EARTH MATTERS

NEWSLETTER OF UBC EARTH, OCEAN AND ATMOSPHERIC SCIENCES | VOL. 5 | 2019

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IN MEMORIAM

Peter Winterburn
Former EOAS NSERC/Bureau Veritas Minerals Executive Industrial Research Chair in Exploration Geochemistry, donations can be made to: https://memorial.support.ubc.ca/peter-winterburn

John Ross
Former Professor of Geology, donations can be made to: https://memorial.support.ubc.ca/john-ross/

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COVER PHOTOS: Front: Joffre Peak landslide by Andrew Mitchell, Back: UBC Faculty of Science

From the Head

Credit: Faculty of Science

Earth Matters Editor-in-Chief Alan Shapiro sat down with Earth, Ocean and Atmospheric Sciences Department Heads Prof. Roger Beckie and Prof. Philippe Tortell to reflect on the past year and discuss the year ahead. Tortell took over from Beckie as EOAS Department Head in July 2019.

Interview with Roger Beckie

What's been the most exciting news from the past year?

Since we last talked, we've hired five new people: Prof. Ali Ameli in hydrogeology/ecohydrology (started in January), Dr. Joel Saylor in sedimentology (starting in September 2019), Dr. Mitch D'Arcy in environmental change (starting in March 2020), Dr. Rachel White in atmospheric science (starting in July 2020), and Dr. Anaïs Orsi in polar climate science (starting in July 2020).

As they say in the movies, movie-making is 90% casting. I think the same thing is true with a university department. Get the right people in place and then the magic happens. We're a desirable place to come to, so we're attracting the top talent, and we managed to get all our first-choice people. It's pretty unusual and spectacular to have that many new people come into the department!

What's the focus for EOAS going forward?

Right now in the Dean's office, there's a visioning and hiring exercise taking place. One of the values the new Dean is promoting is joining forces to work across disciplines and look at problems in a new way. Sparks fly at the interface of disciplines! At the moment, the Faculty of Science is focusing on six interdisciplinary clusters. Data science is one that everyone is excited about. Global health writ very large (the health of the oceans and atmosphere) is another one.

On the teaching and curriculum level, one of the exciting things the Department is exploring right now is experiential learning. This is one of the strategic areas UBC wants to be involved with. The angle we think is underdeveloped for EOAS is field-based experiential learning. When we talk to our alumni, people remember field trips and the conversations that come from them. Seeing the geology, seeing the hydrology - those experiences are super important. It's something that we do well, and we know it has an effect, but we haven't really studied it.

What have been the highlights of your time as Head?

I'm definitely a reluctant department head. I prefer being behind the scenes. But it was my turn, and I'm very grateful for this opportunity. I always joke that calculus and groundwater modelling are really easy things to do, at least

conceptually. These complex, uncertain, multi-factor people and budget problems you face while running a department are cognitively much more complicated. But failure is the best teacher, and I've learned a ton in my term here.

I've really appreciated the behind the scenes people who make this stuff happen. Really, the test of character is what you do when people aren't looking. So many people in EOAS pour their hearts out giving extra feedback and support to the students. I do appreciate the opportunity this role gave me to meet new people, make new relationships, get out of my bubble, and see what's going on in the rest of the Department and the rest of campus.

What are your plans now?

Going forward, I'm continuing with a great group of students and post-docs working on mine waste problems, shale gas, and water. I'm also thinking of developing one more research area. In three to five years, you can do a lot of interesting things if you focus on them!

I'd also like to help support my students. My post-docs have been instrumental in keeping all the balls in the air while I've been Head. Now that a lot of them are coming to graduation, I can help them complete their work.

Read more about new Professor Ali Ameli on page 7.

Former EOAS Department Head Prof. Roger Beckie

Interview with Philippe Tortell

What are your priorities for the next year?

There are a number of important initiatives that we'll begin to tackle this year. There's a real desire to look at how we teach quantitative and computational tools across the EOAS curriculum. Right now, we're teaching much of the same stuff across disciplines.

For example, time series analysis is taught in parallel in oceanography, geophysics, and other courses. Can we teach these skills in a way that's more agnostic of disciplines? Can we say, "Here's a tool, let's talk about how it can be used to solve cross-cutting problems?" We'll also continue to contribute to the momentum we've built up over the past ten-odd years, focusing on things like quantitative and experiential learning.

Are there any longer-term projects in the works?

We're looking forward to 2020, which is the 50th anniversary of Earth Day. We're planning an event at Science World for Apr. 22nd, which will involve science, art, and public engagement.

2021 will be the 25th anniversary of the EOAS Department. We're already thinking about what we can roll out that year to engage researchers and the public.

How will EOAS continue to balance its teaching and research focus?

Teaching and research are more tightly intertwined than people might think. If we're successful in building the new curriculum, I suspect that we'll start to see much more collaboration between mathematical and physical researchers. This is also a great potential for overlap with the Computer Science Department. The tools that they're developing would have a natural home in EOAS. We have a lot of big data sets and interesting data problems that they can attack with a vengeance.

Broadly speaking, this department combines areas of research that might individually be replicated in other departments. But nowhere else on campus or even in Canada are they housed under one roof. Planets, wetlands, glaciers, deep ocean ridges... Our success is in trying to identify the cross-talk between these disciplines. Then we start to get into fertile territory where we're asking ambitious questions and looking for answers. We certainly need to capitalize on our existing strengths and make sure they're sustainable going forward.

Current EOAS Department Head Prof. Philippe Tortell

Department News

Return to the Rocks

by Kohen Bauer & Lindsey Rayborn

After serving as Dean of the Faculty of Science for a total of 12 years (two six-year terms), Prof. Simon Peacock is enthusiastically anticipating his reintegration as a full-time faculty member in the EOAS Department. Part of this enthusiasm, he jokes, comes from his newly acquired ability to put his phone on "do not disturb" mode in the evenings, a luxury not granted to his previous role where he was required to be available 24/7.

Prof. Simon Peacock hiking Aoraki/Mount Cook in New Zealand

Fast-paced responsibilities aside, Peacock reflects on his time as Dean with deep gratitude, remarking that "as Dean, I had the privilege to work with wonderful people across this university. These people are committed to making UBC better, and working with these people is a lot of fun."

One such action to transform UBC in a positive way – and one of Peacock's main initiatives as Dean – was to introduce the Carl Wieman Initiative, a science education strategy aimed at dramatically improving undergraduate education. EOAS was one of the first departments to adopt the program.

"I took great pride knowing that this department is the one that led UBC, and hence became a world leader in transforming how we approach undergraduate science education. This is a department that changed its culture in order to develop strong teaching and active engagement," Peacock reflects.

As someone who has been instrumental in advancing undergraduate education at UBC, Peacock is looking forward to putting these new methods into practice for himself. "I've always considered myself a professor first and foremost," he explains. "While I wore a hat as the Dean, I am still a professor who is keenly interested in student learning and keenly interested in research. I am inspired by the breadth and diversity of this department and its commitment to science education, which I now get to be a part of."

As professor, Peacock also relishes having time to think, explore different ideas, follow multiple trails, and collaborate. "I am still passionate about geology," he says, "I don't know what it is, or what gene I have that says rocks are cool!" Whatever gene it is, it's undoubtedly shared by many in EOAS.

Prof. Simon Peacock in Arizona

Modelling NEMO

by Kohen Bauer & Lindsey Rayborn

Between the months of November and February, coastal communities surrounding southern BC and northern Washington's Salish Sea face risks from hazards related to maritime and meteorological conditions, particularly storm surges. Storm surges occur when strong winds accompany high tides and cause severe flooding and property damage in surrounding areas. Local wind patterns and complicated coastlines cause Salish Sea storm surges to behave differently based on location, making southern mainland communities especially vulnerable.

Prof. Susan Allen has been studying the Strait of Georgia since 2002 and currently leads a team of physical, chemical, and biological oceanographers in collaboration with biologists and social scientists to deliver daily storm surge forecasts to Canadians in high risk areas. The SalishSeaCast model, developed by Allen and collaborators, maps physical oceanographic conditions that pose hazards to human and marine environments using the Nucleus for European Modelling of the Ocean (NEMO) framework. Real-time predictions from this model give coastal communities time to prepare for potential flooding.

In the future, Allen and colleagues hope to improve the model's accuracy by considering mixing parameterizations and frictional energy dissipation, and to extend it by adding biogeochemical elements. Allen emphasizes the importance of collaborative partnerships with researchers from Ocean Networks Canada, Hakai Foundation, Fisheries and Oceans Canada, University of Washington, University of Alberta, Environment and Climate Change Canada, and Dalhousie University to the success of the model.

Flooding at Vancouver's Locarno Beach during the Dec. 20, 2018 storm surge

Watershed Insights

by Kohen Bauer & Lindsey Rayborn

Ali Ameli, the EOAS Department's newest professor, has his work cut out for him bridging the gap between engineering and Earth science. His research explores the impacts of land use and climate change on watersheds' hydrological and hydrogeochemical processes.

Ameli has a background in civil engineering and earned his PhD at the University of Waterloo in 2014. He leverages his unique perspective to link mathematical and modelling approaches to Earth science problems.

Drawn to UBC because of the strong, interdisciplinary Earth science research program, Ameli remarks that "the Faculty of Science provides a nice opportunity for undergraduate and Master's students to study different majors and get to know a wider range of disciplines." This is something he stresses as an important aspect of approaching complex, real-world projects.

To better predict the impacts of climate and land use changes on the quality and quantity of stream water, Ameli's research focuses on what happens between rainfall and river flow. Despite decades of research, there is still limited understanding of the sources, pathways, and residence time of water after it rains (or melts) in watersheds.

"My research will combine virtual aquifer physical experiments, a bottom-up hydrological model, and top-down data science techniques in order to explore how the interactions of different landscape features including climate, bedrock geology, soil properties, land cover, and topography control the way watersheds partition, store, and release water and dissolved solutes," he explains.

Prof. Ali Ameli

This research will provide insight on the sensitivity of watersheds with different landscape features to climate and land use change; suitable locations for forestry, mining, and agricultural land development with minimal environmental impact; and water quality and quantity in a changing climate. Ultimately, Ameli's vision is to extrapolate his results and predictions to different landscapes across Canada and around the world.

Teaching News

Diamonds in the Rough

by David Zeko

The Diamond Exploration and Research Training School (DERTS) is a graduate program that brings together industry, government, and academia to train students on the latest advances in diamond research. This includes geochronology, indicator mineral analysis and interpretation, volcanology, exploration geophysics, and remote sensing. DERTS is run by the University of Alberta in collaboration with EOAS and currently has two UBC Master's students enrolled.

MSc student David Sasse works with Prof. Kelly Russel in the EOAS Volcanology Lab. Sasse uses laboratory experiments to investigate changes in the size and shape of minerals in transported fragments of rock known as mantle xenoliths. These are brought to the Earth's surface by eruptions during the formation of kimberlite diamond deposits.

Marina Karaevangelou works with Prof. Maya Kopylova in the Diamond Exploration Laboratory. Karaevangelou uses diamonds and their inclusions from the Lace kimberlite deposit in South Africa to constrain the origin and processes that formed these diamonds deep in the Earth's crust.

As a requirement of the DERTS program, both Karaevangelou and Sasse completed a four-month internship with Rio Tinto in the summer of 2018, providing them with hands-on experience at the Fort a la Corne exploration site in Saskatchewan. They also enjoyed a DERTS field trip to Guatemala, where they learned about the geology of the Caribbean plate, made field observations of various volcanic rocks, and climbed to an altitude of 3900m to watch the eruption of the Fuego volcano. Both Marina and David look forward to careers in either diamond exploration or gemology upon the completion of their programs.

DERTS students spend some quality time with rock samples

Skiers brave a cold front on Mt. Hood, Oregon (credit: Dr. Greg West)

Teaching iGen

by Birgit Rogalla

"Why are traditional lectures not working anymore?" This is the question that Prof. Roland Stull asked himself three years ago, which led to the creation of a new online course, ATSC113, Applied Meteorology. This course teaches weather using case-study modules on sailing, flying, and snow sports.

Stull recruited content experts Dr. Rosie Howard, Dr. Greg West, Samantha James, and Anthony Di Stefano to design a course specifically for Generation Z ("iGen") students. The focus is on narrative based exercises, specific applications, and short 'tweet' length assignments that can be completed on a smartphone in between classes.

In the case-study modules, students are given real-world scenarios and observations, such as a sailor on the ocean who notices dark clouds on the horizon, and are asked what to do. By placing themselves in these dynamic situations, students become aware of the importance of weather in everyday life. Using their knowledge and the information provided, students make what may be a life or death decision and soon discover the outcome.

As to its success, the course enrollment speaks for itself. The course has grown from 79 students in 2016 to over 700 students in 2019. To meet the high demand, meteorologist Prof. Doug McCollor has been brought on as an additional instructor.

Better Together

by David Zeko

Science Education Specialist Dr. Sarah Bean Sherman has been involved in UBC's Paired Teaching Initiative since its inception. "The main benefit of a paired teaching approach," she shares, "is that a new instructor learns how to use and implement active learning techniques in a supportive environment with regular feedback and mentorship."

In the paired teaching model, courses are co-taught by a senior and a junior instructor. Both instructors attend each class and are observed by a Science Education Specialist. Typically, these classes have already been updated to follow evidence-based pedagogy.

"The immediate outcome of this program is that the new instructor will begin teaching at UBC with knowledge of evidence-based learning techniques and can transfer what they have learned to their other classes, making adjustments to improve the learning experience for EOAS students."

The Paired Teaching Initiative initially started as a pilot study between the EOAS and Physics and Astronomy departments, funded by private donors through the Harris Foundation. The paired teaching trial was run for three years and shown to be successful and beneficial to students. Currently, all departments in the Faculty of Science are implementing this paired teaching approach, now known as Teacher Start Up.

The Paired Teaching Initiative is supported by the allocation of a full teaching credit to both the new and experienced instructor. Usually when two instructors co-teach a course, they are given a half credit; however, interviews with teaching staff suggested that the time required for team teaching was typically closer to a three-quarter commitment each. As both instructors receive a full credit, they are able to put in additional work to make observations, conduct reviews, and give feedback to support professional growth.

The learning goes both ways, and the senior instructor often gains much from the experience as well. Instructors report having fun and feeling more engaged with the Department through receiving feedback and having someone off whom they can bounce ideas. The increased effectiveness of their teaching also supports instructors in balancing their instructional and research responsibilities. The vision is for the Paired Teaching Initiative to eventually be implemented across all UBC departments.

Modern Geology

by Birgit Rogalla

A modernized version of EOSC 330, Principles of Geomorphology, made its debut in fall 2018. Spearheaded by Dr. Siobhan Whadcoat and Prof. Scott McDougall and funded by a Teaching and Learning Enhancement Fund grant, the course now incorporates cutting-edge technological software such as GIS, CloudCompare, and Google Earth, to help students interact with and visualize data. McDougall notes that "coming from industry where I see GIS used all the time, I noticed that although our students had opportunities to take GIS courses through other departments, they weren't seeing GIS in the context in which they would be using it."

Using video tutorials designed and narrated by Anya Leenman from the UBC Geography Department, alongside hands-on practice in labs adapted by teaching assistant Sophia Zubrycky, students mapped out geomorphological features of areas near Vancouver, such as the Garibaldi Barrier, as well as other regions of BC.

EOSC 330 students wear (goofy) 3D glasses to look at landforms in lecture

"We don't want this course to be about training technicians or teaching a specific software because the software is evolving," explains Zubrycky. Instead, a strong emphasis is placed on balancing familiarity with the tools used in industry with teaching the fundamentals of geomorphology. Thus, older tools such as air photo interpretation with stereoscopes are still important components of the course.

Student feedback has been very enthusiastic; students want more GIS and even earlier in their degrees. McDougall credits a large part of the success of the course to the teaching assistants (Dr. Negar Ghahramani, Connor Robinson, Birgit Rogalla, and Zubrycky), who have all played an important role to make the course a success.

Student News

by Andrew Mitchell & Idalia Machuca

Surviving School ESSA

Being a graduate student in the EOAS Department can involve a plethora of responsibilities, such as reearch, TA'ing, and taking courses. Sometimes students need time to unwind, especially during the long, dark winter months.

Throughout the academic year, graduate students from across the Department met for intramural sports, with a futsal team and two volleyball teams. A highlight of the year for the intramural teams was when, after a strong showing through the regular season, the Bedrock Ballers were acclaimed as the Tier 3 Volleyball champions after none of their opponents showed up for the playoffs, clearly intimidated by their dominance on the court!

The Environmental Science Students' Association (ESSA) is a community of students working to gain a better understanding of environmental issues, advocate for sustainability, and tackle solutions that "make real change on campus and in our community," shares club executive Megan Stewart.

ESSA provides academic support for students in EOAS and Environmental Science programs and peer support for environmentally-minded projects. This year, ESSA partnered with the Varsity Outdoor Club, Ski and Board Club, and Surf Club to present the UBC Mountain Film Festival, which explored the intersection of winter sports with climate change and indigenous sovereignty. According to Stewart, the film screenings "triggered a lot of emotion and discussion", which further encouraged attendees to bring issues of sustainability to the forefront of conversations around campus.

ESSA also hosted their annual career fair, during which students had the opportunity to connect with companies and organizations for summer, co-op, and even post-graduate jobs. "From peer reviews, to information on professional networking, to environmental advocacy, there is something [in ESSA] for everyone!"

A film screening at ESSA's UBC Mountain Film Festival

Georox Club

The tagline for the Geological Engineering program is "escape the office", and this March, students in the Geological Engineering undergraduate club, GeoRox, did just that. The group escaped the classroom to visit the Highland Valley Copper Mine, located near Kamloops, BC.

Alumnus Matt King of Piteau Associates toured the students around several open pit mines, providing an overview of the operations of the mine site. GeoRox co-president Joaquim "Shoobie" Pereira shared that after dealing with more idealized problems in the classroom, it was a great opportunity to get out, see structural geology at that scale, and observe how geology controlled the overall shape of the pit.

GeoRox club members visit the Highland Valley Copper Mine

UBC Oceanography Club

The UBC Oceanography Club is a network of students with a range of academic backgrounds, including oceanography, chemistry, and biology, who all share a curiosity and passion for the ocean.

This year, members of the Club organized and participated in beach clean-ups and a year-end outdoor trip, which helped students gain a greater appreciation for ocean features and ecosystems through hard work and adventure.

While it was cancelled this year due to weather conditions, one of the Club's highly recommended annual events is the Meet Your Prof night. Students have an opportunity to chat with professors and teaching assistants and even make meaningful connections that could lead to undergraduate summer research openings and funding.

"If you're interested in anything ocean-related," offer the Oceanography Club executives, "you should come to some of our public events like our ocean speaker series next year!"

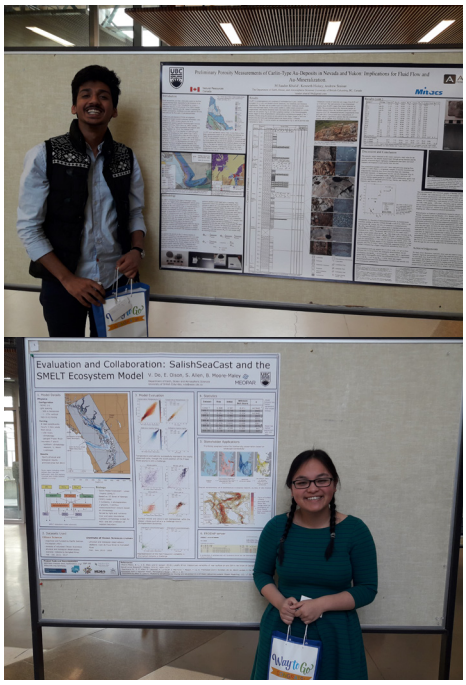
UBC Oceanography Club bake sale

EOAS Poster Corral

This year's edition of the EOAS Poster Corral featured research conducted by undergraduate and graduate students, postdoctoral fellows, research associates, and faculty in the Department. Participating posters were presented in the format of 'extended elevator pitches'. As audience members meandered through rows of posters, presenters were challenged to communicate research to a wider audience.

In preparation, participants considered not only verbal techniques, but also visual tools to facilitate the presentation of complex and specialized concepts to audience members with various academic backgrounds and interests. Sterling Vanderzee (PhD student, Geology) and Xueya Lu (Master's student, Geology), joint recipients of the 'Best Design' award, support finding inspiration even in unlikely places like "The Joy of Painting" by Bob Ross. Producing engaging and attractive posters without relying on text and figures increases the accessibility of information to a larger and more diverse audience.

Through the Poster Corral, student presenters have the opportunity to "see how their work fits in the bigger picture," explains Vicky Do, an undergraduate student in Mathematics and recipient of the 'People's Choice' award. And, once back in school, students can "constantly see how the methods and theories they have learned in class can be used to further improve their work."



Top: Saadan Khalid, an undergraduate student in Geology and the recipient of the 'Most Exciting Research' award. Bottom: Vicky Do

Features

Marine Marvels

Credit: Faculty of Science

by Nicole Doucette

Walking into UBC's Earth Sciences Building, you find yourself face to face with a set of very sharp teeth. These are attached to a 13-metre-long resin-cast skeleton of an elasmosaur, a majestic creature that inhabited the ocean 80 million years ago.

"We hope to ignite a sense of amazement and curiosity in visitors as they imagine this majestic sea creature swimming through a Cretaceous sea," says Kirsten Hodge, Director of UBC's Pacific Museum of Earth (PME). "Complete specimens of this marine reptile are rare, but partial and fragmentary skulls give us a nearly complete look at its fantastic features, potential diet and ecology."

The skeleton was installed in late summer 2018 and is a nod towards the PME's focus on illuminating Earth's evolution.

UBC's elasmosaur was made possible by the support of Wheaton Precious Metals, a Vancouver-based mining sector company that also supported the construction of UBC's Earth Sciences Building. The skeleton assembly and installation was led by Mike deRoos of Cetacea Contracting, a Salt Spring Island-based company that specializes in the design and articulation of marine and terrestrial skeletons, as well as science outreach.

For more information on the elasmosaur skeleton, visit: https://science.ubc.ca/news/ubc-museum-welcomes-ancient-sea-monster

To explore other exhibits at the Pacific Museum of Earth, visit: https://pme.ubc.ca/


SUNBELT
RENTALS
LOUISVILLE


WHEATON PRECIOUS METALS ATRIUM

Scanning for Answers

Barrier Lake in Garibaldi Park, terrestrial laser scanner generously loaned by Prof. Doug Stead's research group at SFU

by Andrew Mitchell & Birgit Rogalla

Alongside the crowds, a group of EOAS scientists hikes up the increasingly popular Garibaldi Lake trail to the Barrier viewpoint, carrying a terrestrial laser scanner. From there, the 250-metre-high, steep lava face inspires awe combined with worry. The Barrier holds back one billion tonnes of water from Garibaldi Lake, enough to send water down the Sea-to-Sky highway as far as Squamish if the structure were to fail. "You don't have to stand at the viewpoint for very long to start hearing rock falls; there's almost a constant frittering away of the rock," shares Dr. Siobhan Whadcoat, a post-doctoral fellow in Prof. Scott McDougall's geohazards group.

The Barrier was formed 12,000 years ago through the meeting of lava from an eruption at Clinker Peak (Mt. Price) with the Cordilleran Ice Sheet in the Cheakamus River valley.

Thousands of years later, the Barrier underwent a series of rock falls and landslides. Sometime around 1856, a massive landslide occurred, covering the area below in large boulders and providing the namesake for Rubble Creek. In 1977, a smaller landslide led authorities to relocate the town and train station of Garibaldi. "All the conditions that are thought to have caused the big 1850s and 1970s events are still in place. At some point, statistically, there is the chance for this to happen again." The possibility of a future landslide remains a significant hazard for the growing town of Squamish and the increasing population of the Sea-to-Sky region, so regular monitoring of the Barrier and its stability is important.

Over the last couple of years, Whadcoat has been involved with a project monitoring the Barrier. Before coming to UBC, Whadcoat studied rock falls on coastal cliffs, focusing on how rock fall scars evolve over time. She mapped clear patterns across a slope in both space and time. These patterns contain many clues, including information about progressive failure processes, which current slope models are either missing or do not explicitly account for.

Whadcoat's data has the potential to be used for rockfall forecasting but comes primarily from a single site. The Barrier has provided another great test site, in addition to other North American locations. "All these sites, which have different geologies, some have been engineered, some haven't, have similar patterns. These patterns require slightly different statistical models to describe the data and therefore forecast where future rock falls may occur."

Every year from June to November, a

Dr. Siobhan Whadcoat

laser scan of the Barrier is collected with a terrestrial LiDAR system. These scans are used to perform change detection analyses to build an inventory of where erosion and deposition has occurred.

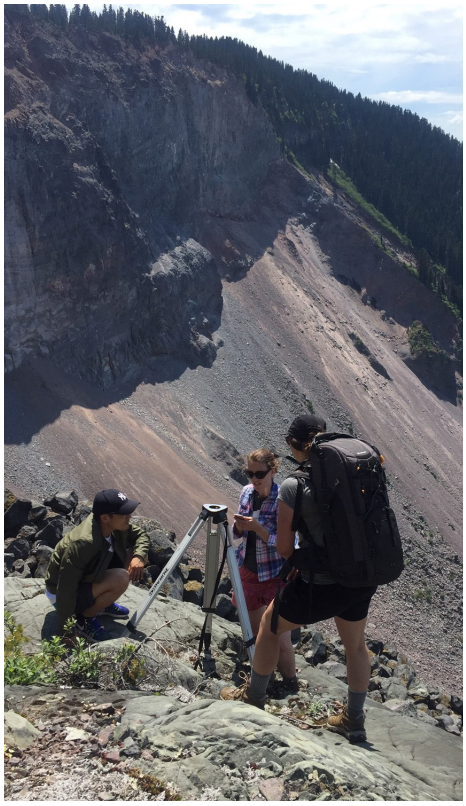
So is there anything that suggests that a big failure in the Barrier should be expected? "I was surprised by the small size of the rock falls that were coming off there. I thought that we would find some larger failures and that they would be more frequent than they have been," Whadcoat remarks.

These patterns are a result of how fractured and weathered the rock mass is, which leaves it prone to small failures. However, these are only the early stages of research to monitor the Barrier and establish an idea of the background rate of erosion at the site.

Technologies are rapidly improving and so are the methods used in geomorphology. This summer, helicopter-based photogrammetry of the Barrier may be conducted in addition to monthly LiDAR monitoring to build a complete model of the slope.

"Moving forward, we are working to develop stronger ties with industry and government bodies; they appreciate the academic input, and we really appreciate having the practical on-the-ground people who are interested in the data."

For more information on the geologic wonders of Garibaldi Park, see 'A Tale of Ice and Fire' on page 16.



Dr. Siobhan Whadcoat, Sophia Zubrycky, and Vincent An set up the terrestrial laser scanner

The Barrier at Garibaldi Park

A Tale of Ice and Fire

Fieldwork at the Lillooet glacier basalts in southwestern BC

by Andrew Mitchell & Birgit Rogalla

When we hear about volcanoes, it's often because of headline-grabbing events like the neighborhood-swallowing eruption of Kilauea in 2018, or the column of ash from Eyjafjallajökull in 2010 that disrupted air traffic across Europe. In BC, we may not see multiple eruptions in our lifetimes like people in some parts of the world, but we do have our share of active volcanoes. The legacy of volcanic activity ranges from problematic, such as landslide activity from rock left behind by past eruptions, to positive, like weathered volcanic substrate contributing to the terroir of your favourite glass of Okanagan wine.

According to Prof. Kelly Russell, one of EOAS' resident volcanologists, the active volcanoes in BC are found in two main areas, the Garibaldi Volcanic Belt and the Northern Cordilleran province. Of these, the Garibaldi Volcanic Belt, the Canadian part of the Cascadian Volcanic Belt, is right in the Vancouver's backyard. In the northern part of the province, there have been at least two notable eruptions in the past 300 years (the blink of an eye in geologic time).

Not many people are aware of the extent of past volcanic activity in the Vancouver area. When Alex Wilson started his PhD, one of his first tasks was to find volcanoes in the Garibaldi Belt. Much to everyone's surprise, he ended up identifying around 100 volcanoes between Vancouver and Pemberton, and that's a minimum estimate! Volcanic events in this area happen fairly infrequently, with the most recent significant eruption occurring around 2360 BP from Mount Meager near Pemberton. One of the questions Alex has been looking to answer is, "What is the frequency of eruptions in this area?"

The study of volcanism in the Garibaldi Volcanic Belt isn't just an academic pursuit. The volcanic arc is still hot, and while specific predictions on exactly when and where an eruption may happen aren't possible based on currently available tools, future eruptions can be expected. And, unlike the volcanoes in the northern part of the province, the local ones are more likely to erupt explosively!

The Sea to Sky Highway winds along the edge of Howe Sounds, a deep fjord north of Vancouver, coming to a broad valley at Squamish. This landscape was carved by

Eyjafjallajokull eruption in Iceland in 2010 (credit: Thorsten Boeckel)

glaciers that once covered much of the landscape. Wilson has found that this glacial history also played a role in the volcanic activity of this area.

Using computer modelling, he has shown that as the crust is weighed down and deflected downwards by glaciers, it compresses the top of the rock and extends the bottom. This allows magma to push up into fissures at the base of the crust. As the weight is removed, the crust bounces back, causing the base of the crust to compress and the top of the crust to extend. Like squeezing the middle of a balloon, the magma which rose into the base of the crust during the peak of glaciation is pushed to the surface.

This process led to the eruptions that formed the Rubble Creek and Ring Creek lava flows between Squamish and Whistler. These two massive events account for approximately 20% of the volume of volcanic deposits in the Garibaldi area. The Barrier below Garibaldi Lake is a stunning example of the landscape created as the Rubble Creek lava flow met with the ice in the valley below.

The rocks left behind by volcanic eruptions also provide a window into past climates. Wilson describes these rocks as "pillars of ancient information". Volcanic rocks left behind by eruptions through glaciers have distinct 'ice-contact signatures'. These signatures allow researchers to reconstruct ice thickness, and the rocks themselves can be dated to tell when the eruption occurred.

These clues can be used to map when and where ice was present through the Quaternary period, which is something scientists know quite little about. This record of glacial advances and retreats also offers insights into periods of warming and cooling over the past one to two million years.

Volcanoes can also be drivers of climate, a process that EOAS graduate student Colin Rowell is researching for his PhD. Along with lava and ash, volcanoes release CO_2 and SO_2 into the atmosphere. While CO_2 traps energy and heats the planet, SO_2, if it makes it into the stratosphere, reflects incoming energy from the sun and cools the planet.

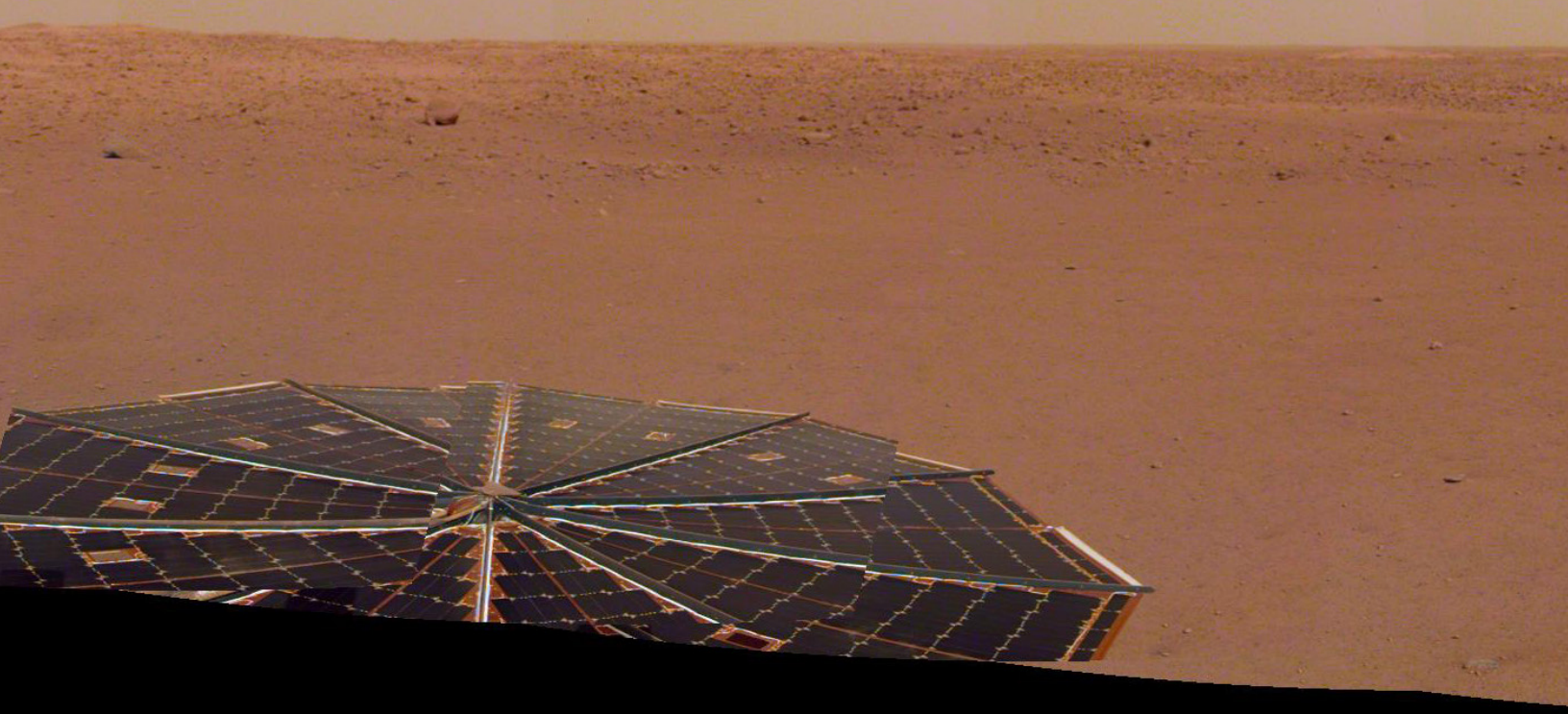
Whether or not SO_2 makes it into the stratosphere depends on how a volcano erupts, which in turn is affected by the amount of water or ice in the vicinity of the eruption. Rowell has been developing an energy and mass partitioning model to represent the interactions between ice, water, and magma and using that to feed into plume models to predict how climate-impacting gases are emitted from a volcano.

Rowell's work uses numerical models, which are constrained using observations of modern glacial-volcanic eruptions. The goal is for the resulting model to extend to a range of scenarios around the globe. One area of interest is Western Antarctica, where over 100 previously unknown volcanoes were recently discovered. Recent findings have also shown that the Western Antarctic ice sheet is becoming unstable and receding at an accelerated rate. The complexity of interactions between the receding ice sheet, volcanic activity, and climate will provide material for further study for years to come.

For more information on the geologic wonders of Garibaldi Park, see 'Scanning for Answers' on page 14.

Geologists examine an outcrop on southwestern BC's Black Tusk

Mount Cayley, a composite stratovolcano in southwestern BC



InSights from Mars

NASA's InSight spacecraft captured this panorama of its landing site on Dec. 9, 2018, the 14th Martian day, or sol, of its mission (credit: NASA/JPL-Caltech)

by Kohen Bauer & Idalia Machuca

In the summer of 1977, NASA captivated a global audience through the launch of the legendary Voyager spacecrafts, posed with the mission of conducting close-up studies of Jupiter and Saturn. Dr. Catherine Johnson, then a young child, recalls the positive impact of the Voyager mission on her own fascination with space exploration. She eagerly read the back page of the newspaper as updates on the spacecraft's observations were reported.

Now an established and award-winning professor, Johnson has worked for over a decade to establish a flourishing planetary science program at UBC. Her research group is regularly involved in space exploration missions headed by NASA and helps to inspire multiple generations in planetary science. Johnson has come full circle (or perhaps full orbit).

Prof. Catherine Johnson and her research group visit California to attend the InSight launch

On one such mission, NASA's Mars InSight, Johnson and her research group have played an integral role in both the preparatory and ongoing investigative work. The full name of the mission, Interior Exploration using Seismic Investigations, Geodesy and Heat Transport, highlights the main research techniques employed by the InSight stationary lander on Mars. The two main objectives of the InSight mission are to understand the formation and evolution of terrestrial planets, and to determine the present levels of tectonic activity on Mars.

To this end, InSight's robotic arm has deployed a seismometer to study vibrations on the Martian surface caused by Marsquakes and meteorite impacts and will sink a heat flow probe into the ground to measure the thermal conductivity of the planet's interior. The InSight lander's payload also includes a suite of supplementary instruments for additional investigations, such as a magnetometer used to study variations in the planet's magnetic

Prof. Catherine Johnson on the beach near California's Vandenberg Air Force Base, where InSight was launched

field and atmospheric sensors for weather monitoring.

In May 2018, Johnson brought her entire group, including students not directly involved with InSight, to California to witness the InSight rocket launch. "The opportunity to see a rocket launch, especially one that is about science, is really an amazing thing to behold," Johnson shares. "As it turns out, we saw absolutely nothing because it was 4 am and very foggy. Regardless, just being able to experience the atmosphere in that moment, I think, was a very cool thing for students."

The research techniques employed by InSight on Mars have long been used on Earth. These techniques have led to our present understanding of not only Earth's interior structure and dynamics, but also by inference the formation and evolution of terrestrial planets (Mercury, Venus, Earth, Mars), Earth's Moon, and rocky exoplanets.

On Earth, traces of the processes that shaped the planet's early history have been largely erased by the constant recycling of the crust by plate tectonics. Mars, on the other hand, lacks plate tectonics. The InSight mission, therefore, seeks to find clues from the interior of Mars about the early evolution of rocky worlds. These new findings are supplemented by knowledge about the Martian surface and atmosphere acquired from previous missions.

The interior of Mars is its heat engine, driving the planet's evolutionary history and governing processes like massive volcanism and tectonism. "Aspects of Mars' interior are very poorly constrained relative to our knowledge of its surface," Johnson remarks. "Something as simple as the current uncertainty in the size of Mars' iron core has profound implications for the chemical makeup of the planet and its evolution." In terms of planetary habitability, the interior of a planet dictates whether the near-surface environment may be amenable to hosting life; it is the 'generator' that powers the planet's evolution.

Johnson's team will also interpret data from the InSight lander's magnetometer, which is capable of measuring magnetic fields generated by the upper atmosphere and by rocks near the surface of Mars. These measurements act as a proxy for interior water content. Surface water and ice were more abundant and the atmosphere thicker during Mars' early history, some three to four billion years ago. Understanding the water content in the interior of the planet thus plays a key role in being able to understand the history of Mars' water, where it came from, and where it is now.

Of course, there are many reasons to study terrestrial-like planets. "As scientists," Johnson offers, "we should not be afraid to state that we straightforwardly aim to understand something better in its own right." This mission, aptly named InSight, seeks to understand the true nature of Mars. And as researchers explore the early history of rocky planets, they can start to better understand of our place within the wider context of our solar system.

"Humans are explorers," Johnson comments. "At some point, people will go to Mars." At present, the InSight lander sits 146 million km away from Earth on the lava plains of Elysium Planitia, gathering and relaying a stream of data about the Martian environment back to Earth. Looking to the future, Johnson advises subsequent generations of scientists and space wonderers and wanderers alike to "follow your heart, do what you're passionate about, and do it to the best of your abilities."

For more information on the InSight mission, visit: https://mars.nasa.gov/insight/mission/overview/

Students from a North Vancouver school attend a public talk at UBC

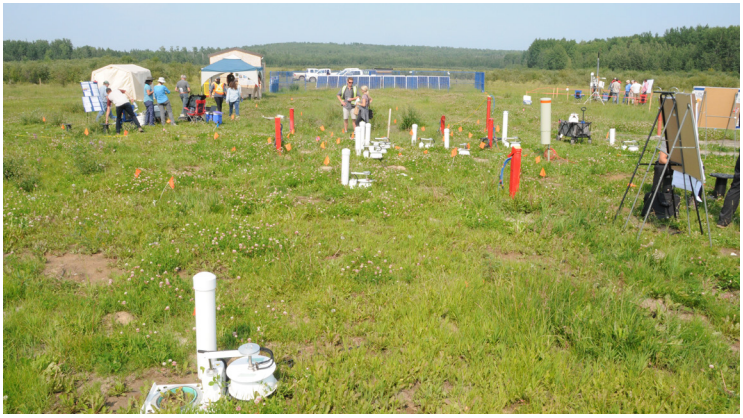
Resources for the Future

Drone photo of the Hudson's Hope Field Research Station

by David Zeko & Lindsey Rayborn

The UBC Energy and Environment Research Initiative (EERI) is a multi-disciplinary research program that works to advance our understanding of potential environmental risks posed by energy resource development. In particular, EERI investigates the unintentional release of fugitive natural gas, which can contribute to greenhouse gas emissions and affect groundwater chemistry.

Hydrogeologist Bethany Ladd is currently the project manager for EERI. We met with her to learn what EERI does, how she got involved, and where the Initiative is headed in the future.



Field demonstration day at the Hudson's Hope Field Research Station

What are some of the EERI's current projects?

There are three projects we are currently working on. One of them, headed by Master's student Elyse Sandl, is a statistical study to understand which oil and gas-related factors such as geology, drilling practices, and well attributes are associated with gas migration and to what extent.

The second project is our Hudson's Hope Field Research Station, where we conducted a controlled natural release experiment involving the injection of natural gas into the subsurface. We tracked how this injected gas migrated and will determine its impacts on a more detailed field scale.

The third project is a large scale regional study in the Peace River Region, where we are installing a network of groundwater monitoring wells to characterize groundwater geochemistry and dissolved methane in the region. These results will be used to inform appropriate groundwater monitoring strategies in light of continued resource development in the region.

What brought you to the Initiative?

Prior to starting at UBC, I worked on similar research at the University of Calgary. I met Aaron Cahill, who was to become the director of EERI, through shale gas research there. EERI formally began with Geoscience BC and Natural Resources Canada grants, which brought along my job and enabled us to fast-track our research. These advances prompted EERI to develop into the exciting multi-disciplinary, multi-university initiative it is today. I've been fortunate to be a part of

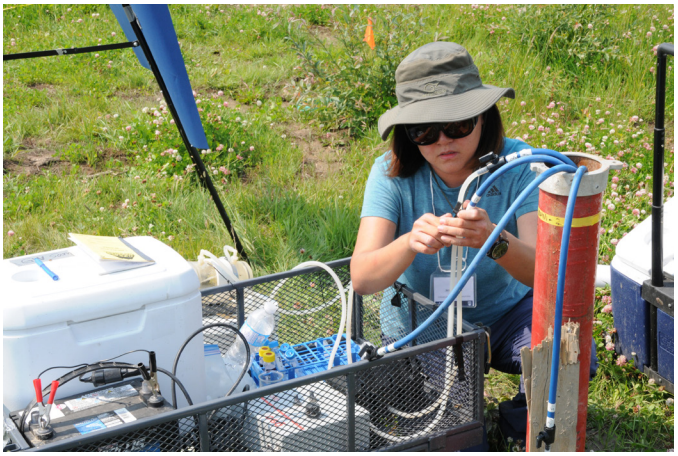
that growth as both a researcher and project manager, helping to brand the Initiative since its inception in 2017.

What is your role in EERI?

My role has developed alongside EERI. I was originally hired as a research scientist, since my background is in hydrogeology and I have shale gas research experience. More recently, my role has morphed into project manager, facilitating the research process by acting as a link between the principal investigators, students, funders, and stakeholders. I am responsible for much of the project coordination, financial management, and infrastructure design for all our experiments in addition to leading an outreach program that engages local communities and First Nations groups. Fortunately, I also get to participate in the research and do field work too.

What goals does the Initiative have regarding community involvement?

The main goal is to make sure that we put our projects out there so people know about what we are doing and why. The second goal is to invite input into our research process from people with local knowledge who have been affected by the impacts of natural gas extraction, particularly First Nations groups. We send out newsletters to the various community leaders and First Nations groups in the Peace River Region of northeast BC. We also hold semi-annual engagement events where we present what we are doing and invite the community to comment. Last time we held one of these engagement events in a coffee shop where anyone passing through was free to ask questions and provide input. We even did a field day where we went to the Hudson's Hope Research Station and invited interested stakeholders to come and see what we are up to.



UBC graduate student Jessie Chao conducting fieldwork at the Hudson's Hope Field Research Station

What is EERI's current focus, and where is the Initative headed?

Right now we are still in the midst of all three projects. The Hudson's Hope Field Research Station injection experiment is wrapping up, so we have plenty of data analysis, publication, and dissemination to do. In the Peace Region, we are in the midst of drilling and installing 30 groundwater monitoring stations, with six completed as of June 2019.

Although one of our directors, Aaron Cahill, has left for an opportunity elsewhere, he is still involved as an adjunct professor. The Dean's office, our researchers, and our funders are all very committed to the work we are doing, and I see the Initiative continuing to advance knowledge in this area for years to come.

For more information on EERI, visit: http://eeri.ubc.ca/

Drillers install monitoring wells at the Hudson's Hope Station

SFU graduate student Andrew Allen samples monitoring wells at the Hudson's Hope Station

Profiles

Renee Haggart

Director of Resources and Operations, EOAS

We hear the pinging of incoming emails in Renee Haggart's office on her first day back from a vacation in the Galápagos Islands. She enthusiastically recalls, "When a 130-year-old tortoise looks up at you, you really feel something! This tortoise knows everything about what it's doing, it's seen everything!" This statement reflects not only Haggart's admiration for the wonders of the natural world, but also the value she places on experience and foresight. Here, Haggart shares how these qualities have helped her ensure productivity and prosperity within the EOAS Department and more broadly across UBC.

by Idalia Machuca

What are your goals for EOAS?

I aspire to create an environment where people want to work and a place of which they can be proud. The EOAS administration and management staff try to provide the best support that we can for our researchers, instructors, and students. We give the structure and foundation so the rest of it can take off.

What is involved in your role as Director of Resources and Operations?

Catastrophizing, it's my specialty! Being on the lookout for potential disasters (for example, safety dangers in the field or in labs, bullying and harassment, or logistical challenges between university policies and how the department works).

Managers in charge of many areas (human resources, finance, technical services, facilities, and the museum) report to me. Though I don't manage their day-to-day administration, I'm ultimately responsible for these components. I need to be on the lookout for challenges, try to manage these along the way, and ensure that we have the best outcomes for everybody.

Tell us about your role as Safety Committee Co-Chair.

Everybody has the right to come to work (and to go home) and be safe. On our Safety Committee, we have representation not just from the EOAS Department, but also from the Dean's office, the Pacific Institute for the Mathematical Sciences, and the Statistics Department because we are all residents of the Earth Sciences Building.

The Safety Committee is responsible for making sure that people have the proper training, equipment, and knowledge. For example, the annual inspections of lab, office, and teaching spaces are mandated by the Joint Occupational Health & Safety Committee of the University and by WorkSafeBC.

Also, the fire department gives us a grade based on our evacuations during fire drills; if the drills don't go well, the Department is in trouble with the University, the fire department, and WorkSafeBC. Accidents happen, but we need to ensure we've done as much as possible to be proactive and safe while not limiting research or curtailing progress.

How do you contribute to the Department's success?

I try to have the best people on staff (administration, technical services, and human resources) to serve the Department's needs. I'm so happy with the team we have put together here, and this has a trickle-down effect on the Department. It helps us succeed! I'm also involved in several committees at the level of the Dean's office and the university. This allows me to speak on behalf of and advocate for the Department on a broader scale within the University.

Given the stressful nature of your profession, how do you relax?

I love travelling! I really like to see how other people live and to put myself in a situation where I'm not in control. As an operations manager, I spend a lot of time looking for opportunities to improve processes and systems. I like going to a big city where I'm not in charge, where I can't understand the language and have to go with the flow. I just got back from the Galápagos Islands, but you don't have to go far away to find a really great place. One of my favourite places is Cortes Island. I love it there!

Randy Smallwood

UBC Alumnus (1995)
BSc Geological Engineering

Geological Engineering alumnus Randy Smallwood has fought hard to leave his mark on the mining industry. "In my early 20s, I became passionate about the geological resources industry and how much value you can create from a bit of hard work and a bit of luck." Since then, he has built an exciting career - founding, working for, and serving on the boards of multiple companies. Smallwood is currently President and CEO of Wheaton Precious Metals, a precious metals streaming company that he helped to start. Smallwood and Wheaton Precious Metals are long-time donors to UBC, supporting the construction of UBC's Earth Sciences Building. In our interview, Smallwood reminisces about his early days in mining and shares advice for young geoscientists.

by Alan Shapiro

How did you choose geoscience?

While I was in high school, my parents bought one of the first Apple IIc computers in Canada, which put me well ahead of the computer curve. After graduating from high school, I studied computer science at Kwantlen College (transferring to Simon Fraser), but quickly discovered it wasn't my passion. After one semester, I dropped out and bounced around the job market.

I was always outdoorsy and spent most weekends hiking, camping, and kayaking. So at 22 years old when I was offered a job staking mineral claims, I was excited to get paid to work outdoors. I quickly discovered my passion for economic geology and started my own small mineral exploration services company, Alpine West Mineral Services. At 25, I started at BCIT and completed a two-year mining engineering program. When I completed that, I enrolled in Geological Engineering at UBC, graduating just after my 30th birthday.

What stands out about your time at UBC?

I was a mature student when I started at UBC. I already had my first daughter, was a single father at the time, and commuted from North Delta. I remember UBC being an open, friendly environment even for an 'old' guy like me. The beauty of the campus itself is inspiring, but what I appreciated about UBC was the really good connections into industry.

Geological Engineering has such a broad reach within the Earth sciences and gave me the ability to diversify into environmental, geotechnical and hydrogeology work. I ultimately wound up specializing in economic geology and geotechnical engineering but pride myself on being more of a generalist than a specialist. The program also helped me bridge the long-standing communication gap between engineers and geologists.

How did you get your start in the mining industry?

I had the benefit through the 80's and early 90's of working in the geological industry when companies were converting their paper and map geological databases into digital databases. While I was at UBC, I was still running Alpine West, and would spend the summers running field programs and winters with contracts to convert paper databases to digital. While at BCIT or UBC, my summers were spent working with companies like Homestake, Teck, and Westmin, and I would always come away with a contract to digitize their geological databases.

Homestake had a mine that I spent one summer working at up in north-western BC – the Golden Bear Mine. When I graduated from UBC, they were in the process of selling Golden Bear to Wheaton River Minerals, which was a small junior company based out of Toronto. Homestake recommended that Wheaton River hire me to join the exploration team. We had immediate exploration success, and over time, that 25 million dollar company eventually became Goldcorp, and out of Goldcorp we created my current company – Wheaton Precious Metals.

What is your advice for young geoscientists?

Get your hands dirty! There's no better way to learn than working in a remote location. Those job sites are where you'll learn the most and get the broadest exposure to different aspects of the resource sector. One part of the equation you have an influence on is your own effort level. My favourite quote: "Funny thing about luck? Seems like the harder I work, the luckier I get!" Work hard, and success will come.

If you're an EOAS alum, tell us what you've been up to! Submit your stories and updates to earthmatters@eoas.ubc.ca.

Meet the Writers

Kohen Bauer
PhD Graduate, Oceanography

Andrew Mitchell
PhD Student, Geological Engineering

Birgit Rogalla
PhD Student, Oceanography

In Earth science, we are part of a global community that tackles many of the complex issues affecting us today and tomorrow. - Idalia

I love being outdoors for recreation, so I tried to find a job that would take me outdoors as well. - Andrew

Why did you choose to study Earth science?

I took an elective course about volcanoes, tsunamis, and earthquakes in the first year of my undergrad at Queens University. The professor instructed us by pointing at hand written overhead transparencies using a hockey stick. I've been hooked ever since. - Kohen

I study the changes to rivers, sea ice, and circulation dynamics in the Canadian Arctic and their implications by incorporating tracers into an ocean-ice model. - Birgit

What are you studying?

I am studying how volcanic plumes become charged to produce lightning. - Lindsey

I investigate the sequestration of carbon dioxide in magnesium rich rocks by characterizing the mineralogical and chemical changes recorded in those rocks. - David

Lindsey Rayborn
MSc Student, Geophysics

Idalia Machuca
MSc Graduate, Oceanography

David Zeko
MSc Student, Geological Sciences

What's your favourite Earth science-related fact?

50 percent of the global fish catch comes from coastal regions that occupy just 1 percent of the ocean! - Idalia

If the Earth's history were compressed into a single year, humans wouldn't appear until 11:40 pm on New Year's eve. - Andrew

The fact that some volcanic eruptions are accompanied by lightning is amazing to me. - Lindsey

Why is science communication important?

Science communication is how science works. It is the way we move science forward. - Kohen

To me, science communication is the empathetic link between the subject expert and someone who may stand to benefit from this new knowledge. - David

Communication with scientists in other fields and the public is important because sharing information and ideas can make answers to scientific questions more robust. - Birgit

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