McGill University

Alumni Newsletter #22 January 2019

Crystals form the building blocks of much of our world. Studying them closely lets us understand the structure of biomolecules of things like our bones and muscles, medications, and even chocolate.

Here are five things you might not know about crystals and crystallography

1. Crystallography takes the prize

The father and son combination of father William Henry Bragg and son William Lawrence Bragg first revealed the structure of salt and won the Nobel Prize in Physics in 1915 for their services "in the analysis of crystal structure by means of x-ray." So far, the Braggs are the only father and son team to receive a Nobel Prize. In fact, crystallography is the science or discipline directly attributable to winning the most Nobel Prizes, taking the award 28 times.

X-ray crystallography has developed at a rapid pace in the last 20 years. Scientists first used the technique over 100 years ago when they determined the crystal structure of salt.

In essence, the method involves placing a tiny crystal in the path of an x-ray beam. As the x-ray passes through the crystal, the radiation is diffracted into a pattern by the atoms that make up the molecules in the crystal structure.

The diffraction pattern is like a fingerprint that identifies not only the nature of the atoms and bonds in the molecules, but also their three-dimensional arrangement. It is the only analytical method that can achieve this level of analysis in such a complete and unambiguous fashion.

2. Around 90 percent of all drugs are crystals
That's because it's much easier to control the solid state of a crystalline structure—even using a gel would involve crystals that are suspended in a gooey substance to aid the delivery of the drug involved. Some drugs that are injected would also be comprised of small crystals as crystalline materials can be arranged in different ways, under different conditions, to create the required effect.

If you take a tablet, it has to dissolve in your gut and get across the gut wall into the bloodstream. How the crystals in the drugs are composed will define how readily they will dissolve in your gut. If you get the wrong form, the drug might go all the way through the body, or dissolve in the wrong place and be useless.

3. They're in our eyes and bones
For example, most of the rods and cones in your eye that conduct the light or form an image are made of crystals. Around 65 percent of the bone mass of an adult is made of hydroxyapatite crystal.

4. Chocolate is crystalline
The National X-ray Crystallography Service at the University Southampton has done a number of experiments on the crystalline structures of chocolate. The cocoa butter added controls the crystallinity and that is important because there are six different crystalline forms of chocolate.

The one that most chocolate wants to be—the most stable form—is the unappetizing one with the white coating on the top. Playing around with the amount of cocoa butter affects the crystalline nature of the chocolate, which is how to get different forms, tastes, and textures.

5. We owe fireworks to crystals
The problem with explosive powders, or other substances like nitroglycerine, is their volatility. However, if they were to be created in a more stable solid state, they would be safer to transport and easier to control.

One solution, discovered at the University of Southhampton, is to move toward a different kind of high-energy material by growing crystals with firework-type properties in a scaffold or lattice-like structure, which stays stable. The material features channels and voids where different dyes can create different colors. Putting nitroglycerine within such a structure would allow it to stay stable longer.

The applications for this kind of firework are not just for entertainment or defense. The airbags in our cars are also initiated by energetic materials that are all mini fireworks, so there are many civilian applications for these crystals as well.

Note from the Chair

Dear Friends and Alumni,

As I pass the halfway mark of my term as Department Chair, I have found myself thinking about how our community makes the Department great. Not only do we have a very engaged group of faculty and students in the department, but an incredible extended community of alumni and friends who continue to give back to the department.

Over the past year, we have benefitted enormously from the very strong financial support provided through gifts. Bob Wares donated a transformative gift to the department that is already engaging and accelerating the Department's research and outreach. In addition, support continues to come from ongoing gifts and there are many first-time donors this year through the #McGill24 online campaign. Thank you for all the support – it is humbling to see such generosity for our department.

This support from our community doesn't only come in the form of financial generosity, but also in generosity of time and support. Alumni Don Bubar and John Prochnau returned to the Department and gave inspiration presentations on their careers, including great advice for our current students. Anne, Angela and Kristy in the main office continue to support our students not only with their paperwork, but helping to organize great department events that let our community interact and get to know each other. These include our Fall picnic, the largest staff and friends Holiday dinner ever, an epic graduation party, and the annual Homecoming Weekend Wine and Cheese!

A special welcome to Professor Nagissa Mahmoudi, a new faculty member in the department. Nagissa's research focuses on geomicrobiology, a field that studies how biological processes can drive and catalyze geological processes. Her specialization focuses on microbial processes in sediments and in the breakdown of contaminants in the environment. Join me in welcoming Nagissa!

If you are attending PDAC or live in the Toronto area, please come to our annual alumni event on the evening of March 4, 2019 (5:00 – 8:00 pm – Intercontinental Toronto Center). It is a great event to catch up with old friends and meet more members of our EPS Community.

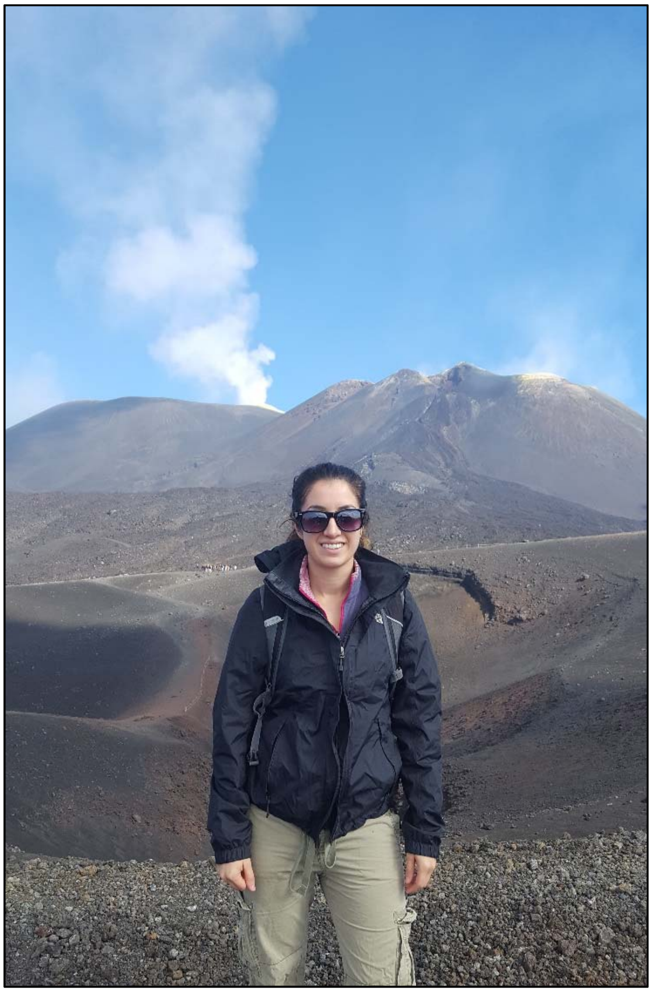
And finally, I'm always excited to talk about the department – you can contact me at jeffrey.mckenzie@mcgill.ca. And, please continue to support the department (visit http://eps.mcgill.ca and click on 'give now').

Sincerely,

Jeffrey McKenzie
Chair, Earth and Planetary Sciences

New Faculty

Nagissa Mahmoudi – Assistant Professor



I joined the Earth and Planetary Sciences Department in August 2018. As a geomicrobiologist, my research lies at the intersection of biology, chemistry and earth science. Microorganisms are found almost everywhere on Earth and have radically altered the chemistry of this planet, making it habitable for all other life forms including us. I use a variety of field and laboratory based tools to study microbial processes that mediate carbon cycling in marine environments. Specifically, my research focuses on the activity of heterotrophic bacteria that break down organic matter and release carbon dioxide (CO_2) as a byproduct. These bacteria are the main producers of CO_2 in ocean and have the potential to alter how carbon is processed and stored in the ocean. The information produced through this research provides insight into the microbial mechanisms that regulate large-scale carbon fluxes in marine environments.

I am in the process of setting up a Geomicrobiology Laboratory in the EPS department that will include facilities to carry out a suite of isotopic, geochemical and microbiological analyses including the extraction and analysis microbial lipids and nucleic acids, the isolation and cultivation of microorganisms as well as large-scale bioreactor incubations. The overall goal of my research program is to understand the fundamental controls on heterotrophic activity as well as the metabolic pathways and ecological interactions that underpin carbon cycling in the ocean.

I completed my undergraduate degree in biology at the University of Toronto where I first became interested in environmental microbiology. I then went on to graduate school at McMaster University where I earned a PhD in Environmental Geochemistry and broadened my knowledge of biogeochemistry. Before joining McGill, I was a postdoctoral fellow at Harvard University where I developed novel isotopic tools to test the mechanistic links between microbial activity and the fate of sedimentary organic matter. I'm excited be back in Canada and look forward to working with students and faculty in the EPS department.

Photo = Mount Etna

BEDROCK SUPPORT FROM A MINING MAVEN

Noted Canadian geologist Bob Wares, BSc'79, DSc'12 (Photo: Owen Egan)

When you consider that Bob Wares' University education played a role in his discovery of one of Canada's largest single deposits of precious metal, it's tempting to say that his McGill experience was worth its weight in gold.

Clichés aside, Wares, BSc'79, DSc'12, remains grateful for the skills he acquired as a student in the Department of Earth and Planetary Sciences in McGill's Faculty of Science. Those formative years led to a distinguished career in mining, highlighted by the discovery of the Canadian Malartic bulk tonnage gold deposit in northern Quebec.

As a way of giving back, the noted Canadian geologist is making a landmark $5-million gift that will support research programs, fellowships, innovative research, lecture series and outreach efforts in McGill's Faculty of Science, with a particular focus on his home department, Earth and Planetary Sciences (EPS).

The gift will provide immediate impact for students and faculty in five targeted areas:

- the Wares Science Innovation Prospectors Fund, designed to support innovative, high-risk research by funding up to four promising projects a year from researchers across the Faculty of Science;

- a Recruitment and Outreach Coordinator Fund, supporting the activities of a coordinator to liaise with CEGEPs and high schools in an effort to attract more students to EPS studies at McGill;

- the Wares Field Study Fund, supporting field studies Canada and abroad for EPS students;

- the Wares Postdoctoral Fellowships, which will provide funding for up to four EPS postdoctoral fellows each year pursuing earth science research;

- an Annual Lecture Fund, to bring globally renowned keynote speakers to Montreal to discuss earth science topics or areas of research.

"We would like to thank Bob Wares for this exceptional gift and for his continued support of McGill," said Suzanne Fortier, Principal and Vice-Chancellor of McGill University. "This donation will make an immediate impact on our Faculty of Science and will greatly enhance important research, education and out-of-classroom student experiences in the Department of Earth and Planetary Sciences."

The motivation for the gift comes from Wares' affinity for the most enduring aspects of EPS that formed the basis of his education.

"What I remember most about McGill is that we had very capable, dynamic young teachers," says Wares. "They molded our entire education. More than that, they taught us how to think."

Wares fondly recalls his time at the University as part of a small EPS cohort who studied together, played squash (sometimes with EPS faculty), and took many fields trips which proved invaluable to his development as a geologist (although as a student living on a shoestring budget, it was a struggle to find the money to pay for the trips).

"I want to bring back a strong field-based approach to EPS," he says. "One of our objectives with this gift is to boost field trips."

After graduating from McGill, success did not come easily for Wares. In 2003, he and two associates founded Osisko Mining Corporation. They had an innovative plan to discover and mine low-grade gold on a large scale in the Abitibi region of Quebec, but the mining industry establishment wasn't impressed and financing was tough to find.

"Everyone told us we were nuts, that it was going to be a train wreck, that it couldn't be done," says Wares.

Eventually they managed to find investors willing to take a risk and the rest, as they say, is history. The fledging company discovered and developed Canadian Malartic, located 25 kilometres west of Val-d'Or, and turned it into the largest operating gold mine in the country, with initial reserves of 11 million ounces gold. Now widely recognized as a mining industry leader and innovator, Wares has been dubbed a 'rock star' because of his remarkable success in assessing, finding and launching various mining projects over the course of his 40-year career. In 2012, Wares received an Honorary Doctorate from McGill in recognition of his achievements in the field of applied economic geology.

A lifelong connection to his alma mater has accompanied Wares' success. He has consistently supported McGill, contributing to the Faculties of Science and Medicine. In 2009, Wares and his company, Osisko Mining Corporation, contributed $4.1 million to endow two faculty research awards, undergraduate and graduate level scholarships and a field trip fund in the Department of Earth and Planetary Sciences, with part of the gift matched by the J.W. McConnell Family Foundation. Wares has supported McGill every year since 2009 and his latest gift brings his total McGill support to date to $10 million.

"When you make money based, in large part, on your education, part of the exercise is to give back," he says.

As a volunteer and member of the Faculty of Science Advisory Board, he has also been generous with his time and insights and he continues to join field trips with EPS staff and students. Three years ago, he took a group of students, faculty and alumni on a geo-safari to South Africa. Next May, he's off to Australia on yet another EPS expedition.

"Working with students is exciting and satisfying and always makes you feel young again," he says. "I wish other McGill alumni would do the same."

"Bob has had a tremendous impact on our Faculty and I am grateful for his involvement, his ideas, and his perspective as a business leader," said Bruce Lennox, Dean of the Faculty of Science. "His continuing commitment to our students and researchers is an invaluable asset, particularly to Earth and Planetary Sciences."

September 26, 2018
McGill Alumni

YOUNG RESEARCHERS CAN DIG DEEPER

Timothy Gibson’s geology research takes place in far-off locations and difficult conditions. But you won’t hear him complain. Thanks in large part to the Eric Mountjoy Fellowship, Gibson (pictured above) spent several months on the northern tip of Baffin Island in Nunavut, completing fieldwork for his geology thesis. Helicoptered into Arctic polar bear territory, he worked on about 20 different sites.

Thanks to this fieldwork, he was able to date an algae fossil that is the first example of a multi-cellular organism to use photosynthesis. It turned out to be about 150 million years younger than scientists had previously thought, about a billion rather than 1.2 billion years old.

That discovery made it into the journal *Geology* and to mainstream news in 2017. “Overall, we’re looking at sedimentary rocks, trying to determine their age, and also understand the environments in which they were formed,” explains the new Dr. Gibson – he graduated from the Department of Earth and Planetary Sciences in spring 2018.

Gibson was the inaugural recipient of the Eric Mountjoy Fellowship in 2013. Although he never had the chance to meet the fellowship’s namesake professor, Gibson feels a certain kinship; in particular, he describes a shared approach to research. “Eric did a lot of the seminal work on the sedimentology of the Canadian Rockies, and he’s definitely an inspiration for me,” says Gibson, who’s originally from West Virginia. “Like him, I’m a sedimentologist looking at big picture questions.”

The Eric Mountjoy Fellowship was established by Earth and Planetary Sciences alumni, as well as colleagues, friends and family of Professor Mountjoy (pictured above), including his widow, Anita Mountjoy, BN'66, MSc'76. Together, they honoured Professor Mountjoy's memory by enhancing funding for outstanding graduate students in the department where he made his career.

Anita Mountjoy, herself a former faculty member in McGill's Ingram School of Nursing, proved her unwavering support when she set up a bequest in support of the fellowship through McGill's Bequests and Planned Gifts program. Without the fellowship, Gibson says, "I would have either had to go elsewhere or waited to start grad school at a later date."

Mrs. Mountjoy (pictured below with Gibson) was a constant throughout Gibson's research adventures and successes. She often took him for lunch at local haunt Amelias Pizza, and even attended his thesis defense.

Despite the inherent challenges of the environment, including an August storm that dumped a half-metre of snow on his campsite, Gibson loved the opportunity to work in the Arctic: "It's an absolutely incredible destination," he say. "Being there in the summer when the sun doesn't set, it just swings around overhead, is really energizing; you can potentially work 20 hours a day." Gibson describes working on sea cliffs, seeing beluga whales, narwhals, and enormous icebergs: a truly unforgettable experience.

"If you have the skills to access remote areas, there are a lot of outstanding research questions to be solved," he says.

McGill Giving
Opportunities that Open Doors
October 20, 2018
https://www.mcgill.ca/giving/why-giving-matters/publications/2018-report-giving/young-researchers-can-dig-deeper

Dawson Chair
Earth & Planetary Sciences
John Stix

John Stix and his Ph.D. student, Fiona D'Arcy, at the erupting Turrialba volcano, Costa Rica

The Department of Earth and Planetary Sciences nominated John Stix for the Sir John Dawson Chair.

John Stix is an internationally recognized expert in volcanology. A hallmark of his research is the breadth and multidisciplinary approach, from laboratory studies to petrographic investigations to field studies, with locations across the world. John Stix is one of the world's foremost experts on the eruptive behavior of volcanoes, including caldera formation, magma replenishment, and degassing processes. He has almost 100 publications, including journals such as *Nature*, *Nature Geoscience*, and *Geology*. Furthermore he is the co-editor of the seminal "Encyclopedia of Volcanoes".

As a faculty member, John Stix has been equally impressive - he has been Chair of the Department of Earth and Planetary Sciences, and is an exemplary teacher having won both the Yaffe and Principal's teaching awards. John Stix embodies Dawson's scientific and university contributions and he is very worthy and well deserving of this honor.

Sir John William Dawson (1820 – 1899)

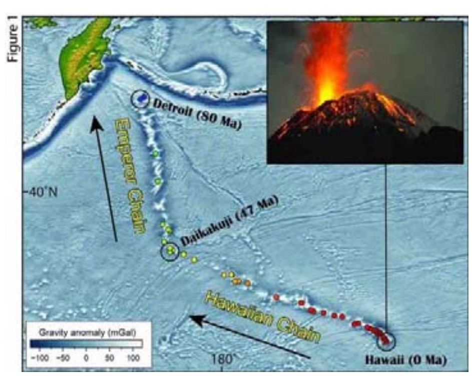
Sir John William Dawson, (born Oct. 30, 1820, Pictou, Nova Scotia [now in Canada]—died Nov. 20, 1899, Montreal, Que., Can.), Canadian geologist who made numerous contributions to paleobotany and extended the knowledge of Canadian geology.

During his term as superintendent of education for Nova Scotia (1850–53), Dawson studied the geology of all parts of the province, making a special investigation of the fossil forests of the coal-bearing strata. In the same year that he published the results of his studies in Acadian Geology (1855), he became professor of geology and principal of McGill University, Montreal. During the following 38 years he transformed McGill from an understaffed, insignificant school into a progressive university with a worldwide reputation. In addition, he maintained a rapid pace of scientific writing, averaging more than 10 papers a year, and he helped found the Montreal Normal School, serving as its principal for 13 years.

Principal Dawson's career spanned the transformation of science from a fixed curriculum of "natural philosophy" to an array of professional disciplines focused on research. Like his predecessors, he wrote on subjects from farming to philanthropy, but he also earned a solid reputation as a geologist, equally at home on a cliff, chipping out samples, or in his study, synthesizing and interpreting the processes of geological time. He was the leading expert of his day on early FOSSIL PLANTS and took special pride in his identification as a coral of Eozoon canadense, thought to be the oldest nonplant fossil known: always controversial, it was not for another 50 years that Eozoon was shown to be a rare crystal formation rather than a living animal.

As well as a modernist in science and education (eg, admitting women to McGill), Dawson was a devout Christian and the leading anti-Darwinist of the late Victorian period. As a geologist, he knew the Earth was very old (100 million years and perhaps older); but he could not see, from his direct knowledge of the fossil evidence, that new species had actually evolved out of earlier ones. Many of his books were technical criticisms of Darwinism and attempts to reconcile up-to-date science with the Christian scriptural tradition. Since the theory of EVOLUTION lacked any mechanical explanation until the science of GENETICS appeared in the 20th century, Dawson's being wrong does not diminish his historical importance. The remoteness of Canada and McGill's newness did not prevent Dawson's leading one faction in the greatest scientific controversy of his day. His international reputation added strength to his mission to establish in Canada the institutions of up-to-date science: higher degrees, lifelong research and publication of research results.

In 1859 he announced his discovery of the then-earliest-known land plant, Psilophyton, which he found in Devonian strata (dating from 408 to 360 million years ago). In Air Breathers of the Coal Period (1863) he described newly discovered fossil animals. Dawson was knighted in 1884.



The Hawaiian-Emperor Chain is an example of a hotspot track – a trail of volcanic islands and seamounts created on a lithospheric plate as the plate slowly shifts over a spot of localized melting sourced by a jet of hot material rising from the deep mantle (mantle plume)

Read more: http://www.geologypage.com/2017/06/mysterious-bend-hawaiian-emperor-chain.html#ixzz4jzGl3TIg

Scrapbook - 1968? Article – Origin Unknown

In the making of McGill

Geological sciences played large part

By P. R. EAKINS,
Associate professor of mineral exploration,
Department of Geological Sciences,
McGill University.

In 1854 the board of governors of Mc-Gill College approached Sir Edmund Head, Governor-General of Canada, on the matter of finding a new principal for McGill.

Very much to their surprise, indeed almost to their alarm, Sir Edmund recommended not a distinguished English scholar but a young colonial geologist from Pictou, Nova Scotia, **J. William Dawson.**

Mr. Dawson was not without experience in educational affairs, for he had recently completed a 3-year term as superintendent of education for the colony of Nova Scotia, and had assisted in the reorganization of the University of New Brunswick. In the world of science of the time he was gaining a considerable reputation as a geologist and naturalist.

After some debate, Mr. Dawson was appointed principal. Thus began a career as one of Canada's outstanding educators and scientists, a career which saw 38 years of active service to the Canadian community.

During this period William Dawson was to build McGill into a university of international repute, introduce vigorous programs for the education of women in Canada, and act as founding president of the Royal Society of Canada. At the same time he continued to produce important scientific works such as the first comprehensive survey of Prince Edward Island, and to write many popular articles and books rationalizing the conflicts between science and religion that raged at the time.

Practical needs

Sir Edmund Head's advice proved very sound. William Dawson recognized the needs in his native land for practical scientists and engineers to develop the vast nation that became Canada in 1867. He worked closely with Sir William Logan, first director of the Geological Survey of Canada, to evolve a university that could produce the geologists and mining engineers the country so desperately needed.

J. W. Dawson was richly and deservedly honored by knighthood, honorary degrees, and the rare privilege of being at different times president of both the American and British Associations for the Advancement of Science. He was to die quietly at the end of the century in a home close by his beloved McGill and its Peter Redpath Museum. This he had personally worked very hard to establish as one of the great natural science museums of its time in North America.

Sir William's son, **Dr. George Mercer Dawson,** was a geologist as great if not greater. Through geological explorations and as third director of the Geological Survey of Canada, he opened up much of Western Canada.

G. M. DAWSON
Director, Geological Survey

George Dawson was literally a "child of McGill University", learning his love of nature on the wilder parts of the McGill campus of the day, playing along the alder-lined banks of the stream that flowed down across what today is the location of the McGill physical sciences and engineering buildings.

A man of poor health but a strong heart, he came to be the beloved "Little Doctor" of the Klondike prospectors — he was the Dawson of Dawson City. His sudden and untimely death at a relatively young age in 1901 shocked the nation.

One of Canada's internationally known geologists, **Frank D. Adams,** began his active teaching career at McGill in the 1880s. He pioneered the use of the petrographic microscope in Canada, and won renown for his original work upon the flow of rocks under experimental conditions around the turn of the century. He was president of the 12th international geological Congress which came to Toronto in 1913. He was the first director of the graduate school at McGill, Logan Professor of geology, and finally retired in 1922 as vice-principal. He remained active over the next 20 years, producing the first geological map of Ceylon, the defenitive history, "Birth and development of the geological sciences", and incidentally a history of Christ Church Cathedral, Montreal.

The chairman of McGill's geological department in the twenties was **J. Austen "Bankie" Bancroft,** a dynamic teacher and enthusiastic economic geologist. He left McGill in the late twenties for southern Africa, where he carved out a niche as Grand Old Man of southern Africa geology consulting for the Anglo-American Co. He brought many men out from Canada to work in Rhodesia and South Africa, and sent many South African geologists to McGill for graduate studies. The link he forged between Canadian and South African geologists still exists, long after his death.

Various deanships

Vice-principal O'Neill of McGill held at various times the deanships of science, graduate studies, and research and engineering, as well as the chair of the department of geological sciences.

A McGill graduate, he was geologist to one of the early Canadian government expeditions to the Arctic. He went north in 1913, to come out in 1915 and discover a great war was raging. Later he had a distinguished career as an economic geologist as well as influential educator.

Thus over nearly 100 years, from J. W. Dawson to J. J. O'Neill, geologists sat in high places at McGill University, each influencing its development as well as contributing to their surrounding community, profession and country.

Seeking data on McGill history

Professor Eakins is engaged in the compilation of a history of the geological sciences at McGill University. This delves into the influence of geologists at McGill as well as their contribution to geological developments in Quebec, Canada and the world.

In connection with this a standard biography form has deen developed, to provide a means of recording the biographical details of McGill geologists, past and present. The cooperation of all is requested, to provide records which will be deposited with the University Archivist, in the interest of future generations of McGill geologists and historians. Any additional material such as photographs would be appreciated. Material deposited can be treated as confidential for periods of up to 30 years.

McGill Student Chapter of the Society of Economic Geologists (SEG)

Mongolia 2018

A convoy of 2 Russian vans hurtled through the desert on their way to Southern Mongolia and the Gobi desert. Happily housed within the vans were a total of 7 graduate students from McGill University's EPS department as well as 2 graduate students, a research associate and a professor from the Mongolian University of Science and Technology. This was to be the beginning of an unforgettable journey.

Our trip started outside of the famous Oyu Tolgoi Copper-Gold Mine. Our guide for the day was Garamjav, the man who originally discovered the Oyu Tolgoi deposit and a living legend in Mongolia. He'd flown-in specially from Ulaanbaatar to spend some time with us. The day was spent surveying a large granitic intrusion on the outskirts of the Oyu Tolgoi Mine. The intrusion itself was interesting in the sense that it contained large surficial swirling structures up to several kilometers in diameter. The Buddhist temple where we had lunch that day was built upon the epicenter of one of the swirling structures and is regarded by Mongolians as a mystical "energy center". In the whereabouts of the temple we observed flowing peridotite streams studied for their Rare Earth Element (REE) enrichment. Later that day we retreated to a geology mapping camp consisting of a group of traditional Mongolian tents or gers in the middle of the desert. Here Garamjav talked to us about his discovery of the Oyu Tolgoi deposit, discussing how he'd triangulated the location of the deposit based on the reported locations of other gold prospects in the region. We celebrated that night under the starry desert sky over a sumptuous meal of mutton and vodka and engaged against our better judgement in traditional Mongolian wrestling and singing. Our trip had started in stellar fashion.

Over the next few days we continued to travel around southern Mongolia. We visited Xanadu Mine's exploration camp that was drilling for copper in the Kharmagtai region of Mongolia and were brought-in to see some recently obtained chalcopyrite-rich drill core from a nearby porphyry deposit. We also visited a coal mine near to Tsottsetsii village where we got to see open-pit mining of a coal seam which was several meters thick and extended for over a kilometer. We also got to see how coal was crushed and separated based upon density into coking coal, thermal coal or waste product. We learnt that the coking coal is generally high grade and shiny in appearance and is shipped off for steal manufacturing whilst the thermal coal is duller and is burned on site to generate energy for the surrounding townships.

We left the coal mines in a trail of soot headed east for the eerie, dusty mining camp of Olon Ovoot orogenic gold deposit. The Olon Ovoot deposit consisted of highly deformed Silurian to Devonian sedimentary and volcanic rocks. Gold here was mainly transported in hydrothermal fluid along large shear zones and is commonly enriched in quartz-carbonate and quartz-tourmaline veins. Whilst in the region, we also made sure to visit Flaming Cliffs, a paleontological site near to Olon Ovoot, where several important dinosaur fossil discoveries have been made. The hematized sandstones looked magnificent against the clear blue desert sky. However, our search for fossilized Protoceratops eggs was cut short by a sand storm and we were forced to retreat to the warmth and shelter of our gers for the night.

Along the southern leg of our journey we also encountered the Mushgai Khudag REE outcrop, a mound consisting mostly of phlogopite, fluorite and REE-enriched apatite mineralization. We even had the chance to quickly visit a small fluorite mine as we were leaving the desert on our way back to Ulaanbaatar. We were pleased reach our stylish hotel in Ulaanbaatar as the day was ending, just in time for a much-needed shower and some sleep.

Upon waking the next morning, we immediately departed for the Boroo placer Gold Mine just north of Ulaanbaatar. We were kindly greeted in the Boroo mine by the local geologists who invited us to a delicious lunch followed by a tour of the mine. We observed how the gold-rich soil at the mine was excavated by tractors and dumped in a pile for processing. A water gun was used to manually wash the soil into a large, turning wheel where the gold-rich grains were then sorted-out by gravity. We were impressed to see that many of the mined-out open pits at Boroo had been rehabilitated and repurposed for growing local crops such as potatoes. Whilst still hot and arid, the countryside in Boroo can sustain more vegetation than the Gobi Desert to the south of Ulaanbaatar.

The last stop on our tour was the massive Erdenet porphyry granodiorite-hosted deposit, the fourth largest copper deposit in the world. The trip concluded with a tour of the processing plant and the drill core shack of the Erdenet deposit followed by an invitation to see a live blasting at the Erdenet open pit. All of a sudden in the midst of smoke and explosions, our fantastic Mongolia trip was over. As we made our way from the Erdenet mine back to Ulaanbaatar we stopped along the way to have one last mutton-themed meal and celebration with our Mongolian hosts who we'd come to know as good friends over the course of the trip. Mongolia holds a truly special place in our hearts.

EPS Student Participants: Jethro Sanz-Robinson, Philippe Drouin, Duncan McLeish, Nick Ogasa, David Martineau, Regina G. Moguel and Sarah Bodevi

McGill & Earth & Planetary Sciences

PRESENT THE 3rd ANNUAL

EPS RESEARCH SYMPOSIUM

SEPTEMBER 14 from 9:30 AM to 3:30 PM

Session 1 : Earth and Planetary Surface Processes (FDA 232)

9:30AM Jeff McKenzie • 9:45AM Richard Léveillé
10:00AM Natalya Gomez • 10:15AM Nick Cowan

10:30 AM to 11:30 AM : Poster session 1 (in front of the lounge)

Pascale Daoust • Debarati Das • Anna Hayden • John Onwuemeka
Andres P-wave • Monika Rusiecka • Caroline Seyler • Jon Stix • Robert Wu

Session 2 : Tectonics and Biogeoscience (FDA 232)

11:30AM Christie Rowe • 11:45AM Bill Minarik
12:00PM Peter Douglas • 12:15PM Nagissa Mahmoudi

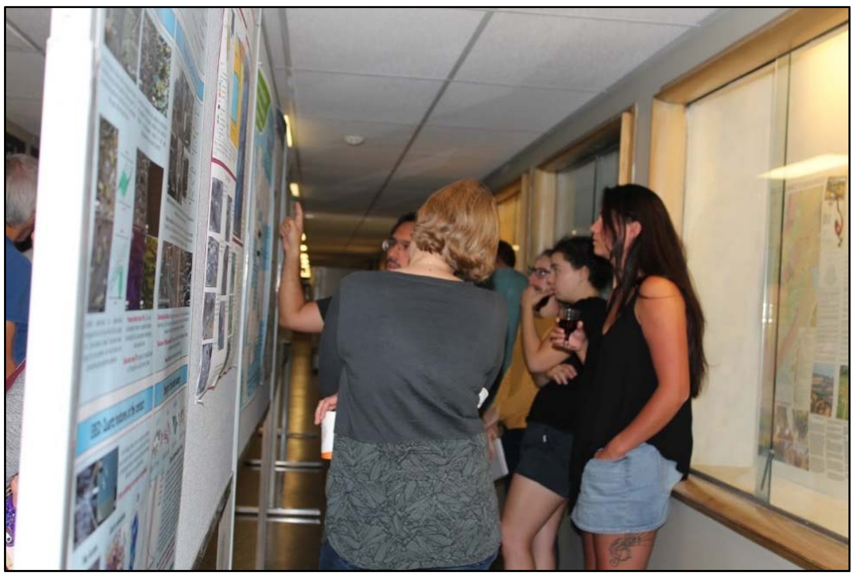
12:30 PM to 1:30 PM : Free lunch for all departmental members!

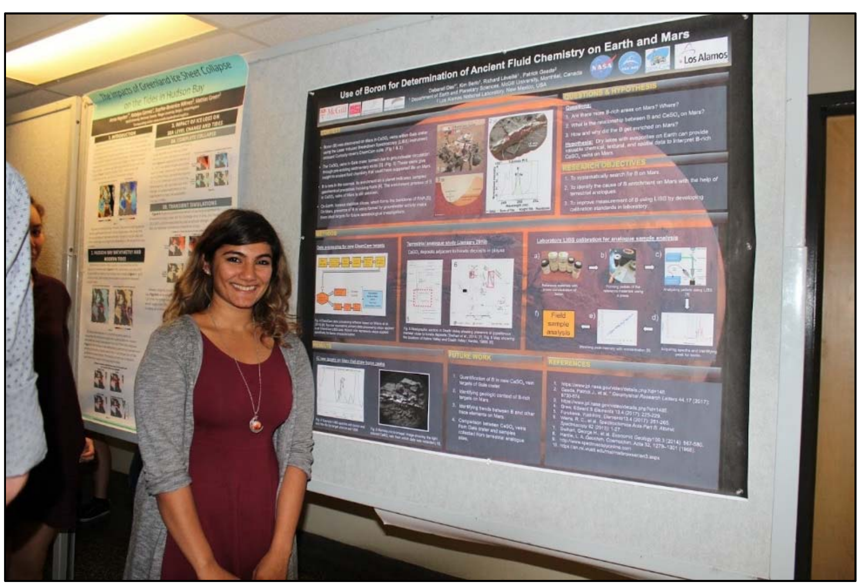
Session 3 : Earthquakes and Petrology (FDA 232)

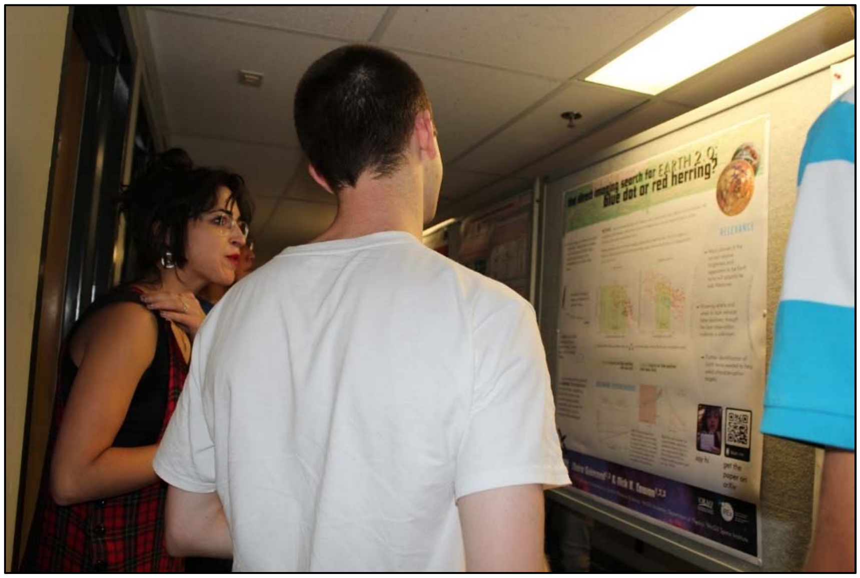
1:30PM Yajing Liu • 1:45PM Jamie Kirkpatrick
2:00PM Don Baker • 2:15PM Kim Berlo

2:30 PM to 3:30 PM: Poster session 2 (in front of the lounge)

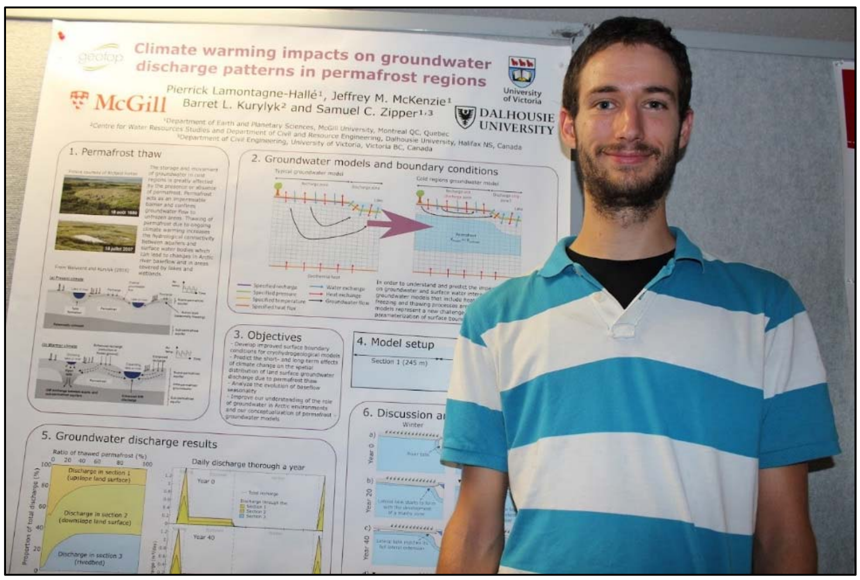
Lise Alalouf • Alexis Beaupré-Laperrière • Sam Carruthers
Erin Gibbons • Claire Marie Guimond • Pierrick Lamontagne-Hallé
Nicholas Ogasa • Noah Phillips • Shane Rooyakkers



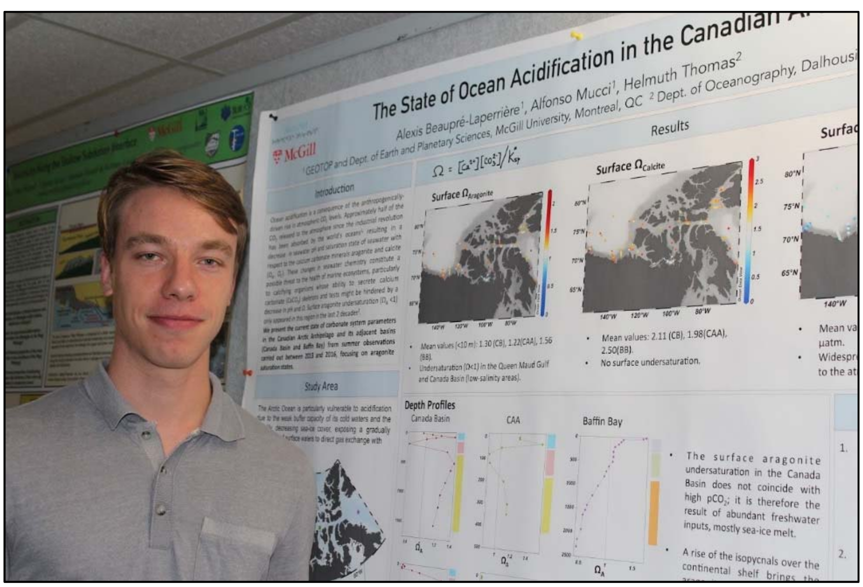

The Impacts of Greenland Ice Sheet Collapse
on the Tides in Hudson Bay
Use of Boron for Determination of Ancient Fluid Chemistry on Earth and Mars
Los Alamos
QUESTIONS & HYPOTHESIS
RESEARCH OBJECTIVES



Blue dot or red herring?



Climate warming impacts on groundwater discharge patterns in permafrost regions
McGill
Pierrick Lamontagne-Hallé1, Jeffrey M. McKenzie1
Barret L. Kurylyk2 and Samuel C. Zipper1,3
University of Victoria
DALHOUSIE UNIVERSITY
1. Permafrost thaw
2. Groundwater models and boundary conditions
3. Objectives
4. Model setup
5. Groundwater discharge results
6. Discussion a



The State of Ocean Acidification in the Canadian
Alexis Beaupré-Laperrière1, Alfonso Mucci1, Helmuth Thomas2
GEOTOP and Dept. of Earth and Planetary Sciences, McGill University, Montreal, QC 2 Dept. of Oceanography, Dalhousi
McGill
Introduction
Results
Surface Ω Aragonite
Surface Ω Calcite
Mean values: 2.11 (CB), 1.98(CAA), 2.50(BB).
No surface undersaturation.
Study Area
Depth Profiles
Canada Basin
CAA
Baffin Bay
The surface aragonite undersaturation in the Canada Basin does not coincide with high pCO2; it is therefore the result of abundant freshwater inputs, mostly sea-ice melt.


Ask me about
tides in Hudson Bay!

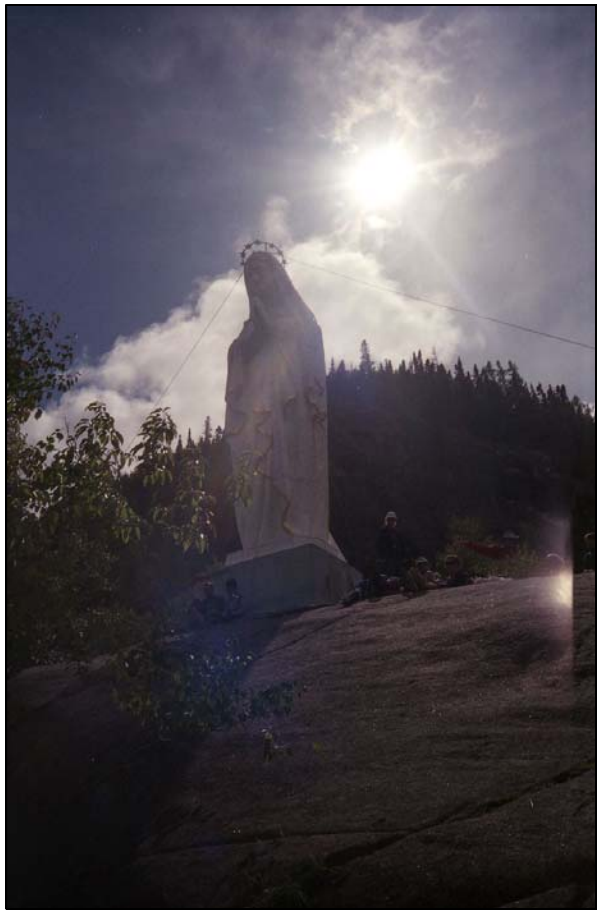
Organizing Committee: *Lauren Somers (Ph.D. student), Jeffrey McKenzie, Peter Douglas, and Pierrick Lamontagne-Halle (Ph.D. student)*

Jeffrey McKenzie, ***1^{st} Prize - John Onwuemeka*** *(Ph.D. student, supervisor = Yajing Liu),*
2^{nd} Prize - Debarati Das *(Ph.D. student. supervisors = Kim Berlo and Richard Levielle),*
3^{rd} Prize - Caroline Seyler *(Ph.D. student, supervisor = James Kirkpatrick), and Peter Douglas*

Adams Club Field Trip
Saguenay Fjord
September 7-9, 2018

Graduate students went for a weekend camping trip to Parc national du Fjord-du-Saguenay and hiked up to the Statue de Notre-Dame-du-Saguenay for beautiful views of the fjord (alas, no whales were spotted). Saguenay Fjord, carved out in the edge of the North American continental ice sheet, is the southernmost fjord in the word and has the rare characteristic of being intracontinental. Three geomorphological units lie at the edge of the Laurentian Highlands: Lac Saint-Jean, Lac-Kenogami, and St-Lawrence River, where the fjord empties. These features are delimited by a system of faults. The fjord is located at the center of a collapsed trough on the edge of the Canadian Shield, making it less resistant to erosion. The current part of the fjord is attributable to glacial erosion.

Participants included: Sarah Bodeving (Ph.D. student), Robert Bogue (M.Sc. student), Andres Castro, Fiona d'Arcy (Ph.D. student), Morgane Flament (UGRT), Erin Gibbons (M.Sc. student), Wilder Greenman (Ph.D. student), Anna Hayden (M.Sc. student), Mathilde Jutras (Ph.D. student), Regina Moguel (Ph.D. student), Nick Ogasa (M.Sc. student), Noah, Phillips (Ph.D. student), Stan Roozen (Ph.D. student), Caroline Seyler (Ph.D. student), Lauren Somers (Ph.D. student), and Longbo Yang (Ph.D. student).



Photos courtesy of Longbo Yang

1st Year Field Trip

21 September 2018

Led by Bill Minarik students explored a few locations that provided an overview of the regional stratigraphy and geologic setting. Montreal lies within the St Lawrence Lowland geological province and is characterized by the presence of the striking topographic feature on the island, Mount Royal. This mountain is part of the Monteregian Hills, igneous plugs intruded into the surrounding Paleozoic platform sedimentary rocks that, in this area, are more than 2 km thick! Finally, the morphology and young sedimentary rocks of the region reflect modification by recent glaciers (~18ka).

Below are two photos of the student group at Coteau du Lac and the Beauharnois power station: Jeannette Wan, Scout Stipec, Julia Morales-Aguirre, Anna Hayden, Ru Keshvardoost, and Magda Mroz, Emilienne Hamel.

Homecoming Wine & Cheese
12 October 2018

Photos courtesy of Jennifer Abbott

Faults & Faulting

Utah & Nevada Field Trip

Advanced Structural Geology

October 14-20, 2018

Trip participants. From left to right: Sam Metteer, Jamie Kirkpatrick, Stan Roozen, Nick Ogasa (crouched), Tim Howell, Chris Lambert, Brindley Smith, Lise Alalouf, Carly Faber

The students of EPSC550, Advanced Structural Geology, flew to Las Vegas, Nevada, for a week-long field trip to study fault structures and evolution. The trip focused on fault geometry, architecture, and impact on fluid flow in the subsurface. Utah and Nevada are excellent destinations for fault enthusiasts as the arid climate makes for spectacular bedrock exposures and should mean pleasant conditions for fieldwork in the late fall, although we were not always so lucky. On this trip, the students presented posters they had made highlighting geological features and processes and led the discussion on the outcrops. We flew to Las Vegas, grabbed equipment from the EPS storage locker in north Vegas, stocked up on groceries, and drove to Green River Utah for the start of the trip.

Day 1: Deformation band faults in porous sandstone

We visited sites near Goblin Valley State Park to see multiple crosscutting generations of deformation bands cutting the top of the Late Jurassic Entrada sandstone. With the San Rafael monocline looming to the west, mesas of sandstone to the south, and the Rocky Mountains to the east, the location was spectacular. Deformation bands are narrow bands of crushed grains that have small shear offsets, representing nascent faults in porous rocks at low strain. Because the grains in them are crushed together and compacted, they are harder than the surrounding sandstone so are more resistant to weathering. In the morning, Chris Lambert (PhD student from École Polytechnique de Montréal) informed the group about the petrophysical properties of deformation bands and how they coalesce to form larger faults. After a lunch stop to see the goblins (hoodoos) in the park, McGill MSc student Sam Metteer expanded on the discussion by showing how fault slip causes fault rocks to develop.

Day 2: The Little Grand Wash Fault, a reservoir-scale analog

The second day began with an overview of the stratigraphy of the Colorado Plateau from an overlook just south of the town of Green River. After driving through an abandoned cold war era missile silo, the group took in a panorama from the top of a cliff, which turned out to be the footwall of the Little Grand Wash Fault. This normal fault is around 30 km long, with 200 m throw. It consists of multiple fault strands, which dissect the stratigraphy and compartmentalize the rock into ~100 m-long packages along strike. McGill MSc student Nick Ogasa gave the group an overview of the architecture and implications for fluid flow from an overview at the east end of the fault. We worked west, taking in various aspects of the fault, to where the fault intersects the Green River. Arriving in the early afternoon, we just missed the eruption of the Crystal Geyser. This geyser is manmade, having initiated when a prospecting well was not properly completed, and the hole left open to the atmosphere. Bullet holes in the steel casing at the site today attest to the damage to the hole subsequently, which includes explosives dropped down the well. Roughly every 18 hours, it erupts CO_2-charged groundwater sourced from an aquifer at depth. McGill PhD student Stan Roozen explained methods for studying the effect of faults on fluid flow in the subsurface and in the rock record, then the group explored a travertine mound formed by an ancient geyser that erupted through the fault in the past.

Day 3: The Moab Fault, architecture of a basin-bounding fault

Day 3 dawned unseasonably cold and wet. We made our way through the rain to exposures of the Moab Fault system, just north of Moab, Utah. Our first destination was the famous Bartlett Wash strand of the Moab fault, which is pictured in many structural geology textbooks. McGill MSc student Tim Howell introduced the group to scaling of fault damage zones, and current understanding of how faults develop as they grow and increase in displacement. We climbed the Slickrock member of the Entrada for an overview of the fault and the clustering of deformation bands and joints in the damage zone. On the way to the Courthouse Rock area, we stopped at the Mill Canyon dinosaur trackway and debated the formation mechanisms of the tracks (sauropods, therapods, and crocodilia). At the imposing Courthouse Rock, McGill MSc student Brindley Smith led a discussion of the ways in which faults act as baffles to fluid flow, and can seal reservoirs. Driving back to camp in the late afternoon, the weather became worse, with heavy rain and hail so we grabbed a hot meal and cold beers at Ray's Tavern in Green River, where the rain was only a problem in some places where the roof leaked!

Day 4: Markagunt gravity slide

Continued cold wet weather in central Utah prompted a change in plan on day 4, which took us to the Markagunt gravity slide, southern Utah, on the way back south toward Las Vegas. The Markagunt gravity slide is a sheet of bedrock that underwent catastrophic gravitational collapse around 22 million years ago. It covers 1600 square miles (4160 km^2), larger than the smallest state in the USA. Various grooves and striations, as well as deformed rocks such as pseudotachylyte (frictional melt), cataclastic breccias, and clastic dikes provide strong evidence of catastrophic emplacement. We visited a small but striking outcrop in a stream terrace west of Panguitch, Utah, where pseudotachylyte formed along a shear plane within the landslide. The group discussed the conditions necessary to achieve frictional melting and marveled at a group of cowboys herding cattle nearby, which included a 9-month old baby strapped to his mother's chest on horseback. After completing the drive south, we set up camp that evening on the edge of the mountains of the Buffington Windows, warm and marveling at the Las Vegas lights 40 km to the southwest.

Day 5: Muddy Mountain Thrust

The last field day was spent exploring the Muddy Mountain Thrust in the Buffington Windows, the same location Field School 1 visits. Our longest hike of the trip was completed in about half an hour, but met with some complaints. From an overlook providing views of tens of kilometers of fault trace, McGill PhD student Lise Alalouf gave the group an overview of the mechanics of thrust faulting. Truly exceptional exposures of the fault contact between hanging wall Cambrian dolomites and footwall Jurassic Aztec sandstone kept the fault busy all day. A large tarantula was sitting on a key outcrop where clastic dikes injected from the footwall tens of meters into the hanging wall. Undaunted, the group climbed on, and debated whether decarbonation of the dolomite driving by frictional heating during earthquake slip could have pressurized fluids in the fault sufficiently to cause the dikes to form. Such a dramatic hypothesis made for a fitting end to a memorable trip.

The students are extremely grateful for the departmental support, which allowed this trip to happen. Thank you EPS!

Top: *Panorama of the San Rafael desert looking south from the first stop of the trip. Molly's Castle, located just northeast of Goblin Valley state park rises from the desert floor where deformation band networks and larger fault are very well exposed.* ***Lower left:*** *The group study a highly polished fault slickenside a range of kinematic indicators and discuss how the sandstone is crushed and smeared during slip.* ***Lower right:*** *Drone photo showing Sam Metteer presenting a poster to the group next to. Large panels of exposed fault surfaces.*

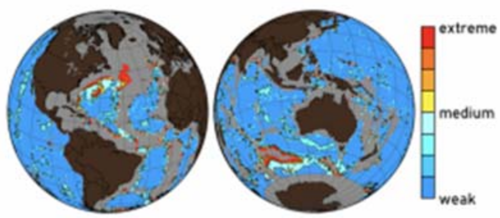
Top*: Overview of the Buffington Windows, through the Muddy Mountain thrust where Cambrian dolomite (dark rocks on the horizon) was thrust over the bright yellow to red Jurassic Aztec Sandstone.* ***Lower left:*** *Examining an outcrop within the Markagunt gravity slide where slip within the upper plate caused frictional melting to occur, preserved today as pseudotachylyte.* ***Lower right:*** *Drone photo showing the group studying an exposure of the Muddy Mountain thrust.*

Photo credits: *Photos by Nick Ogasa. Drone photos by Tim Howell*

IN THE NEWS

Alterations to seabed raise fears for future

Ocean acidification caused by high levels of human-made CO2 is dissolving the seafloor



The ocean floor as we know it is dissolving rapidly as a result of human activity.

Normally the deep sea bottom is a chalky white. It's composed, to a large extent, of the mineral calcite (CaCO3) formed from the skeletons and shells of many planktonic organisms and corals. The seafloor plays a crucial role in controlling the degree of ocean acidification. The dissolution of calcite neutralizes the acidity of the CO2, and in the process prevents seawater from becoming too acidic. But these days, at least in certain hotspots such as the Northern Atlantic and the southern Oceans, the ocean's chalky bed is becoming more of a murky brown. As a result of human activities the level of CO2 in the water is so high, and the water is so acidic, that the calcite is simply being dissolved.

The McGill-led research team who published their results this week in a study in PNAS believe that what they are seeing today is only a foretaste of the way that the ocean floor will most likely be affected in future.

Long-lasting repercussions

"Because it takes decades or even centuries for CO_2 to drop down to the bottom of the ocean, almost all the CO_2created through human activity is still at the surface. But in the future, it will invade the deep-ocean, spread above the ocean floor and cause even more calcite particles at the seafloor to dissolve," says lead author Olivier Sulpis who is working on his PhD in McGill's Dept. of Earth and Planetary Sciences. "The rate at which CO_2 is currently being emitted into the atmosphere is exceptionally high in Earth's history, faster than at any period since at least the extinction of the dinosaurs. And at a much faster rate than the natural mechanisms in the ocean can deal with, so it raises worries about the levels of ocean acidification in future."

In future work, the researchers plan to look at how this deep ocean bed dissolution is likely to evolve over the coming centuries, under various potential future CO_2 emission scenarios. They believe that it is critical for scientists and policy makers to develop accurate estimates of how marine ecosystems will be affected, over the long-term, by acidification caused by humans.

How the work was done

Because it is difficult and expensive to obtain measurements in the deep-sea, the researchers created a set of seafloor-like microenvironments in the laboratory, reproducing abyssal bottom currents, seawater temperature and chemistry as well as sediment compositions. These experiments helped them to understand what controls the dissolution of calcite in marine sediments and allowed them to quantify precisely its dissolution rate as a function of various environmental variables. By comparing pre-industrial and modern seafloor dissolution rates, they were able to extract the anthropogenic fraction of the total dissolution rates.

The speed estimates for ocean-bottom currents came from a high-resolution ocean model developed by University of Michigan physical oceanographer Brian Arbic and a former postdoctoral fellow in his laboratory, David Trossman, who is now a research associate at the University of Texas-Austin.

"When David and I developed these simulations, applications to the dissolution of geological material at the bottom of the oceans were far from our minds. It just goes to show you that scientific research can sometimes take unexpected detours and pay unexpected dividends,"said Arbic, an associate professor in the University of Michigan Department of Earth and Environmental Sciences.

Trossman adds: "Just as climate change isn't just about polar bears, ocean acidification isn't just about coral reefs. Our study shows that the effects of human activities have become evident all the way down to the seafloor in many regions, and the resulting increased acidification in these regions may impact our ability to understand Earth's climate history."

"This study shows that human activities are dissolving the geological record at the bottom of the ocean," says Arbic. "This is important because the geological record provides evidence for natural and anthropogenic changes."

To read "Current $CaCO_3$ dissolution at the seafloor caused by anthropogenic CO_2" by Olivier Sulpis (Ph.D. student – Supervisor = Alfonso Mucci) et al in PNAS: https://doi.org/10.1073/pnas.1804250115

McGill Newsroom – Media Relations office – 29 October 2018

Alfonso Mucci

Prix Acfas Michel-Jurdant

Alfonso presented with the Prix Acfas Michel-Jurdant in recognition of his outstanding work on the health of the St. Lawrence Estuary and the world's oceans *Photo:* Hombeline Dumas

Alfonso Mucci, professor in the Department of Earth and Planetary Sciences, was among nine of Quebec's leading academics honoured by the Association francophone pour le savoir (Acfas) for their exceptional contribution to research at the Acfas Gala held in Montreal on November 13, 2018.

Prof. Mucci was presented with the Prix Acfas Michel-Jurdant in recognition of his outstanding work on the health of the St. Lawrence Estuary and the world's oceans.

Prof. Mucci made a name for himself in the early 1980s with his research on the solubility of calcium carbonate minerals in seawater, with which he established a reliable means to measure ocean acidification. To this day, his work provides a benchmark for monitoring the progressive acidification of the world's oceans due to absorption of anthropogenic carbon dioxide emitted to the atmosphere – a process that represents a significant threat to marine life.

Unfolding catastrophy

In the early 2000s, Prof. Mucci turned his attention to the problem of deep-water acidification in the St. Lawrence Estuary and in the Arctic. He was the first to document an oxygen-depleted deep-water zone in the St. Lawrence Estuary, identifying a phenomenon that has led to the disappearance of specific species of fish, crustaceans and other forms of marine life from what was once a biologically-rich environment.

“There is a catastrophe unfolding but we are not seeing it and we are not talking about it,” Prof. Mucci has said of the health of the St. Lawrence Estuary and the world’s oceans.

In subsequent research, he confirmed a link between oxygen depletion in the water column and acidification – a phenomenon that is likely to have a drastic impact on the health of marine ecosystems at the surface of the world’s oceans by the end of the century.

Trapping mercury

Prof. Mucci made another significant contribution to environmental science with work he carried out prior to and following the Saguenay River flood of 1996. The Saguenay Fjord sediments contain high levels of mercury, a legacy of industrial activity between 1947 and 1976. Thanks to meticulous fieldwork carried out over a period of 10 years, Prof. Mucci’s research team discovered that the mercury is now trapped by the layer of sediment deposited by the flood. The findings provided valuable insight into how mercury – a notorious marine contaminant – could be permanently sequestered.

Prof. Mucci has participated in numerous national and international research initiatives, including the Joint Global Ocean Flux Study (JGOFS). Along with his students, he has taken part in ArticNet voyages aboard the research icebreaker CCGS *Amundsen* since 2003, studying the effect of melting ice on carbon dioxide exchange at the air-sea interface and the acidification of Arctic waters.

Fergus Grieve

Communications Strategist

Faculty of Science

McGill Report – 15 November 2018

James W. Gill *(M.Sc. ’76)* Inducted into Canadian Mining Hall of Fame

On January 10, 2019, the Canadian Mining Hall of Fame (CMHF) will welcomed five individuals who have made lasting contributions to Canada’s mining industry: Kate Carmack (joining the Klondike Discoverers), James Franklin, James Gill, Sandy Laird and Brian Meikle.

James Gill *(M.Sc. ’76)* secured a place in mining history through the exceptional success and staying power of Aur Resources, which he launched in 1981 with $250,000 of seed capital and a large land package in Quebec’s Val d’Or mining camp. Aur caught the attention of the entire industry in 1989 when it made the breakthrough Louvicourt copper-zinc discovery, which was at the time, the largest base metals discovery in Canada since Kidd Creek. Gill’s technical prowess and entrepreneurial savvy led to the eventual development of Louvicourt into one of Canada’s premier copper-zinc mines. Gill continued to acquire and develop mines in Canada and around the world until 2007, when he negotiated a $4.1 billion buyout of Aur by Teck Resources. Mining is part of Gill’s DNA, following the footsteps of his grandfather who was inducted into the Canadian Mining Hall of Fame in 2003.

Founded in 1988 by the Northern Miner, the Mining Association of Canada, the Prospectors and Developers Association of Canada and the Canadian Institute of Mining, Metallurgy and Petroleum, the CMHF recognizes outstanding achievement in the mining industry, celebrates individual leadership and inspires future generations in mining. Members are selected through a fair, inclusive and accessible process driven by the CMHF Board of Directors and its member associations. For more information, please visit: http://www.mininghalloffame.ca

For the past 31 years, the CMHF has recognized outstanding achievement in the mining industry, celebrated individual leadership and inspired future generations in mining. Canadian mining leaders set the standard for the global industry and these individuals reflect the very best of mining excellence, determination and skill.

“The Canadian Mining Hall of Fame is proud to recognize these five outstanding individuals for their lasting contributions to the mining industry, both here in Canada and across the globe,” says Jon Baird, Canadian Mining Hall of Fame Chair. “Whether it was through historic discovery, ground-breaking research or delivering significant value to shareholders, each of these individuals made a profound impact on Canada’s mining industry and helped to shape it into the global leader it is today.”

Each of the inductees were honoured at the Canadian Mining Hall of Fame’s 31st Annual Dinner and Induction Ceremony on Thursday, January 10, 2019 at the Metro Toronto Convention Centre. This premier event is a celebration of Canada’s global mining leadership and the individual achievement that has fueled it.

Canadian Mining Hall of Fame – October 11, 2018

McGill Researchers Honoured in Québec Science List of Top Discoveries

Peter Crockford and Galen Halverson

Billion-year-old lake deposit yields clues to Earth's ancient biosphere - Finding could help inform astronomers' search for life outside our solar system

Peter Crockford (Ph.D. '17)

A sample of ancient oxygen, teased out of a 1.4 billion-year-old evaporative lake deposit in Ontario, provides fresh evidence of what the Earth's atmosphere and biosphere were like during the interval leading up to the emergence of animal life.

The findings, published in the journal *Nature*, represent the oldest measurement of atmospheric oxygen isotopes by nearly a billion years. The results support previous research suggesting that oxygen levels in the air during this time in Earth history were a tiny fraction of what they are today due to a much less productive biosphere.

“It has been suggested for many decades now that the composition of the atmosphere has significantly varied through time,” says Peter Crockford, who led the study as a PhD student at McGill University. “We provide unambiguous evidence that it was indeed much different 1.4 billion years ago.”

The study provides the oldest gauge yet of what earth scientists refer to as “primary production,” in which micro-organisms at the base of the food chain – algae, cyanobacteria, and the like – produce organic matter from carbon dioxide and pour oxygen into the air.

A smaller biosphere

“This study shows that primary production 1.4 billion years ago was much less than today,” says senior co-author Boswell Wing, who helped supervise Crockford’s work at McGill. “This means that the size of the global biosphere had to be smaller, and likely just didn’t yield enough food – organic carbon – to support a lot of complex macroscopic life,” says Wing, now an associate professor of geological sciences at University of Colorado at Boulder.

To come up with these findings, Crockford teamed up with colleagues from Yale University, University of California Riverside, and Lakehead University in Thunder Bay, Ontario, who had collected pristine samples of ancient salts, known as sulfates, found in a sedimentary rock formation north of Lake Superior. Crockford shuttled the samples to Louisiana State University, where he worked closely with co-authors Huiming Bao, Justin Hayles, and Yongbo Peng, whose lab is one of a handful in the world using a specialized mass-spectrometry technique capable of probing such materials for rare oxygen isotopes within sulfates.

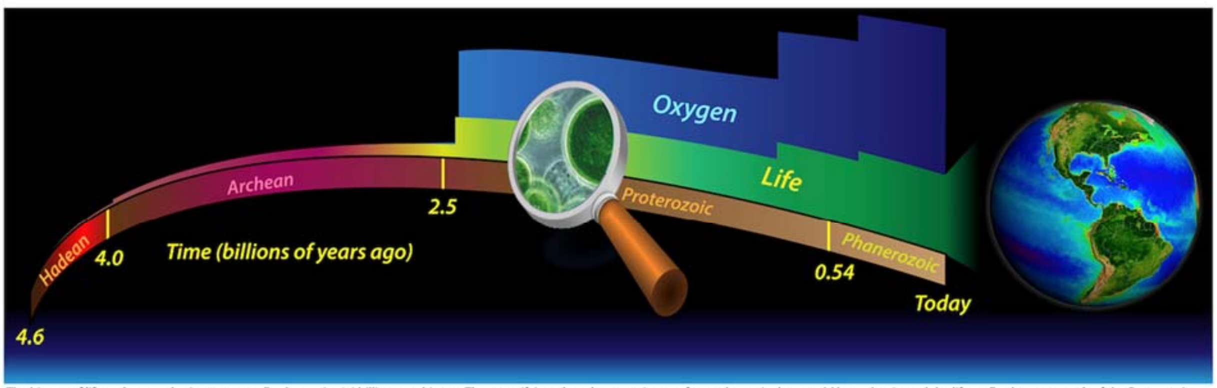
The work also sheds new light on a stretch of Earth’s history known as the “boring billion” because it yielded little apparent biological or environmental change.

“Subdued primary productivity during the mid-Proterozoic era – roughly 2 billion to 800 million years ago – has long been implied, but no hard data had been generated to lend strong support to this idea,” notes Galen Halverson, a co-author of the study and associate professor of earth and planetary sciences at McGill. “That left open the possibility that there was another explanation for why the middle Proterozoic ocean was so uninteresting, in terms of the production and deposit of organic carbon.” Crockford’s data “provide the direct evidence that this boring carbon cycle was due to low primary productivity.”

Exoplanet clues

The findings could also help inform astronomers’ search for life outside our own solar system.

“For most of Earth history our planet was populated with microbes, and projecting into the future they will likely be the stewards of the planet long after we are gone,” says Crockford, now a postdoctoral researcher at Princeton University and Israel’s Weizmann Institute of Science. “Understanding the environments they shape not only informs us of our own past and how we got here, but also provides clues to what we might find if we discover an inhabited exoplanet.”



The history of life and atmospheric oxygen on Earth over its 4.6 billion year history. The magnifying glass shows a picture of cyanobacteria that would have dominated the life on Earth across much of the Proterozoic beginning around 2.4 billion years ago. On the far right is an image of the Earth that highlights vegetation on the continents and cholorphyll concentrations in the ocean. What our study shows is that these colours would have been much less vibrant in Earths deep past due to a smaller biosphere.

“Triple oxygen isotope evidence for limited mid-Proterozoic primary production,” Peter W. Crockford et al., *Nature,* published online July 18, 2018. DOI: 10.1038/s41586-018-0349-y

The research was supported by funding from the Natural Sciences and Engineering Research Council of Canada, the Fonds de recherche du Québec – Nature et Technologies, and the University of Colorado Boulder.

McGill Newsroom
Media Relations Office

About William E. Logan

by Thomas H. Clark (1893-1996)

William Edmond Logan – Born in Montreal on 20 April 1798; and died in Llechryd, Wales on 22 July 1875

Logan's grandfather, James Logan, emigrated from Stirling, Scotland, to Montreal in 1784 and soon developed a prosperous bakery business, which passed upon his retirement to his eldest son, William. The latter married Janet Edmond of Stirling; and their second son, William Edmond, was born in Montreal. Logan's education began at Skakel's Private School in Montreal and continued at the Edinburgh High School (1814-1816) and Edinburgh University (1816-1817), where he studied chemistry, mathematics, and. logic. He spent the years 1818-1831 in his uncle Hart's bank in London, becoming its manager upon his uncle's retirement in 1827. Later (1831-1838) he joined the management of a copper-smelting and coal-mining venture near Swansea, Wales, in which his uncle was interested, remaining there until his uncle's death. He soon found that chemistry and geology were essential to the success of the business and embarked upon a geological study of the local Glamorganshire coalfield - ultimately, in 1838, producing a memoir, with maps and sections. Its excellence was recognized by the director of the Geological Survey of Great Britain, Sir Henry De la Beche, who with Logan's permission incorporated it *in toto* in the Survey's report on that region. From that time on, Logan devoted himself exclusively to geology, particularly to the coal formations.

Logan's work on underclays with fossil Stigmaria in South Wales coalfields was to weigh heavily on the side of the in situ theory of the origin of coal, and, with his papers on the packing of ice in the St. Lawrence River, soon established him as a geologist of note. In 1842 the appointment of a provincial geologist was approved by the Canadian government under Sir Charles Bagot, who set about finding a suitable candidate. Logan obtained "a mass of testimonials," including letters from four of the most influential British geologists of the time: De la Beche, Roderick Murchison, Adam Sedgwick, and William Buckland. As a consequence he was offered, and accepted, the directorship of the newly created Geological Survey of Canada, a post which he held until 1869. For twenty-seven years he and his assistants traveled in all reachable parts of Canada from the Great Lakes to the Maritime Provinces; they also issued reports of progress, of which "Report on the Geology of Canada" (1863), his magnum opus, provided a compilation of twenty years of research. After more than a century, it is still a reservoir of important information.

Logan was fortunate in the choice of his assistants for both fieldwork and office work. Alexander Murray was his first and most important field geologist until he resigned to become director of the Geological Survey of Newfoundland in 1861. T. Sterry Hunt, his chemist, was responsible for hundreds of analyses of minerals, rocks, and ores. Elkanah Billings, his paleontologist, examined all fossils collected by field geologists and provided Logan with information invaluable for the correct identification of the age and the stratigraphic position of rock formations. Others included the geologists James Richardson and Robert Bell and the draftsman Robert Barlow. Later, Edward Hartley, Thomas Macfarlane, Charles Robb, and H. G. Vennor joined the Survey.

A twelve-hour day in the field was the rule for Logan. He was usually alone, carrying all necessary equipment together with the day's collection of specimens; he recorded his progress by means of pacing and compass in regions of which, for the most part, there were no reliable maps. If at the end of a day in the bush his plotting of his traverse showed an error of more than two chains, he was disappointed. In the evenings he wrote up his notes and completed his maps. Logan's notebooks, preserved in Ottawa, are marvels of simplicity, perspicacity, and brevity, here and there embellished by illuminating pen sketches of the country covered. He was equally tireless during the winters, composing his reports of progress, revising those of his assistants, and above all seeking adequate governmental financial support. Thousands of pounds of his own resources .were poured into the early ill-supported organization.

Following the publication of the 1863 report one can detect a slight but increasing diminution of Logan's powers, which in 1869 he recognized had reached a point where a younger man was needed to carry the burden of a vigorous and growing organization. As a consequence, in that year he resigned as director and divided his time between an estate he had bought in Wales and exploration, at his own expense, in Canada, designed to settle certain vexatious problems which had been left unsolved at the time of his resignation. While preparing for a summer's fieldwork in the eastern townships of Quebec, he became ill; and following a short illness he died in 1875. He was buried in the churchyard at Llcchryd, Wales.

Logan's bibliography is not extensive and consists mostly of progress reports to the government concerning the work of the Survey. Many of these reports, sixteen in all, he wrote in his own handsome in quadruplicate. The most important, and nearly the last, was his 1863 report, which provided the first complete coverage, according to information then available, of the geology of Canada from the Great Lakes to the Atlantic seaboard. In this remarkable compilation Logan was ably assisted by Sterry Hunt, whose work as chemist provided the foundation on which much of the information concerning the rocks, minerals, and ores of Canada was based. Early articles on underclay, the Glamorganshire coalfield, and ice packing have been mentioned. Others, mostly short notes, recorded his observations on the copper-bearing rocks of Lake Superior, animal tracks in the Potsdam sandstone, the supposed fossil Eozoon, subdivision of the Precambrian rocks of Canada, and remarks on the Taconic question, in which he avoided controversy by using the term "Quebec group" for equivalent rocks in Canada. Although he was the first to publish the discovery of Eozoon, and exhibited specimens of it during his visits to England, Logan later became noncommittal as the battle was waged between those who saw it as a fossil and those who advocated its metamorphic origin.

Photo taken in 1897 of FD Adams (on rock) holding piece of Eozoon

Among Logan's achievements was his recognition of an anomalous structural condition in which rocks of the Quebec Group lay structurally above younger (Middle and Late Ordovician) beds of the St. Lawrence Lowland. This he explained by proposing "an over-turn anticlinal fold, with a crack and dislocation running along its summit, by which the [Quebec] group is made to overlap the Hudson River [Upper Ordo-vician] formation." He traced this thrust fault from Alabama to the Canadian border, and thence to the tip of the Gaspe peninsula. Although made up of a multitude of imbricating faults the structure is still referred to as Logan's Line. The earliest use of that term is not known.

Login was never directly connected with university affairs, although as a result of his regard for Sir John William Dawson he donated $19,000 to found the Logan chair in geology and lesser amounts for Logan medals. Both McGill University in Montreal (1856) and the University of Bishop's College in Lennoxville, Quebec (1855), conferred honorary degrees on him. The excellence of his display of Canadian rocks and minerals at the London exhibition of 1851 led to his election as fellow of the Royal Society; he was sponsored by the most prominent contemporary Birtish geologist, Sir Roderick Murchison. A similar exhibit at Paris in 1855 earned him the Grand Gold Medal of Honor from the Imperial Commission and an investiture as chevalier of the Legion of Honor in the same year. The following year he was knighted by Queen Victoria and also received the Wollaston Palladium Medal from the Royal Society. He was a fellow of the Geological Society of London (1837) and of the Royal Society of Edinburgh (1861), and a member of the Academy of Natural Sciences of Philadelphia (1846), the American Academy of Arts and Sciences, Boston (I 859), and the American Philosophical Society (1860).

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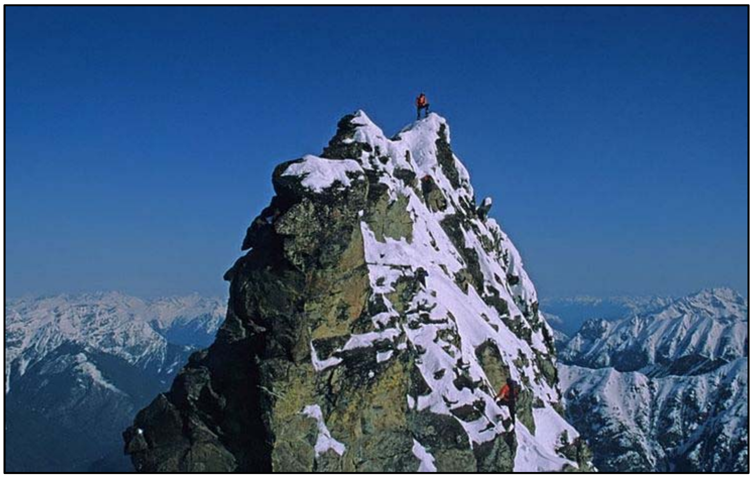


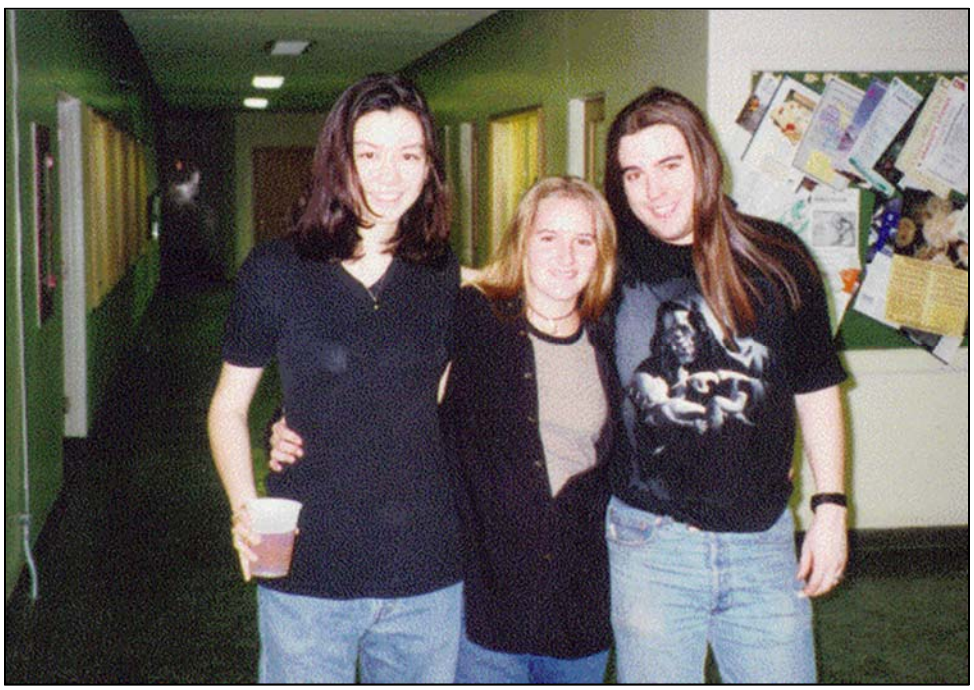
Summit of Mount Logan – Canada's highest mountain at 5,959 m (19,551 ft)

Located in the icefields of Kluane National Park - St. Elias Range – Yukon

MINEX - 1990-1991

Standing: Kanit Prasittikarnkul, Mary Stalker, Somchai Subprinyaporm, and Gustavo

Sitting: Wallace (Wally) MacLean, Sharon Cunningham, Jeff Best, Bruce Robbins and David



Leyla Hoosain (B.Sc. '96, M.Sc. '99), Sharon Allen (B.Sc. '98), and Lawrence Yane (M.Sc. '97)

In Memoriam

FLANAGAN, Michael *(M.Sc. '84)*
1953 – 2018

Michael passed away Thursday, June 14, 2018 at the Brome-Missisquoi Perkins Hospital in Cowansville. He leaves behind his wife Jane Livingston, his two sons Tristan (Audrey Chagot) and Beavan, and his sprightly granddaughter Claire (Tristan and Audrey's daughter). Claire will miss her "Banka" very much. Michael is also survived by his brother Neil (Nancy Stryde) and his sisters Patti (Michel Berlinguette) and Maureen. He was predeceased by his brother Kevin. Michael was the son of Peter Flanagan and Shirley Palmer Flanagan, "Shirl." Michael was a very dear man. He was a loving and caring husband, father, and friend to many. He will be greatly missed. Professionally, Michael was an impassioned geologist, a graduate of Memorial University in Newfoundland and Labrador, followed by a Master's degree from McGill. Michael took a hiatus from mineral exploration when the boys were young. He and Jane moved to the Eastern Townships in 1994 and opened Auberge Baker Pond. Following that they owned and operated JL Flanagan's General Merchants in Knowlton. In later years, Michael returned to his first love, Geology. He was Vice President of Exploration at Fancamp Exploration, based in Montreal. Michael died of prostate cancer. It was a long and arduous struggle but he was helped immensely by the caring professionals at the BMP Hospital and the Jewish General Hospital. Michael was truly grateful to the wonderful care given to him, most especially from his "groupies." There will be a service at Grace Anglican Church in Arundel, his birthplace, on Thursday, June 21 at 11 a.m. A gathering will be organized in Knowlton at a later date. In lieu of flowers, donations in his memory would be appreciated, either to the Brome-Missisquoi Perkins Hospital Foundation or to the Michael Flanagan Memorial Foundation for Prostate Cancer at the Jewish General Hospital.

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Left Photo: Late Holocene moraine-dammed lakes in the Cordillera Huayhuash, Peru
Right Photo: Purgatoria Fault scarp in southern Peru

DAWSON FIELD STUDY SUPPORT

Don Francis, Jonathan O'Neill *(Ph.D.'09)*, and Shake

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McGill's Arts Building on a winter day.