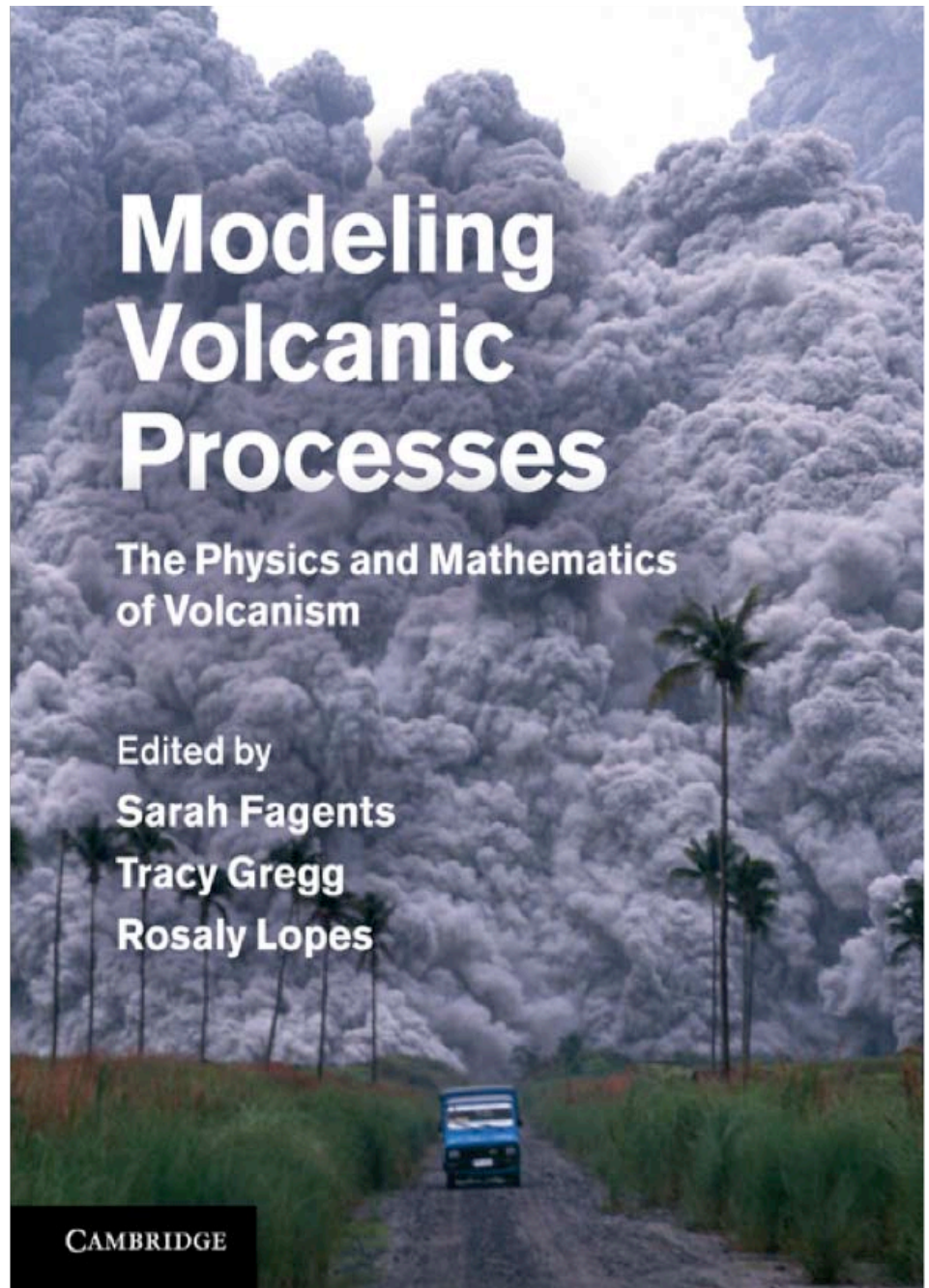
Mr. Mickaël Smolen participated in an international exchange program called "International Geological Masters in Volcanology and Geotechniques (INVOGE)" and came to the Lava Lab to complete the 2nd year of his M.S. studies, after completing his first year at the University of Blaise Pascal, France and a summer at the University of Milan Bicocca in Italy. He examined the formation and evolution of pit-crater chains on Mars through a combination of laboratory simulations and structural mapping.

Lunar sinuous rilles were **Ms. Carolyn Robert's** focus for her M.S. research. Using newly available data from the Lunar Reconnaissance Orbiter, along with Lunar Orbiter data, she carefully examined the morphologies of rilles within Oceanus Procellarum to test various hypotheses for their formation. Scientists continue to debate the relative roles of erosion and construction in the formation of these

lunar volcanic features. The results of Ms. Robert's research suggest that lunar rilles begin as constructional features and evolve into erosional features during the course of the eruption.

Mr. Andrew Rankin looked at potential

volcanic hazards that might be inflicted by future eruptions of Sabancaya volcano, Peru, for his M.S. thesis. Sabancaya volcano last erupted from 1990-1998. Mr. Rankin used data collected from this eruption, combined with computational modeling and remote



The Physics and Mathematics of Volcanism, published by Cambridge University Press

sensing data to constrain possible effects of larger eruptions in the future.

Paleo Lava-Labber, **Mr. Daniel Krysak** (M.S. 2011) was hired by Malin Space Science Systems in San Diego, CA. This prestigious company controls cameras that are currently orbiting Mars (the Context Camera and the Mars Color Imager on board the Mars Reconnaissance Orbiter) and running around its surface (mast cameras, hand lens imager, and

the Mars Descent Imager on board the newly landed Mars Science Lander Curiosity). Way to go, Danny!

Finally, **Dr. Tracy K.P. Gregg** was elected to be a Fellow of the Geological Society of America. In addition, she worked diligently with co-authors **Dr. Sarah Fagents** (University of Hawaii) and **Dr. Rosaly Lopes** (Jet Propulsion Lab) in the creation of a new volcanology textbook called

Modeling Volcanic Processes: The Physics and Mathematics of Volcanism, published by Cambridge University Press. She also helped to organize a conference in Anchorage, Alaska called “Volcano-Ice Interactions on Earth & Other Planets Conference III” under the auspices of the IAVCEI Volcano-Ice Commission (http://volcanoes.dickinson.edu/iavcei_iacs_viic/index.html).

BURR Labs Update

Dr. Howard Lasker & Dr. Mary Alice Coffroth



The Burr Team

Greetings from the **BURR** labs!

What is BURR, you may be wondering? It is the acronym for **Buffalo Undersea Reef Research**. About 20 years ago, perhaps longer (but we won't admit it), we decided that we needed a moniker for our labs and started brainstorming with our grad students. Being winter at the time, first came BURR: the acronym, then the name Buffalo Undersea Reef Research, and of course that was followed by BURR: the t-shirt. Aside from our website the name has no official blessing, but we can report that the t-shirts have been seen around the world from Australia to East Aurora.

More recently both of us, along with **Shelby McIlroy**, one of Mary Alices's grad students in the EEB program, presented papers at the 12th International Coral Reef Symposium in Cairns, Australia this year. The meeting is held at 4-year intervals and brings together a very large proportion of the world's coral reef researchers. This year's meeting was attended by over 2,000 scientists including a small, but enthusiastic group of UB alumni. Both of the BURR labs have been busy this past year. Just as the copy was closing on last year's issue of *The EPOCH*, we were both in the Bahamas

at the Gerace Research Centre running a workshop on the Ecology and Geology of Coral Reef Environments. Fifteen UB students spent 2 weeks on San Salvador surveying habitat sites ranging from a still beautiful Caribbean foreereef, to a 100,000 year-old fossil reef. There were also trips into the mangroves and grass beds - and since this is a geology audience, we should mention the hypersaline lakes with actively growing stromatolites. The workshop is associated with a course, but the College of Arts and Sciences runs it as a summer workshop open to non-students as well. We will not be offering it again for a couple of years, but keep your ears open for future offerings if you (or your college-age children) are interested in a salty field camp experience.

Our respective research programs also continue apace. Mary Alice and her students continue work on the early development of the symbiosis between algae and corals. For those of you unfamiliar with her work, the vast majority of reef corals harbor microscopic algal symbionts, which provide the coral with much of their nutrition. That relationship has powered calcification and the construction of reefs from at least the Mesozoic age. Coral bleaching - a topic that has deservedly received a lot of attention - is the loss of those algae. Bleaching often, but not always, leads to the death of the coral. Mary Alice's lab has been finding that

corals are actually quite picky in which algae they host. In particular, many species start off with a wide variety of the possible algal symbionts, but then winnow that selection down to one or just a few types. Whether or not corals can change their symbionts is an important question as reefs get hotter and hotter, and; understanding the process by which the host picks its algae (or vice versa) is crucial to knowing whether reefs are likely to adjust to the environmental changes.

Howard and his students continue working on Caribbean gorgonians in the Bahamas, focusing on the processes controlling recruitment, the arrival of larvae to reefs, and their success in establishing themselves. A lack of recruitment has been as much a part of the problem on reefs as the death of large colonies. Work on gorgonians is showing how recruitment on different reefs and by species varies in sensitivity to declines in the number of adult colonies on those reefs. Not too surprisingly, healthy reefs with large

adult populations are more capable of surviving big population fluctuations than reefs that are already degraded. We cannot stop events like hurricanes, and in the short run cannot prevent coral bleaching, but reducing overfishing, pollution, and sedimentation can go a long way to helping reefs.

Hydrogeology Research Group

Dr. Christopher Lowry



Things are really starting to flow in the Hydrogeology research group. We have had a very busy and exciting year with new faces coming into the group and old faces leaving for new adventures. Both on the research and teaching front we are expanding to new field sites and bursting at the seams in our classes.

In August of 2011 we had three new members join our research group to start M.S. degrees. All three have been working hard this year and doing a great job. **Ethan Mamer** came to us from Wisconsin and is working on a modeling and laboratory study quantifying groundwater

discharge to stream. Ethan has developed a coupled groundwater flow and heat transport model of a streambed and is now building a large physical model to simulate groundwater discharge to streams. **Katie Feiner** came to us from New York on the eastern side of the state and is investigating the impacts of beaver dams on regional groundwater flow using a groundwater flow model. In the last year Katie had a bit of a change of plans as a family of beavers came and flooded her field site, but she made modifications resulting in a really interesting data set. Katie received funding for a portion of her fieldwork through the Mark



Diamond research fund. **Laura Best** also comes to us from New York and is working on a water supply issue in the eastern part of New York. Laura's work focuses on evaluating the potential impact of extracting large volumes of water from the surficial aquifers as a result of natural gas development. As part of Laura's work she received both funding from the Mark Diamond Research Fund and the Champion Summer Travel award.

The other half of our group, who have now been with me for two years, have dropped from three students to two. **Jeremy Crowley**

has successfully defended his M.S. and has accepted a Hydrogeology position at the Montana Bureau of Mines and Geology in Butte, MT. Jeremy has done a wonderful job here at UB and we will really miss his leadership in the group. **Nicholle Griffith** is now starting her final semester of classes and is scheduled to finish in December. Nicholle has accepted a position at a local consulting firm here in Buffalo. **Jonathan Malzone** has

continued to make great progress on his PhD work investigating physical and geochemical changes at the interface between streams and aquifers (hyporheic zone). Jonathan gave an oral presentation of his work at the upcoming International Association of Hydrogeologists meeting in Niagara Falls, Canada this past September.

It has truly been an exciting year here in the

hydrogeology lab and things are going well. For any of the Alumni who are passing through Buffalo on your travels please come by and see us. We would love to show you what we are working on and develop new connections between current and past UB grads.

Man-Made Maars at the new Geohazards Field Station

Dr. Greg Valentine

When most people hear the word “volcano” they imagine a high, picturesque, Fuji-like mountain with a small crater at its top. However there is a type of volcano that is not a mountain, but just a crater. These holes in the ground are called maars, a German word derived from the Latin word for sea (*mare*). In Germany, *maars* are usually filled with water to make nice round lakes, or little seas – hence the name (see Figure 1).

Maars form when rising magma, with a temperature of about 1000 °C (1800 °F), interacts rapidly with groundwater, generating powerful steam explosions. Maar volcanoes can be active for many days to several years, during which there are many explosions. Some of the more powerful explosions eject material out of the crater, forming a low rim of deposits that thin rapidly as distance from the crater increases. Ejected blocks of rock can exceed three meters (about 10 feet) in size, and sometimes the explosions create pyroclastic flows. These processes, along with shock waves from the blasts, create a significant hazard for nearby populations. In order to predict potential hazards from maars in volcanic fields we would like to be able to use features such as crater morphology (e.g., diameter, depth, volume) to estimate energies that were produced by blasts at older volcanoes,



Figure 1. A maar volcano in Australia with a little sea filling the lower part of its crater.

which are then used to constrain what might happen in the future. Scientists and engineers who have studied craters from chemical and nuclear explosions, and from meteorite impacts, have developed empirical equations that relate crater size to explosion energy, when explosions occur at an optimum depth (note, if an explosion is too shallow or on the surface, much of its energy goes into atmospheric shock waves rather than crater excavation, and if an

explosion is too deep it is not able to lift and eject as much material). Unfortunately, these relationships only work for cases where there is a single explosion, but maar volcanoes have many explosions.

Maar volcanoes also have economic importance, because the structures that are beneath them, referred to as *diatremes*, can be source of diamonds. Diatremes are funnel-

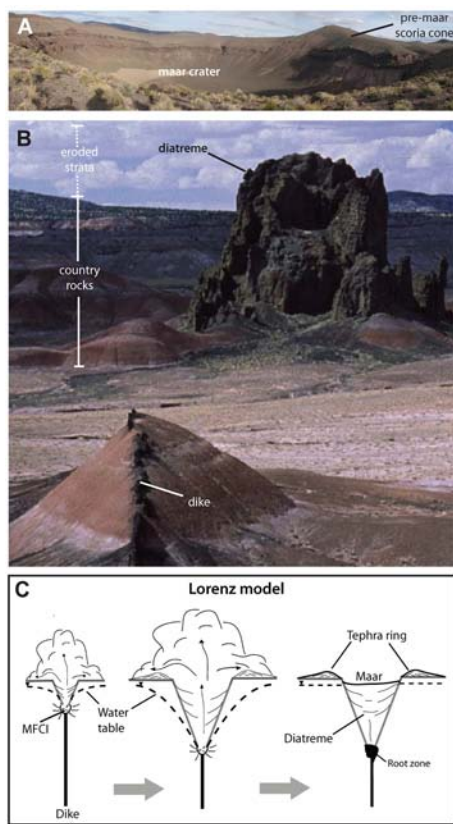


Figure 2. (A) Lunar Crater maar in central Nevada. The crater is about 1 km in diameter. (B) Standing Rocks diatreme in northern Arizona. The butte is about 150 m high and its top is about 100 m below the pre-eruptive landscape surface. Magma is supplied to most diatremes by thin dikes (essentially magma-driven fractures similar to hydrofractures), such as shown in the foreground. (C) A classic model for the growth of maars and their diatreme, where magma-water explosions begin at a shallow depth and get progressively deeper with time.

shaped bodies of broken up country rocks and solidified magma. Many readers have seen Monument Valley, and some of the buttes there are diatremes; the area was once volcanically active but the landscape has eroded, removing the surface volcanoes and exposing their underlying diatremes. Because the diatremes have been indurated by heat and alteration processes, they are more resistant to erosion and end up as high buttes. Figure 2 shows a maar crater that our group is studying



Figure 3. UB graduate students Peter Johnson, Dayana Schonwalder, and Steve Pansino (tan and white shirts) prepare one of the test pads, using rakes to smooth out the top of a layer of pea gravel while Jessica Ball (light blue shirt) uses a laser transit to ensure that a consistent height is maintained. Professor Greg Valentine “supervises.”

in Nevada (Lunar Crater; Figure 2a), and a diatreme in Arizona (Hopi Buttes area; Figure 2b). Diatremes are complex structures because they record the integrated effects of all of the explosions that occurred at that particular volcano. We would like to understand more details about how individual explosions distribute material in diatremes, which could, in turn, aid in searching for diamonds.

So, we have two problems: (1) how can we relate crater size to explosion energy in multi-explosion maars, and (2) how can we better understand the way individual explosions contribute to the formation of diatremes beneath maars? Answer: EXPLOSIVES!

We decided to take advantage of UB’s new **Geohazards Field Station**, a facility for large-scale, outdoor experiments about 30 miles south of Buffalo. In July, 2012, we conducted a preliminary set of experiments using “pads”

of layered sand, pea gravel, and crushed asphalt. Department of Geology graduate students helped with preparation of the pads (Figure 3), each of which was about 4 m × 4 m in plan view, and between 1 to 1.5 m deep. The plan was to compare craters formed by different blast configurations. In the first pad, we planned to bury one pound of explosive at a depth of 50 cm, which should give us an optimal crater size for that single blast. In the second pad we split that explosive into three charges, each 1/3 pound, and detonated them one after the other at the same level (50 cm) as in Pad 1. This test allowed us to see the effects of dividing up the energy into small explosions but without varying depth. After each explosion we documented the crater and ejecta, before setting off the next charge. In the third pad we again used three equal (1/3 pound) explosive charges, but each was detonated deeper than the previous one. This was done to explore the effects of a well-established model



Figure 4. Material being ejected during the one-pound blast on Pad 1.



Figure 5. Example of excavated “diatreme,” showing the crater and cross-cutting relationships of black and light gray materials beneath.

for diatreme formation in which magma-water explosions are progressively deeper (Figure 2C). When all the explosions were done, we planned to carefully excavate the pads to expose cross sections of the craters and underlying “diatremes.”

After several days of preparation, it was finally a day for blasting. In addition to students, collaborators from Italy, Germany, New Zealand, and Canada – and places as geographically far away as the UB Department of Mechanical and Aerospace Engineering – participate by bringing equipment such as seismometers, electrical field sensors, high-speed cameras, as well as their geologic expertise. Engineering colleagues collected imagery for high-resolution photogrammetric characterization of crater shapes and ejecta distribution. Mats were set out at regular distances from the “ground zero” points in order to collect ejected material. The first blast was the largest (Figure 4), ejecting material more than 15 m from the explosion site, and creating a crater 2 m in diameter and about 45 cm deep. Explosions at the other sites created more complex craters with unusual shapes.

Although we are still analyzing the data (the experiments took place one week before this writing), a major conclusion is that the final crater diameter is only slightly sensitive to the way energy is released (assuming the total energy is constant from one case to another) for the depths of explosion that we explored, but the morphology of the crater is very sensitive. Excavations revealed complex cross cutting relationships that result from lifting of the granular layers and then slapping back down (Figure 5). Although the surface crater diameter did not vary that much from one pad to another, the two pads where explosions were smaller resulted in damaged and crosscutting zones that are only about 50% as wide as the overlying craters. For comparison, the damaged subsurface zone beneath the single large explosion was about the same diameter as its surface crater.

This series of explosions was a major success in three ways. First, even though these are preliminary experiments, we learned a lot from them! Second, the series provides us with a solid base from which we can propose more detailed studies in the coming years. Finally, and very

importantly, this was the inaugural experiment for the Geohazards Field Station, which we are developing to be an international user facility. In addition to the scientific importance of the results, the experiments provided an opportunity for student involvement and for collaborators to “tag on” their own instruments in a multidisciplinary, team approach – all of these are major goals for the Center for Geohazards Studies and the Field Station.

UB Geology Alumni and Friends:

Reaching Others and Changing Lives

Thank you to all of our alumni and friends of the Department, who have supported us through their generous gifts during 2011-2012. The Annual Fund provides the department with vital resources it needs to support student activities and scholarships, replenish our laboratories, and continue our mission of academic excellence. Many of you choose to donate by means of endowments, scholarships, and matching gifts. Due to your gifts, our department has been able to continue to support vital student activities, including field trips and scholarships.

Your gift, in a very real way, **reaches others and changes lives.** We are most grateful to you for your help and continuing support. On behalf of all of our students who benefit from your generosity, we thank you.

Donations to UB Geology

Thank you to the following alumni and friends who have donated to UB Geology since July 1, 2011 (Reporting on donations received July 1, 2011 – June 30, 2012).

Mr. Khurram Ahmed
Mr. David L. Aloysius
Dr. Mary and Mr. Charles Anderson

*Apache Corporation
Dr. David and Mrs. Julie Barclay

Mr. John H. Barnes
Mr. Paul M. Basinski
Mr. William W. Beck, Jr.

*BHP Billiton Petroleum
Dr. Barry A. Bienstock
Mr. James F. Brennan, Jr.

Mr. Walter Brooks
Mr. Brett Burkett
Mrs. Karen H. Campbell

Mr. Adam C. Carey
Dr. and Mrs. Duane E. Champion
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Mr. John L. Krajewski
Mr. Andrew J. Kucserik

*Lenape Enterprises, LLC

Mr. Stuart Loewenstein
Dr. Frank R. Luther
Mr. John F. Mahl III
Mr. Brian C. Malick

Mr. David E. Mann
Mrs. Ann F. Maxwell
Mr. Joseph A. Maxwell
Mrs. Kathryn M. McKee

Mrs. Gail I. Mesker
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*Minard Run Oil Company

Ms. Eileen T. Mohr
*National Fuel Gas Company Foundation

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Mr. Robert C. Peterson
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Dr. Ardyth M. Simmons
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Mr. Thad P. Stry

Dr. Jack F. Sweeney
*Tectonic Engineering & Surveying Consultants, P.C.

Mr. Michael J. Teeling
Dr. Irving H. Tesmer
Mr. Dennis A. Tyburski
*UBS Matching Gift Program

Mr. Paul S. Vallone
Mrs. Kathy E. Vasilius
Mrs. Bonnie G. Weisberg
Mr. Burton S. Wienke, Jr.
Cpt. Donald R. Wiesnet
Mr. Harold O. Wolf
Mr. and Mrs. Jonathan and Darlene Zybala
Mr. Gregory D. Zynda

*matching corporate gift program to alumni donation

Alumni Notes

Katche, Adou (M.A. '11)

e-mail: kadou369@gmail.com

Geology is the reality of the world. It doesn't change anywhere you go. To perform, it is better to start with field practices and grow with the fields like environmental, social and economic to boast with a concrete management of this discipline.

I just have started with North American practices, even though I have some years of experience from the old African continent. Everything is slow because of the economic recession, but gradually it will be fine. I encourage all of us in this field to keep on moving in the right direction and be optimistic. Teachers and Educators from year to year, be

blessed from the bottom of your knowledge to its spreading to students, and congratulations!

Toy, Adam (B.A. '02, M.S. '06)

e-mail: adammtoy@gmail.com

After leaving UB in 2007 I taught Earth Science and Physical Science at Victor Junior High in Victor, NY for four years. I loved every minute of it but missed the challenges actually "doing" geology. In July of 2011 I made the switch to the private sector and joined Chesapeake Energy in OKC as an associate geologist and am currently working the Eagle Ford Shale play in South Texas.

Venturino, Christian (B.S. '12)

Christian recently accepted a position with

Columbine Logging, in Denver, CO.

Waldron, Keith (B.A. '98, M.S. '03)

e-mail: keithwldr@gmail.com

I recently left my employment with the U.S Air Force at Edwards AFB in Lancaster California where I was the Base Historic Preservation Officer. I am currently employed by the Bureau of Reclamation, Upper Colorado Region as the Regional Archaeologist with responsibilities for Native American Consultation (NAGPRA issues), and Museum Properties (Curation of Federal Archaeological Properties). The position involves regularly traveling to meet with Native American Tribes across the western states to discuss issues that are of importance to them.

Degrees Conferred and Student Honors

Minor

Matthew D. Petito	Jun-12
Timothy T. Pryshlak	Jun-12

Bachelor of Arts

Eric J. Bryce	Sep-11
Christopher W. Ellingson	Jun-12
Jason M. Pantke	Jun-12
Philip Phommala	Jun-12
David E. Seidler	Jun-12

Bachelor of Science

Rhiannon Collins	Sep-11
William E. Philipps	Sep-11
Kenneth E. Rhoades	Sep-11
Jason J. Lubniewski	Feb-12

Brandon Mikolin	Feb-12
Jena B. Woodward	Feb-12
David J. Brooks	Jun-12
Anna E. Hrywnak	Jun-12
Rachel L. Kolenko	Jun-12
Justin L. Miceli	Jun-12
Patrick L. Staub	Jun-12
Stefan R. Truex	Jun-12
Ethan J. Ulm	Jun-12
Christian S. Venturino	Jun-12
John W. Weinerth	Jun-12
Matthew J. Wendt	Jun-12

Master of Arts

Roy Widrig	Jun-12
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Master of Science

Andrew D. Hawkins	Sep-11
Trevelyn A. Lough	Sep-11
Thomas R. Malizia	Sep-11
Melissa M. Zelazny	Sep-11
Kenneth W. Christle	Feb-12
Robert L. Dennen	Feb-12
Shannon S. George	Feb-12
Michael E. Badding	Jun-12
Jeremy J. Crowley	Jun-12
Lauren A. Fortson	Jun-12
Sonja M. Melander	Jun-12

Doctorate of Philosophy

Sung Wook Choung	Sep-11
Patrick L. Whelley	Jun-12

Duttweiler Field Camp Award:

Alumna Dorothea Duttweiler was the first woman to graduate from our department, with a BA in Geology in 1937. This was a time when few women attended university at all, let alone collecting a major in a male-dominated science field such as geology. She eventually became

a professor in UB's School of Education, and she never lost her love for geology. Her annual gift has been awarded since 1994 to benefit students attending field camp, with a preference to enable young women, and the department continues this award in her memory. The 2012 recipients of twelve hundred dollars each were

Larene Cameron, Matthew McClellan, and Kasey Zitnik. See page 16.

Pegrum Field Camp Awards:

One field camp award was made from the **Reginald H. Pegrum** fund. Due to increased donations to our department from alumni

and a generous endowment account return, the department expanded support of students attending field camp through use of these funds. This year's recipient of twelve hundred dollars was **Thomas Macomber**.

James P. Owens Scholarship:

The **James P. Owens scholarship** was set up by Lucy McCartan-Owens to honor the memory of her husband James. Mr. Owens began his studies at UB in 1941, but interrupted his education to serve in the US military and returned to UB in 1946 under the GI bill. He received his Bachelors degree from Geology and Chemistry in 1948 and completed his graduate degree in 1949. His graduate work included extensive study of the Cazeonvia Creek and he credits the University at Buffalo with much of his later professional success. This scholarship was set up to assist an outstanding undergraduate student or an applicant to the Geology Graduate Program who is interested in fields related to surface and near-surface geology.

For 2012 we are pleased to award this scholarship to **Nicholas Dahn**. In the words of **Dr. Bea Csatho** "**Nicholas Dahn** is a great student who performs exceptionally well both in research and coursework. He is interested in everything related to volcanology, which eventually led him to explore the possibility of subglacial volcanism in Greenland as his thesis research. Understanding subglacial geology and the control it exerts on ice flow is an exciting goal and Nicholas is up to the challenge."

Gilbert Jaffe Memorial Award:

The Gilbert Jaffe Memorial Award was established by Mrs. Charlotte Rosenshine in memory of her brother, Gilbert Jaffe, who received a BA in Geology from UB in 1949 and an MA in 1950. After graduation, Gilbert entered the field of oceanography at the U.S.



Field Camp Award Recipients: Kasey Zitnik, Larene Cameron, Matthew McClellan, and Thomas Macomber

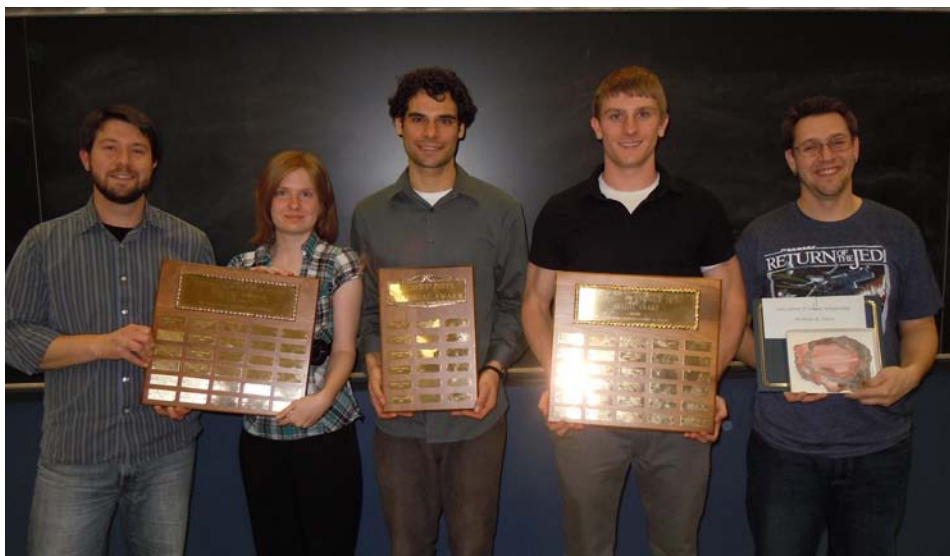
Navy Oceanographic Office in Washington, DC.

He began his career in design and development of sensory, telemetric, and recording equipment. Later he founded and directed the Naval Oceanographic Instrumentation Center. Ultimately he became Director of the National Oceanographic and Atmospheric Administration Instrument Center. The award is intended for an outstanding undergraduate student who plans to pursue further education in the study of marine or environmental sciences. This year we have selected **Justin Miceli** for this award of \$750.

Dr. Indra Kalinovich stated the following about Justin: "I've had the pleasure of getting to know Justin over the past year while he's been working on his undergraduate thesis in the our lab... he has taken on an extremely challenging project, developing a method for carbonaceous matter extraction and analysis. His results are important for interpreting organic contaminant behavior in aquifer materials. Justin's ambition, hard work, combined with his ability to process large volumes of information have helped him greatly with his research. Justin is a most deserving recipient of the Gilbert Jaffe Memorial award."

Reginald H. Pegrum Undergraduate Award:

The Pegrum award was established with funds from an anonymous donation in the name of the founder of our Department, Dr. Reginald H. Pegrum, and it has been given annually since 1970. Dr. Pegrum decided to use this award to recognize the outstanding personal achievements of a graduating senior. While Pegrum specified that scholars of substantial academic achievement would be obvious candidates for this award, he also specified that other students should not be eliminated from consideration. The Pegrum award recipient must be a person of imagination, integrity, and humility. Other characteristics such as leadership, willingness to help others, loyalty, reliability, cooperation and enthusiasm are also considered. The 2012 recipients of the \$750 awards are **Rachel Kolenko** and **Jeffrey Pietrzak**. **Dr. Charles Mitchell** had the following to say about Rachel: "For the past year **Rachel Kolenko** has been working on an independent research project in my lab. Rachel has learned the complex methods to study the patterns of shape change in a species lineage during the great Hirnantian mass extinction. This work will be part of a synthesis on



Geology Degree Award Recipients: Jeffrey Pietrzak, Rachel Kolenko, Justin Miceli, Kyle Jones, and Nicholas Dahn

evolutionary responses to the profound climate and ecological changes that took place at that time and Rachel's results are a valuable contribution. Rachel has worked steadily on the project and has displayed considerable insight along the way. "

Rachel has also been awarded this year's College of Arts & Sciences Outstanding Senior Award in the Geology Department. The selection criteria for this award are: demonstrated academic excellence exemplified by an exceptional grade point average, election to honor societies, participation in research, and other academic achievements. Rachel will be presented this award at the University Commencement Ceremony in May. Excellent work, Rachel!

When asked about **Jeffrey Pietrzak**, **Dr. Joaquin Cortes** (Caco) said, "I believe in Jeff we have an example of how those two aspects [life and school] can be blended in the best possible way. Jeff, you did it, a successful geology student and an amazing dad!"

Graduate Pegrum Awards:

Thanks to a large donation of close to \$140,000 from alumnus James W. Cadwell, the Pegrum Fund is now also able to give additional awards to students. The graduate Pegrum Award is given

to a graduate student that excels in teaching, research or both. This year the department is pleased to recognize **Kyle Jones** with a Pegrum Award for Excellence in Teaching. Kyle has served as the head teaching assistant for our introductory geology laboratory courses this year. See page 15.

Dr. Chuck Mitchell stated, "I have had the pleasure of working with Kyle Jones over the past two years on a project about the depositional history of the Utica Shale in the region between Amsterdam and Schenectady NY. Kyle has shown a great ability to take charge of his project and work independently. He has secured funding from the *American Association of Petroleum Geologists* and the *Society for Sedimentary Geology*, based on proposals that he has written. Kyle has presented interim project reports at two regional scientific meetings and secured a donation of basin analysis software from Patte River Associates. I have been very impressed by his energy and maturity and the skills he has refined through his research project. As I said at the outset, it has been a pleasure to work with Kyle and I expect he will enjoy considerable success in his future professional career."

Dr. Tracy Gregg had the following to say:

"Mr. Jones has performed above and beyond the call of duty...He is an exemplary teaching assistant, as shown by his teaching evaluations. Mr. Jones is an effective teacher...organized, creative, thorough and responsible. It has been a great relief to me to know that Mr. Jones is overseeing the labs through which almost 400 undergraduates pass every week. He's helped me to improve the concepts and implementation of the labs with dedication, ingenuity, and a genuine desire to help our students to learn. Most importantly to me, I know that he's "got my back," and that when I drop the ball, Mr. Jones is right there to pick it up and follow through with a slam-dunk. "

Students have described Kyle as effective, knowledgeable, helpful, fantastic, and informed. Others have mentioned his ability to make class fun and interesting, and have highly recommended him in their evaluations. Congratulations Kyle!

Pegrum Professional Development Awards:

Since 2001 the department has offered the Reginald H. Pegrum Professional Development Award. This Award provides financial support to undergraduate and graduate students for the purposes of attending professional meetings, workshops and other programs that would aid in their professional development. For the 11-12 academic year, this fund supported 16 Students totaling \$7,290.

Kyle Jones

Pegrum Teaching Award Recipient



A Geologist, as they outcrop in the Mohawk Valley- immersed in the Flat Creek member of the Utica Shale

My area of study is the depositional environment of the Utica Shale as it outcrops in New York, and upon graduation I plan on pursuing a career in the oil/ gas industry. I truly enjoy the relationship between structural control and sedimentation, in particular as it

relates to ocean basin history and development. My research is focused on both the timing and effect of faulting on Utica Shale properties, ranging from mineral content and grain size to total organic carbon.

While pursuing my Masters of Science degree I have enjoyed instructing labs for the introduction Geology classes, GLY 101 in the fall and GLY 102 in the spring. I found my second year of teaching more rewarding than the first, as I was named Lead TA of the intro classes. As such, I became responsible for assembling labs and serving as an intermediate between the other intro TA's and the course professors.

As my second year of graduate school ends and the culmination of my work comes into focus I am beginning to reflect more heavily on everything the department has afforded me. Steady employment for two years is certainly the most obvious. While I am employed via an internship this summer, the Pegrum Award allowed me a few extra weeks to finish my analyses before the internship began. For this I am very grateful.

During my brief but memorable teaching career I tried to instill my view on geology into my students. Several, I am happy to say, switched majors into our program each semester. While I cannot take full credit for the switch I like to think I helped a little. Like many geologists, I did not know I wanted to pursue this career when I entered college. After just a few weeks in my introductory course I knew I had found my field and I haven't looked back. Geology provides not only answers, but also a connection through understanding with the rocks and hills I do not think others understand.

Once again I would like to sincerely thank you for the Pegrum Teaching Award. While the monetary value is very much appreciated, the history of other recipients, as well as its reason for existence provide, for me, the greatest satisfaction.

Kasey Zitnik

Duttweiler Field Camp Award Recipient

Due to the field camp scholarship I was given this year, I was able to buy all of the supplies I needed to be able to be at my best for this endeavor. This class will be a test of all of the geological knowledge I have accumulated over the past three years and I'm eager to face this challenge. I have a love of geology that was never realized until I came to UB. When I was a child my older sisters would always take me to the beach or the creek by our house and without fail I would come back with my pockets full of multi-colored stones. My parents weren't particularly thrilled with this, but I certainly was. When I came to UB I had plans to be

a history major and to go to grad school for library science; then I took Tracy Gregg's GLY101 class and my plans were immediately changed. I had never realized before just how versatile the geological sciences were and how much I wanted to be a part of this society. As soon as I joined the major, I knew it was where I belonged. A more earthy (pun intended) and laid back group of people I have yet to meet. Before then I had stuck to people I knew from high school, but in my geology classes I quickly developed a whole other group of friends that I will likely remain in touch with well after college is over. While I enjoyed every class

I took from the department, it wasn't until I was in Dr. Cortes' petrology class that I found my personal branch of geology. I broke for metamorphic rocks. I'm extremely thankful for the opportunity made available to me thanks to the Dorteia Duttweiler Award, and I will do the best I can at field camp this summer!

Justin Miceli

Gilbert Jaffe Memorial Award Recipient

My name is Justin Miceli and I am a recently graduate with a Bachelors of Science with Honors in the spring of 2012. I am pursuing a career in physical hydrology and hydrogeology with a concentration in how heterogeneities in the subsurface influence contaminant transport and remediation. My goal is to be a college

professor and conduct research that can be used in environmental remediation efforts of contaminated groundwater.

I am honored to be a recipient of the Gilbert Jaffe Memorial award. The reason I enrolled in geology is because I wanted to get involved

in environmental remediation through hydrogeology. It means a lot to be recognized by Gilbert Jaffe Memorial Award during my pursuit of a hydrogeology career. The award means a lot to me financially as well. I will use the money to help pay for visits to graduate schools.

Rachel Kolenko

Reginald H. Pegrum Undergraduate Award Recipient

My name is Rachel Kolenko and I have currently just finished a Bachelor of Science degree with Honors in Geology. I am currently taking a year off from my education to work and hope to return next fall to pursue a Master's degree in Paleontology. I would like to thank the department for awarding me the 2012 Reginald

H. Pegrum Award. The past four years in the department have been awesome and I feel that I am well prepared to enter graduate school.

This award is going to help me cover the costs that are going to come with selecting the graduate school I attend. I hope to pay for

my GRE testing and cover travel costs from when I go to visit potential schools with this award. Once again, I would like to thank the department and those who make this award possible.

Larene Cameron

Duttweiler Field Camp Award Recipient



On route to our first campsite in Colorado!

On May 16th I travelled to Denver, Colorado to begin a four week mapping field course. With only an itinerary of where we would be travelling to, I had no idea of the incredible experience that was about to unfold. Out of the four mapping sites the most spectacular was located in Dinosaur, Utah. Before being exposed to this site, the only structural geologic formations I had seen existed within textbooks. The mapping site at Rainbow Valley Ranch was breathtaking for there was both large-scale

folding and faulting altering the environment. Not only was this mapping site incredible but camping within dinosaur national park which is one of the top dinosaur sites in the country was awesome! I made many great friends and memories that will last a lifetime on this trip. Thank you to the enthusiastic and knowledgeable professors for making my field camp experience the best!

The Dr. Duane Champion Summer Travel Award

Dr. Duane Champion received his B.A. in Geology from UB in 1971, and his M.A. in Geology from UB in 1973, and currently works at the United States Geological Survey, in California. His Summer Travel Award was created to provide support to graduate students in our department for the purpose of

research-related work in the lab or field, and the following students were awarded in 2012:

Laura Best has been awarded \$489 to use towards her project modeling regional groundwater flow in Broome and Tioga Counties. Her goal is to understand if

additional water usage will negatively affect the aquifer system in the Southern Tier, and her results will be useful to development scenarios, particularly in relation to hydraulic fracturing of the Marcellus Shale.

Simon Pendleton has been awarded \$951 towards his research investigating glacial activity in the Brooks Range, Alaska. His project has been partially funded by the National Science Foundation, and the additional funds from the Champion Travel Award will aid him in sample analysis. He hopes to use his results to piece together a more accurate and precise picture of glacial advance and retreat in the region.

Dawn Ruth has been awarded \$560 to supplement her work determining if trace elements are transported during passive degassing in an active volcanic system. She has been working on this project since 2009, and has completed most of her geochemical analyses as a Smithsonian Graduate Fellow in 2010. The purpose of her final trip to Villarica volcano, Chile, is to collect the final FTIR analyses on olivine hosted melt inclusions obtained during

the 2011 field season. Dawn's project has opened up collaborative relationships between UB Geology and the volcanology group at the Smithsonian, allowing our Department access to analytical facilities that would otherwise be unavailable. This work will complete her PhD dissertation.

Glaciers of Arctic Alaska and the Stories they Tell

A Research Update by Simon Pendleton



Figure 1: Aufeiss along Anatuuvuk Creek on our way to a small cirque glacier over the hanging valley on the right.

The Brooks Range of Northern Alaska is a 1,000 mile long set of mountains running from the Chukchi Sea in the west all the way to the Beaufort Sea in the east, with peaks rising to above 8,000 feet. This rugged Arctic landscape is home to few people, even fewer roads and millions of square miles of wilderness, earning Alaska its motto of the Last Frontier. However, even in this desolate landscape, carved by multiple episodes of glaciation, there is a wealth of information regarding recent climatic events literally etched into the earth. The small alpine glaciers of the Brooks Range have left behind a record of glacial advance and retreat on the landscape, which is integrally linked to the local and regional climate of Arctic Alaska and the greater Polar region. While the extent of the Last Glacial Maximum (LGM) is well defined in the Brooks Range, climatic and glacial



Figure 2: From left to right Simon Pendleton, Liz Ceperely, and Dr. Briner After a long day of sampling East Erratic Glacier.

activities are poorly constrained during the last 15,000 years. Armed with a new technique for dating glacial features and landscapes, Simon Pendleton of UB's Paleoclimte research group spent a month this past summer living and working in the Brooks Range. A site on the Central North Slope of the Brooks Range was chosen as well as an additional glaciated area on the southern edge of the range to apply the new technique; Cosmogenic Nuclide Exposure dating. The technique, based on the accumulation of radionuclides in earth materials due to exposure to cosmic radiation at known rates, can provide accurate and precise absolute ages on glacial landforms and features where other methods (radio carbon, U/Pb, lichenometry, etc.) are impractical or not accurate enough within the timeframe.

Living and working out of several base camps, Simon and his fellow researchers were able to gain access to the high valley cirques and glaciers inaccessible for shorter excursions. At both sites several glacial cirques were surveyed and moraines leftover from glacial advances and exposed bedrock from glacial retreat were found and sampled. After dealing with inclement weather, hordes of mosquito's and occasional sunny days, a large collection of samples were obtained which Simon and his colleagues hope will shed substantial light on the activities of the glaciers of the Brooks Range over the last 15,000 years. These records, combined with climate records from lakes cores (collaboration project) should provide a record of local and regional climate of Arctic Alaska that has yet to be documented.

Remember When...



