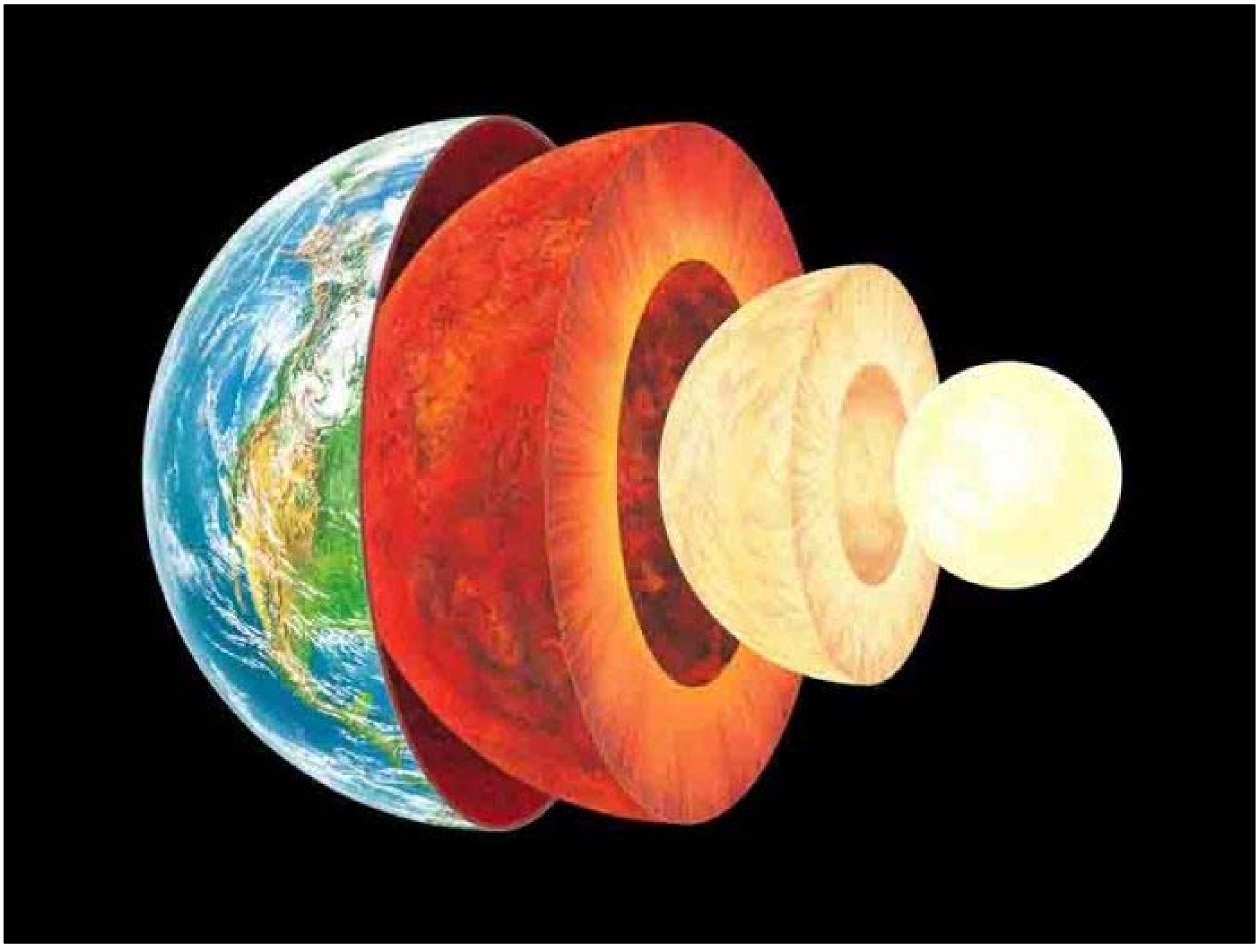
McGill University

Alumni Newsletter #21 June 2018



Inner Earth. Credit: Gary Hincks/Science Photo Library

1. In 1692 Edmond Halley (of comet fame) proposed that the Earth is hollow. Below the outer crust where we live, he pictured two concentric shells and a core about the size of Mercury, all floating in a luminous gas.
2. Hellோooo down there: Halley even imagined that these shells might be inhabited. Jules Verne riffed on this idea in his classic Journey to the Center of the Earth.
3. Halley was right about the planet-size core, at least. At Earth's center is an iron-rich orb more than 4,000 miles wide—bigger than Mercury, actually—closer to our feet than L.A. is to New York.
4. Its outer part is molten. Its inner part is a solid hunk of metal that spins independently of the rest of the planet.

5. Earthquake waves that pass through the inner core travel faster north-south than they do east-west. One theory: The inner core consists of metallic crystals aligned with Earth's poles, and the waves move more rapidly when they go with the grain.
6. The inner core is nearly as hot as the surface of the sun, and the pressure down there is 3 million times what it is on the surface.
7. Earth's solid and liquid cores together generate the magnetic field that keeps the solar wind—a nonstop, 250-mile-per-second stream of charged particles emitted by the sun—from stripping away our atmosphere.
8. Earth's mini-me: A group at the University of Wisconsin is attempting to model Earth's field by bottling 500,000-degree plasma in a 10-foot-wide aluminum sphere with really solid walls. The currents inside should mimic flows in the outer core.
9. The deepest place ever reached by human technology is the Kola Superdeep Borehole near Murmansk, Russia, the product of a Cold War inner-space race.
10. Bacteria have been discovered in the cavities and cracks of gold mines 2.4 miles beneath Earth's surface. They live on hydrogen and sulfates, and their primary source of energy is radiation, not the sun. Yum.
11. Microbiologist James Holden of the University of Massachusetts at Amherst speculates that our planet's deep biomass could weigh as much as all the things living up here on the surface.
12. According to NASA scientists, life on Mars may be huddling out of sight in a similar deep, hot biosphere.
13. Change is inevitable, even in the core. Examining paleomagnetic data, geoscientists at Johns Hopkins University suggest that the eastern and western halves of Earth's core take turns growing and melting.
14. That may be why the axis of Earth's magnetic field is cockeyed, leaning these days to the east, while a few geologic eyeblinks ago it tilted to the west.
15. The Johns Hopkins researchers think the axis gets anchored in the growing half. Which could account for our planet's weird history of magnetic field reversals, with north and south poles swapping places.
16. Such magnetic field quirks might also be explained by pandemonium at the boundary between the molten core and the overlying mantle.
17. Berkeley physicist Richard Muller speculates that oxygen, silicon, and sulfur are being squeezed out of the inner core and floating up to the core-mantle boundary, where they collect into hot, slushy dunes. Every once in a while, one dune may violently tumble into the mantle, revving up convection and disturbing the magnetic field.
18. Reduce, reuse, recycle. The slow churn of plate tectonics pulls crust into the interior, where any plant and animal life in it gets trapped and cooked. Organic material eventually resurfaces in lava and volcanic gases, including atmosphere-warming carbon dioxide.
19. Such cycling, and the protective magnetic field generated by the core, keep our planet at the perfect temperature for life.
20. Look at Venus, with its 900-degree Fahrenheit days and nights. If not for our planet's restless insides, that could be us.

Note: The above is reprinted from materials *provided by* Discover Magazine. *The original article was written by Rebecca Coffey.*

Note from the Chair

Greetings from the Chair's Office!

As I end my second year as the Chair of Earth and Planetary Sciences, I am more impressed than ever by what our students, staff and faculty are accomplishing. As I'm sure you will see when you look through our largest newsletter yet, we have had another incredible year of teaching, research, and travel. I'm continually struck by the dedication of our current and past department members to the department, and how this commitment makes EPS such a special place.

This summer we look forward to the arrival of our most recent hire, Nagissa Mahmoudi. She is a geobiologist studying microbial degradation of organic compounds including pollutants and natural organic matter.

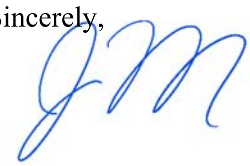
Our faculty continue to be leaders in research and teaching, and this past year our faculty have received numerous awards for both. Christie Rowe is now a prestigious Canada Research Chair. Yajing Liu received the Canadian Geophysical Union's Young Scientist Award. Al Mucci received the Canadian Meteorological and Oceanographic Society's 2017 François J. Saucier Prize in Applied Oceanography. Peter Douglas is now a Trottier Fellow. And, deservingly, Willy Williams-Jones received the Canadian Federation of Earth Sciences' Mentorship Medal. Congratulations to all.

While our faculty are world-class, our true strength always remains our undergraduate and graduate students. For the upcoming academic year, we continue to have record numbers of incoming graduate students. Furthermore, our strong tradition of field instruction and international travel continues; as you will see over the past year our students' field experiences have included Nevada, Indonesia, Mongolia, Iceland and China. And as I write, our undergraduate students are in France for an incredible month-long field school.

Our annual Fall Wine and Cheese on Friday, October 12, 2018. This event is a longstanding department tradition – and it now corresponds with McGill's Homecoming Weekend. I hope to see you there!

If you want to hear more about what is happening, please contact me (jeffrey.mckenzie@mcgill.ca). And I encourage you to support the excellent teaching initiatives in our department (visit http://eps.mcgill.ca and click on 'give now').

Sincerely,



Jeffrey McKenzie
Chair, Earth and Planetary Sciences

Past & Present Chairs

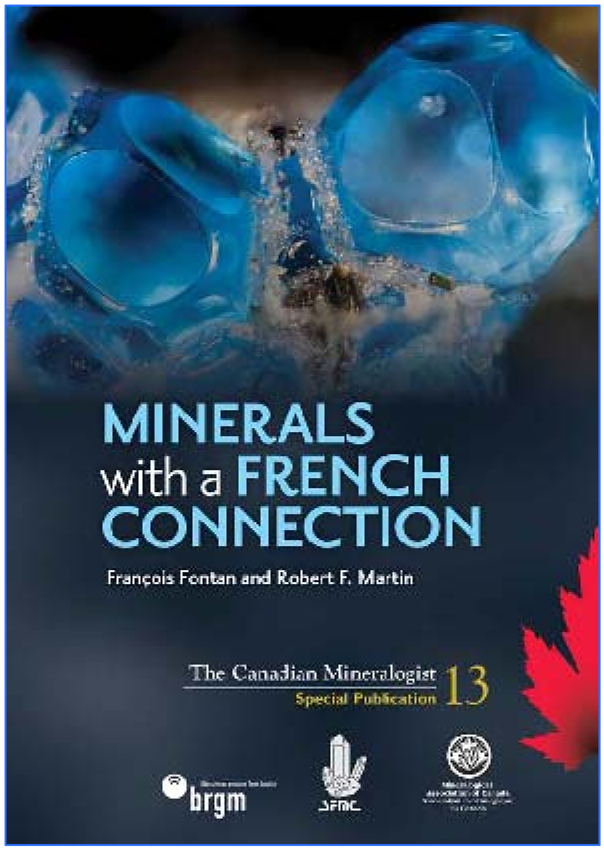
Jeff McKenzie & Andrew Hynes

Niagara on the Lake

14 June 2018

Minerals with a French Connection

François Fontan & Robert F. Martin



The book contains information on all minerals with a type locality in France (including New Caledonia), as well as all minerals discovered elsewhere and named after citizens of France. The book was undertaken in 2005 by François Fontan, CNRS, Université Paul-Sabatier, in Toulouse, at the suggestion of Bob Martin. François was very keen to celebrate the accomplishments of French scientists, whose collective work established France as the cradle of mineralogy and crystallography. Unfortunately, he died suddenly in 2007. Bob took over the project, and the resulting opus of 588 pages appeared in 2017. The detective work took that long! Minerals with a French Connection is a copublication of the Mineralogical Association of Canada and the Société française de Minéralogie et de Cristallographie.

Special Publications of **The Canadian Mineralogist** –
ISBN: 978-0-921294-59-7, SP 13, 588 pages, 2017

Dr G. Donnay: Tourmaline is a fascinating mineral

In the year 315 B.C. Theophrastus wrote that lyngourion (known to us as tourmaline) came from lynx urine and had the power to attract animals. "These statements, while interesting, are unconfirmed", says Professor Gabrielle Donnay, of Geological Sciences who is an authority on tourmalines. Although many people may be familiar with the beauty of this semiprecious stone, jewellery is only one of its minor uses. Tourmalines are pyro and piezoelectric which means that the mineral develops opposite charges at its two terminations when its temperature is changed or when it is put under pressure. For example, when rubbed on a wollen dress it quickly charges up. The crystals have been used in very sensitive thermometers measuring changes in temperature of as little as 1/100,000 of a degree, and also in pressure gauges in submarines.

When ordinary light passes through a transparent crystal it is broken up into two plane-polarized vibrations at right angles to one another. In tourmaline one of these vibrations is almost completely absorbed so that the emerging light is plane polarized. Thus tourmaline was used as a polarizer long before polaroid sheets were available for this purpose.

Dr. Donnay's fascination with tourmalines goes back a quarter of a century and began with her Ph. D. thesis at the Massachusetts Institute of Technology. The first area of her research was the crystal-structure determination and the correlation of the tourmaline crystal-structure with the morphology of the mineral. Later, and together with physicists and chemists, she studied properties such as the texture of colored specimens, magnetic behaviour, their Mössbauer spectra, which tell about the environment of iron atoms in the structure. She is now working with Professor J. Cowley and Dr. S. Iijima of the Arizona State University on very high-resolution electron-microscope images of tourmaline in which small groups of atoms can be seen with the naked eye. Her husband, Professor Emeritus J.D.H. Donnay, retired from Johns Hopkins University, still teaches Crystallography at the University of Montreal. He discovered early in his career relationships between crystal morphology and crystal-structure which the two Donnays have applied successfully to tourmaline. Another field in which they share an interest is in the Generalization of Symmetry, going from the three-dimensional symmetry of ordinary space to four-dimensional symmetry in which one additional property can have one of two values. Russian crystallographers have also carried out a great deal of work in this field and the Donnays have some joint publications with them.

Dr. G. Donnay is also intrigued with instrumentation and with the development of simple instruments suited for solving special experimental crystallographic problems.

When Dr. Donnay began her graduate work as Miss Gabrielle Hamburger, at MIT, Professor M.J. Buerger assigned her the problem of the crystal-structure of tourmaline. This had been handed to three previous graduate students one of whom took her aside and told her, "Gai, you are absolutely insane if you let Buerger push that tourmaline problem down your throat, you will never get your Ph. D. I lost three years on it and got nowhere". Gai refused, to believe in the hopelessness of this research, however, and three years later the structure and description of it were brought forward by her and announced at a meeting.

Tourmaline was always considered to be a very complicated mineral and indeed its chemistry is extremely involved, consequently Dr. Donnay was surprised to find that two other laboratories reported the structure of tourmaline almost simultaneously. Professor T. Ito and his co-workers at Tokyo University found a very similar structure and there was news from Moscow University where Professor N.V. Belov was receiving the Stalin Prize for having solved the tourmaline structure — a seriously different one. Dr. Donnay was able to convince Professor Belov that his was incorrect, he immediately acknowledged it and published a note to that effect in the Russian Academy. Even so, the East German mineralogy text books still today carry the incorrect Belov structure. A scientific result that received the Stalin Prize cannot apparently be admitted to have been wrong.

Dr. Donnay is seen standing infront of a ball-and-stick model of a unit cell of tourmaline. Below the model on her right is a high-resolution electron microscope image of tourmaline. This photograph was taken by Professors Iijima and Cowley at the Arizona State University. It is the first time so complicated a crystal structure has had its atomic arrangement photographed so that the crystal structure is evident to the naked eye. Dr. Donnay is holding a specimen criss-crossed by tourmaline needles.

Since that time many other tourmaline structures each with a different chemistry, have been refined. The magnesium, the ferrous iron and the lithium-aluminum crystal-structures are now known in great detail and during the process of studying these, a new one — the ferric tourmaline — was discovered and has had its crystal structure refined by X-ray and diffraction studies.

Ceylon was one of the earliest famous localities for tourmalines but nowadays they are to be found in many parts of the world. Sadly many of the areas are pretty well depleted of beautiful large specimens which are now hard to find. Tourmaline is nevertheless a very common mineral and comes in all colours. At one time the black ones (schorl) could often be picked out of the stones in the countryside. In the Western hemisphere buergerite (brownish-black) named to honour her former professor by Dr. Donnay and Dr. Brian Mason of the U.S. National Museum was located in Mexico, elbaite (pink) in Alta, California and dravite (green) and melon (green to pink) in Brazil.

One of Dr. Donnay's graduate students is Suzanne Fortier, the second student and the first female to graduate from McGill with an undergraduate degree in crystallography. Miss Fortier has already refined the crystal-structure of a schorl tourmaline to remarkable accuracy. For her doctorate, Miss Fortier plans to work on the structural interpretation of the pyroelectric phenomemon a property that tourmaline shows so strikingly. The question to be answered: "What is happening to the inter-atom arrangement in the crystal when charges develop due to sudden heating or cooling?"

"It is amazing", comments Dr. Donnay, "that we know nothing yet about the relationship of pyroelectricity and structure. Solid-state physicists have done this type of study for the piezoelectric property because it has great technical applications. Indeed thousands of scientists have spent millions of dollars to increase our knowledge in this field, but not a single paper has been found by us in which someone seriously tried to study the relationship of pyroelectricity and crystal-structure".

Whether Dr. Donnay is wearing her tourmalines as jewellery or carrying out further research into their structure and properties, she enjoys having these semiprecious stones around her. If you are the owner of an attractive piece of jewellery set with beautiful tourmalines handle it with care for the stones are relatively soft and can be scratched, but more important they have many unusual qualities apart from their obvious beauty and they would not easily be replaced in the same colour.

The Legacy of Frank Dawson Adams in Canada and in Sri Lanka

Robert F. Martin

Friday, February 9th, 2018   3:30PM   Redpath Museum

We work in the Frank Dawson Adams building, and we walk by his portrait every day. Just what were his claims to fame? Why is he so well known in Sri Lanka? Why is his work still quoted today? Answers will be provided in a talk first presented in December 2017 at the University of Peradeniya, under the auspices of the Geological Society of Sri Lanka. In his writings, Dr. Adams pointed out the great similarities between the metamorphic rocks of Sri Lanka and those of the Grenville Province. Thus the conveners made a request, that I speak about the Grenville Province. For the McGill audience, I will comment on the geology of Sri Lanka, a country that is the focus these days of studies of ultrahigh-temperature (UHT) metamorphic suites, and the state of marble in this context.

Alumni in the News

The new ‘gold’ of the Yukon

High above the treeline in the Yukon’s remote mountains, pieces of rock hold evidence of the Earth’s tumultuous climate swings that took place millions of years ago.

By Vivien Cumming

8 September 2017

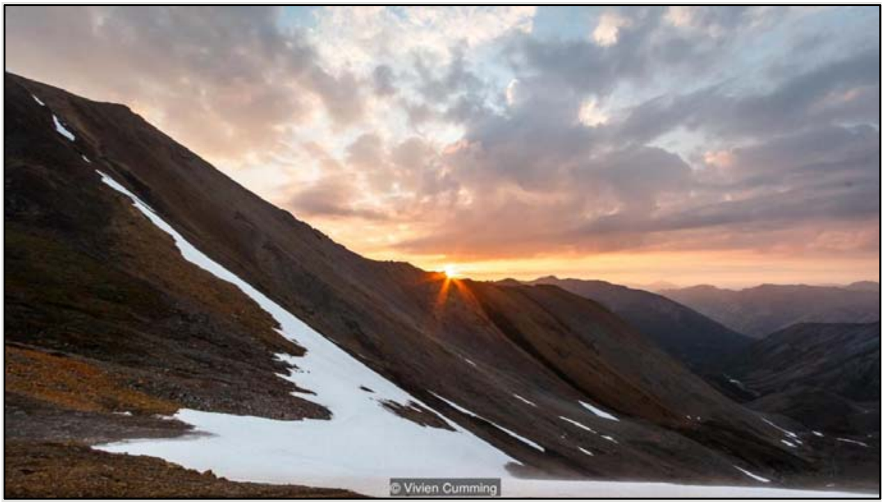
Gold country
The Yukon conjures up thoughts of the epic Klondike Gold Rush, when hundreds of thousands of men and women flocked to Canada’s Yukon’s mountains at the end of the 19th Century to find their fortune.

Today, people visit Yukon province for very different reasons than those who travelled here 100 years ago. Some come for the history, to see for themselves the story of the gold rush. Others visit for the mountains, wilderness adventures and the great variety of wildlife, including bears, elk, moose, lynx, foxes, mountain goats, muskoxen and marmots. (Credit: Vivien Cumming)

Another priceless find
Still another group of people visit the Yukon to find their own version of ‘gold’. Geologists come in search of sedimentary rocks that hold evidence of *Snowball Earth events* – instances when the Earth’s climate was swinging in and out of major glaciations – that took place between 750 and 600 million years ago. (Credit: Vivien Cumming)

Untouched wilderness
In July 2014, I and several other geologists from Harvard and McGill Universities travelled to the Yukon to hunt for new evidence that would help us complete the picture of this period of extreme changing climate.

Our destination wasn’t easily reached. Expansive mountain ranges make this large province a desolate and wild place that’s largely inaccessible by road. Some of the mountains here aren’t even named – and many have never had a human set foot on them. (Credit: Vivien Cumming)



Never before explored
Deciding where to go involved studying old aerial photographs and geological maps, but in such an unexplored area it can be hard to get it right. We planned to make camp high up in the Wernecke Mountains in central Yukon, north of the small town of Mayo. These are the most northern part of the North American Cordillera, a chain of mountains that stretches from Alaska to southern Mexico. (Credit: Vivien Cumming)

A bumpy ride
The first leg of the trip required us to take a twin-propeller plane from Mayo north-east to Rackla, an old mining air strip deep in the wilderness of eastern Yukon. We were then picked up by helicopter to get to our camp, 65km further into the mountains.

As we neared our intended location, clouds were rolling in. The pilot swerved through the dense vapour and around jagged peaks – he didn't seem fazed, but we were horrified as he weaved through pinnacles of rock that would suddenly appear out of the clouds right next to us. After finding somewhere flat to land, a perfect saddle between two mountains, he delivered us safely back to Earth. (Credit: Vivien Cumming)

At the mercy of nature
As the sound of the helicopter disappeared into the distance I realised we were at the mercy of the weather, the terrain and the wildlife, unable to be rescued unless the weather allowed for a helicopter to fly. (Credit: Vivien Cumming)

Making camp
This was our home for the next few weeks. We nicknamed our camp ‘Mordor’ for the ominous black peaks surrounding it. The camp was sparse, high above the treeline at more than 2,000m. Up here there are more rocks to see as they are not covered by vegetation. But, just as importantly, bears rarely venture this high up as there is no food for them here. (Credit: Vivien Cumming)

Bear scare

However, there were days when we had to venture several hundred metres down into the valleys. One day we were walking back up to camp when we saw a big brown shape ahead and heard marmots making their piercing alarm calls.

Getting our bear spray out, we began hatching an escape plan. We must have discussed this for at least half an hour, and all the while the bear didn't move. Eventually we felt brave enough to edge closer, and only then did we realise our mistake: it was not a bear after all, but rather a big, brown boulder. There was a lot of laughter and some cursing while we enjoyed a late meal back at camp. (Credit: Vivien Cumming)

Evidence of a Snowball Earth event

The 'bear encounter' was the same day we saw our first evidence of a Snowball Earth event. Layers form at the bottom of the ocean as rocks and sand accumulate, but when the Earth is covered in ice, the layers thin as less sediment is deposited. Meanwhile, larger rocks and boulders sit on the surface of the ice, where they are carried along as the ice sheets move. When the ice melts, these boulders fall to the ocean floor, where they disturb the already formed layers before being slowly encompassed by new sediment deposits.

Embedded in a rock face in this remote valley, large boulders were within fine sedimentary layers that had been disturbed by the heavier rock being dropped onto the fine seafloor sediment. It's a rare geological phenomenon and one that helped prove the Snowball Earth theory. (Credit: Galen Halverson)

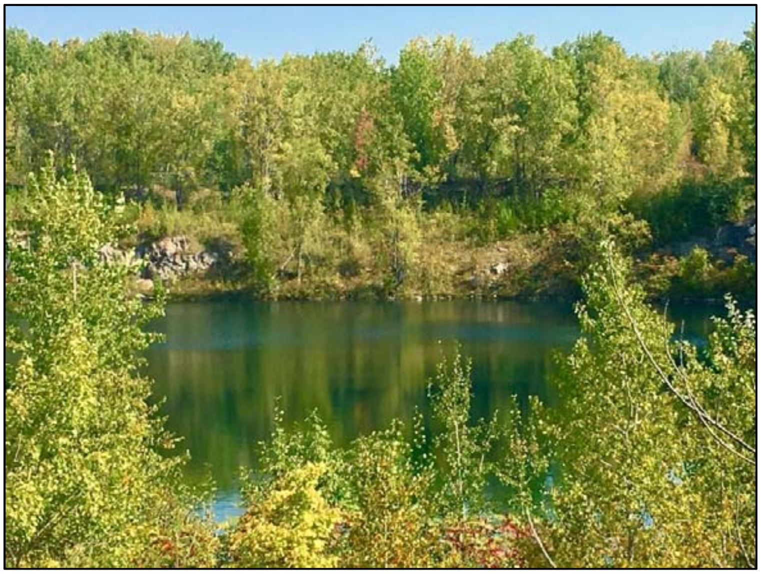
A find worth its weight in gold
Our exploration in the Yukon wasn't about fortune in the way that it was all those years ago for the Klondike prospectors. We returned home after a month with buckets filled with hundreds of rocks, totally worthless in monetary value. But to a scientist looking for clues about the Earth's mysterious and eventful past, they are worth their weight in gold. (Credit: Vivien Cumming)

McGill University cohort included:
Galen Halverson *(Associate Professor – TH Clark Chair)*
Tim Gibson *(Ph.D. student)*
Sarah Worndle *(Ph.D. student)*
Malcolm Hodgkiss *(B.Sc. '16)*
Vivien Cumming *(Post-Doctoral Fellow)*

Article appeared online in ***BBC - Travel*** *–*
http://www.bbc.com/travel/story/20170907-the-new-gold-of-the-yukon

New Grad Field Trip

17 September 2017



Quarry at St. Lawrence Columbium Mine

On a warm and sunny day, thirteen new grad students (Alexis Beaupré Laperrière, Robert Bourque, Catherine Crotty, Pascale Daoust, Debarati Das, Erin Gibbons, Regina Gonzalaz Moguel, Anna Hayden, Benjamin Keenan, Laura Lyon, Nick Ogasa, David Purnell, Stan Roozen) of the EPS department and three group leaders (Fiona D'Arcy, Ying Lin, Monika Rusiecka) took a field trip to visit Oka, home of a world-renowned carbonatite deposit and world-renowned cheese. It is a department tradition to take new grads on a fieldtrip each year to learn some of the regional geology, get a taste of Quebec, and of course give them a chance to get to know each other.

This year's trip was focused on the Oka carbonatite, the formation of the Monteregian hills, and regional glaciation! In addition to geology, participants got a chance to do some hiking, join in some fun outdoor games, visit the beach, and stop at the Abbey for some traditional Oka Cheese and local products.

Itinerary:

10:30 – Meet up in FDA parking lot

11:00 – Leave for Oka

12:00 – Arrive at 13 Rang Sainte Sophie, look at rocks and discuss regional geology. This is the site of the quarry from the St. Lawrence Columbium mine which operated in the 60s and 70s. The main ore is pyrochlore, and other Rare Earth Element (REE) bearing minerals. Columbium is a historical name for Niobium, the popular REE mined here. Today, the quarry consists or two water-filled pits, surrounded by piles of beautiful calcite and dolomite speckled with alkaline minerals.

12:45 – Visit Oka abbey to enjoy local cheese and have picnic lunch

13:45 – Hike up Mount Oka and discuss local geology, including the formation if the Monteregion hills. The Monteregion geologic province is a 125Ma (Cretaceous) series of alkaline intrusions, which was first coined by none other than Frank Dawson Adams himself. These intrusions never breached the surface, hence they are plutons rather than volcanoes, which were eventually revealed at the surface due to erosion. Technically, Oka is not a hill, but a depression formed from a ring-like intrusion. Mount Oka is remnant of other igneous products, and later glacial sediments from the Champlain Sea which covered the area during the last deglaciation 12Ka.

15:00 – Participants then split into teams, and raced down Mount Oka competing in THE-ULTIMATE-FOREST-SCAVENGER-HUNT for first prize! The winning team was Ben, Debarati, and Pascale!

16:15 – Visit Oka Beach: swimming, chatting, and fun-in-the-sun group games

17:45 – Leave Oka for FDA






1st Year Field Trip

22 September 2017

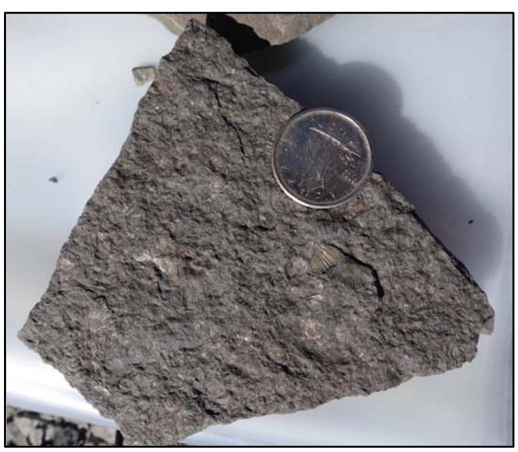
Left to right: Kaelyn Chaulk, Bill Minarik, Dawn Xiao, Jenna Randazzo, Kaelyn (Jiaqi) Liang, Celia Denepoux, William Wong, Shanshan Li, Alexandra Mayor Del Aguila
(not pictured: Holly Han and Galen Halverson)

Students, led by Bill Minarik and Galen Halverson, explored a few locations that provided an overview of the regional stratigraphy and geologic setting (Fig 1). 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).

Fossil Finding







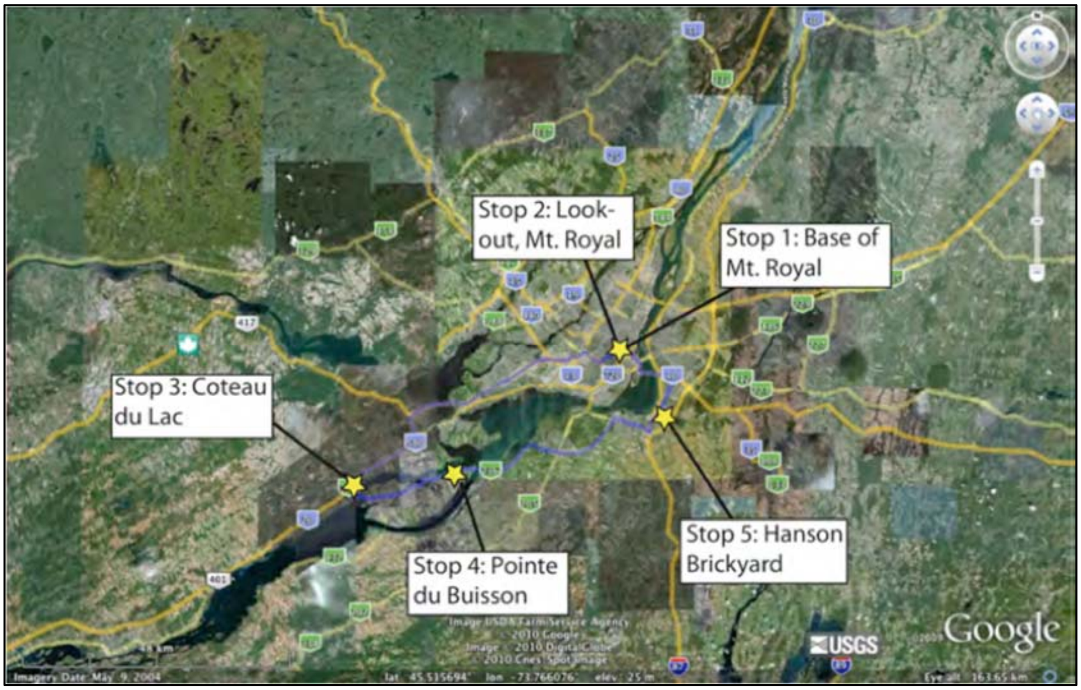


Figure 1: Localities visited on this trip (Google Earth image)

Stop 1: Outcrop near the plaque at the base of the Mt Royal: Here at the base of the mountain we can observe an outcrop of the fossiliferous Trenton Group (Fig 2 and 6).
Take a look at the outcrop: Do you see fossils? What is the grain size of these rocks? Are there layers? How many different types of rocks do you see here? What is the relationship between the different rock types?

Figure 2: Locations of the Frank Dawson Adams building and Stops 1 and 2. Stop 1 is the outcrop at the base of the mountain and Stop 2 is the overlook at the top of the mountain. (Google Earth image).

From Stop 1, we will continue walking up the stairs stopping along the way to look at the Utica shale, and cross-cutting dikes. The Utica Shale lies stratigraphically above the Trenton Group (Fig 6). We will reassemble at the look-out on the top of the mountain (Fig 2). *As you walk, take note: what does the shale look like? Does it change as you walk up the stairs? Can you see any minerals?*

Stop 2: Mt Royal over-look – Regional Geology overview: Monteregian Hills, glaciations, stratigraphy, tectonic setting during the Cambrian-Ordovician.

Platform Sediments: Cambrian-Ordovician sandstones, dolostones, mudstones, limestones, and conglomerates. These formed ~550-450 million years ago when a narrow sea existed between the Laurentian landmass and a landmass to the east. By looking at the entire package of these sediments (Fig 6), we can reconstruct what the geologic setting for different times in the past (Fig 8).

Monteregian Intrusions: These igneous intrusive rocks (alkaline) occur throughout the region in the form of dikes, sills, and a SSE-trending chain of plugs (Monteregian Hills). They are either related to the rift associated with the opening of the Atlantic or are a hot-spot trace (Cretaceous ~110Ma; Fig 7).

Logan's Line/Appalachian Mountains rocks: During the late Ordovician-early Silurian (~430-400Ma), the sea in which the platform sediments were being deposited closed as the landmass to the east collided with and sutured to the Laurentian landmass. This event is called the aconic Orogeny. Many orogenic events followed as oceans opened and closed and new land was added on to Laurentia. The westernmost boundary of these accreted rocks is a fault-line or suture zone referred to as Logan's Line (Fig 7). These accreted rocks east of Logan's Line are located in the Appalachian Mountains region.

Glaciations: The most recent major geological event shaping the Montreal area involves ice-sheet expansion during the last million years, most recently during the Last Glacial Maximum (~18 ka). At that time this region was buried by thick ice that reached as far south as central New York, and southern Ohio. As the ice retreated northward at ~12.5ka, the ocean completely inundated this region flooding the St. Lawrence Lowland (the Champlain Sea, Fig 8). This sea drained ~10ka leaving behind stranded lake and stream deposits, shorelines and terraces that are still preserved on the island of Montreal and surrounding regions.

Stop 3: Meridian Brickyard: This is a very shallow quarry that is mainly excavated for brick-making material. When snowfree (~8 months of the year), the quarry works as a "ripoperation" where the bottom of the quarry is ploughed up twice a year and the material is allowed to weather for ~3 months. Through this effort, the quarry is deepened ~30-45cm per year and provides ~100,000 tons annually (Hofmann, 2006).

These dark grey shales are part of the Nicolet River Formation within the Lorraine Group. Within the quarry wall small Monteregian dikes can be seen cutting through the shales. The shale beds are host to abundant fossils: trilobites, brachiopods, crinoids, bivalves, gastropods, epholopods, graptolites. Have a look at Fig 9 to help with identification of any fossils that you find!

Figure 3: Stop 3 - Meridian (was Hanson) Brickyard (LaPrairie): Lorraine Fm shales are being excavated for commercial use. Here we will observe and collect fossils! (Google Earth image).

Stop 4: Pointe de Buisson Archeological Park (Fig 4): Near the rapids between the St. Lawrence River and Lake St. Francis, this locality was an important Amerindian fishing and portage site. The museum contains Amerindian artifacts as well as a Fossil Garden assembled largely by Pierre Groulx, and the newly built "Hans Hofmann Hall", a dedication to the work of McGill professor and paleontologist. Here we can view many samples from the regional stratigraphy. No rock hammers please! Particularly of interest are the Climactichnites trace fossils within the Potsdam Sandstone . Some of the largest and smallest of these trace fossils ever found are now located here in the museum. Other features to note are mud-cracks, ripples, and cross-beds. After we visit the Fossil Garden and Hans Hofmann Hall, we'll walk down to the portage site along the river. Here we can see the Potsdam Sandstone in place where sandstone dikes and sills, breccias (seismites?), and joints dissect the sandstone. Glacial striae, polish and gouges are preserved on the outcrop surface (see Fig. 10 for glacial erosional forms; Hofmann, 2006). *Try to identify some erosional forms. Which way do you think the ice was moving?*

Figure 4: Stop 4- Point de Buisson Fossil Museum and Portage Site: Potsdam Sandstone, Climactichnites, and Seismites! (Google Earth image).

Figure 5: Stop 5- Coteau du Lac Historic Site: Here we will look at stromatolites in the Beekmantown Group and locks along an old canal (Google Earth image).

Stop 5: Coteau du Lac Historic Site (Fig 5): This location was one of the first portage sites to bypass rapids along the St. Lawrence River. A canal was built here for easier passage along this major Seaway. Geologically, this site hosts a wonderful exposure of the early Ordovician Beauharnois Fm, part of the Beekmantown Group (Fig 6). The dolostone that can be observed within the old locks contains stromatolites and chert nodules/lenses. *Check out the mounded structures along the shore of the river. What do you think these could be?*

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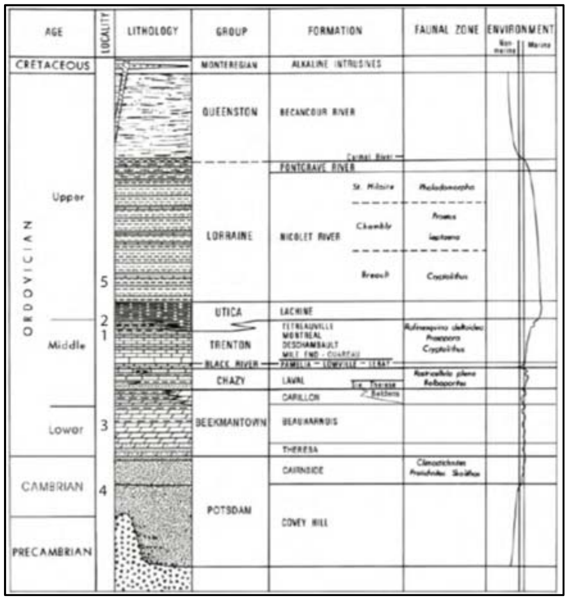


Figure 6: Generalized stratigraphic column for the Montreal area. The numbers indicate the position within the stratigraphy of the locations visited on this trip (after Hofmann, 1972)

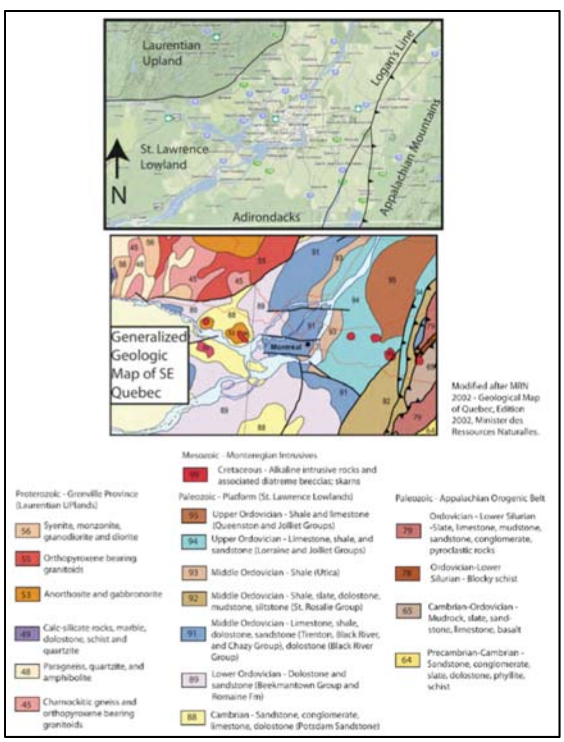


Figure 7: Geographic and Geologic map of the Montreal region. Montreal lies within the St. Lawrence Lowlands between the Laurentian Uplands to the NW, the Appalachian Mountains to the east, and the Adirondack Mountains to the south (generated in Google Earth and modified after MRN 2002)

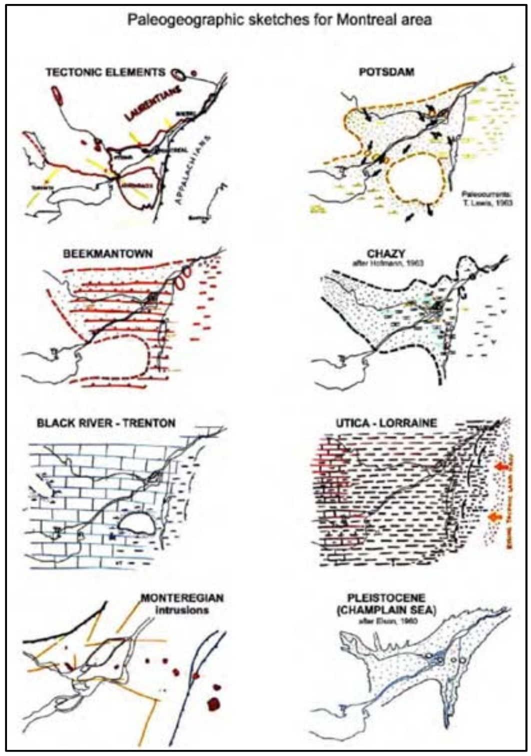


Figure 8: Paleogeographic sketches for the Montreal area (after Hofman, 2006).

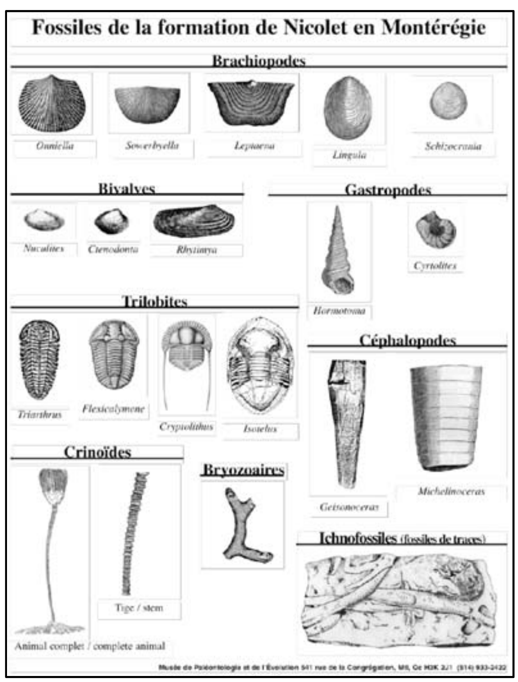


Figure 9: Common fossils of the Nicolet Fm (Lorraine Group). Use this as a guide for the fossils you find at the Hanson Brickyard quarry (from the Museum of Paleontology and Evolution, Montreal).

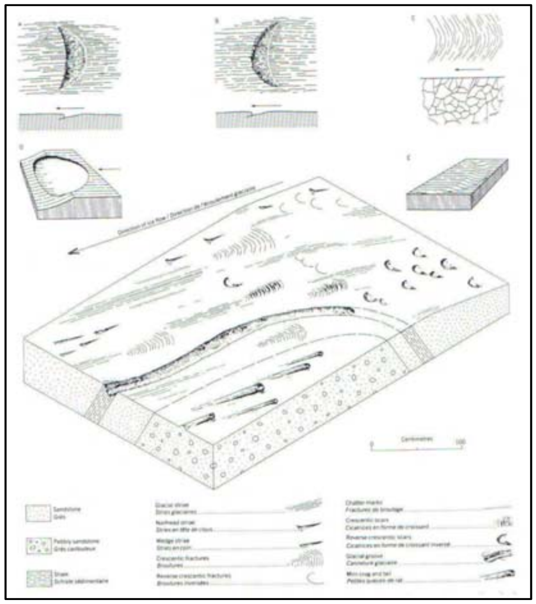


Figure 10: Glacial erosional forms in bedrock. Notice that crescent shapes may form with the horns facing up or down ice, however the dip of the surface will always be down ice (dip in the flow direction). You can see this in the cross-section view of the two types of crescents shown in A and B above. The arrow shows the direction of ice-flow (Benn and Evans, 1998).

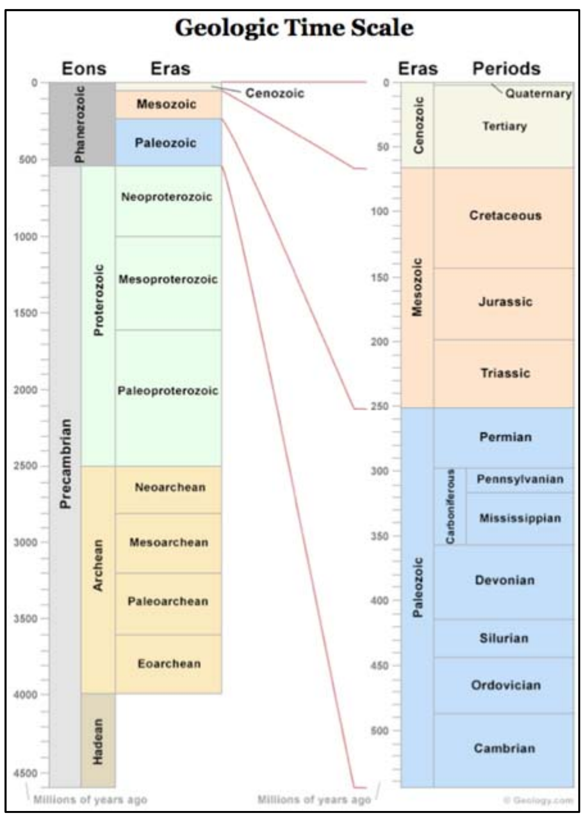
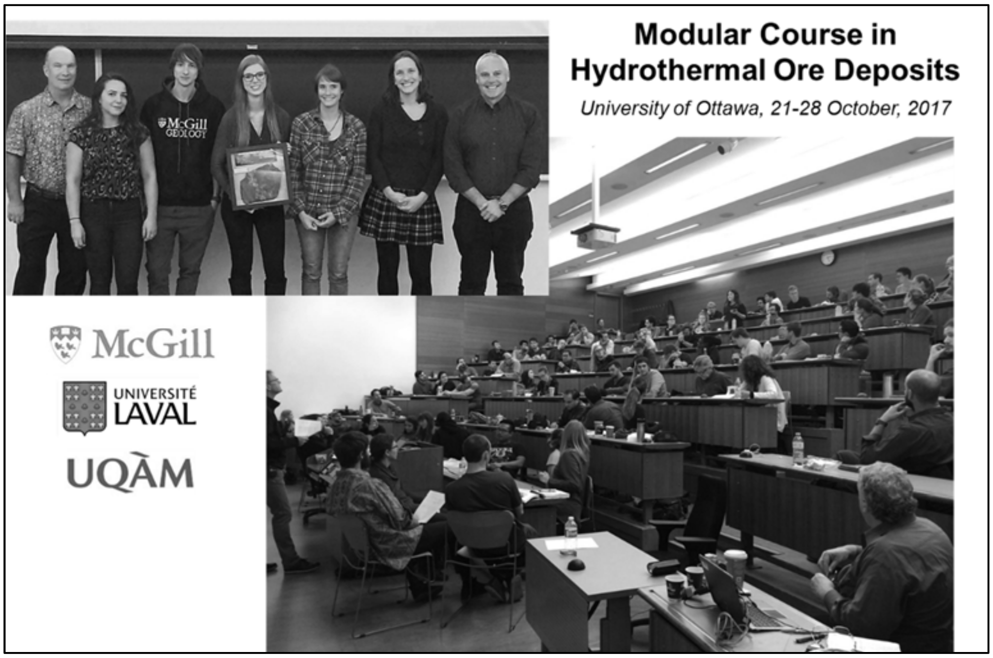


Figure 11: Geologic Timescale (Geology.com, from U.S. Geological Survey Geologic Names Committee, 2007, Divisions of geologic time—Major chronostratigraphic and geochronologic units: U.S. Geological Survey Fact Sheet 2007-3015, 2 p.)

Modular Course in Hydrothermal Ore Deposits

University of Ottawa



McGill participants included: Caitlin Beland (Ph.D. student – AE Williams-Jones, supervisor), David Martineau (M.Sc. student – AE Williams-Jones, supervisor), Victoria Tweedie (M.Sc. '18 – John Stix, supervisor), Emily Laycock (M.Sc. student – AE Williams-Jones, supervisor), and Sarah Bodeving (Ph.D. student – AE Williams-Jones, supervisor)

The University of Ottawa Joint Modular Courses in Hydrothermal Ore Deposits are intensive 8-day short courses on the geology and genesis of ore deposits deposits involving universities across North America and Europe. This year's course will focus on hydrothermal ore deposits at a range of crustal levels – from deep orogenic systems to the surficial environment. Leading experts will introduce the basic principles that govern the evolution of ore-forming fluids, the importance of different ore-fluid reservoirs, the interaction of hydrothermal fluids with different rock types, and the causes of mineral precipitation. Case studies will be presented for some of the world's most important ore deposit types in both continental and submarine settings, with an emphasis on where ore fluids originate, how and where they derive their metals, and where they end up – all fundamental pieces of the mineral systems puzzle. The material will be suitable for graduate students with advanced 3rd and 4th-year training in ore deposits and for professionals in industry.

The course will be presented as four 2-day modules that focus on the following topics:

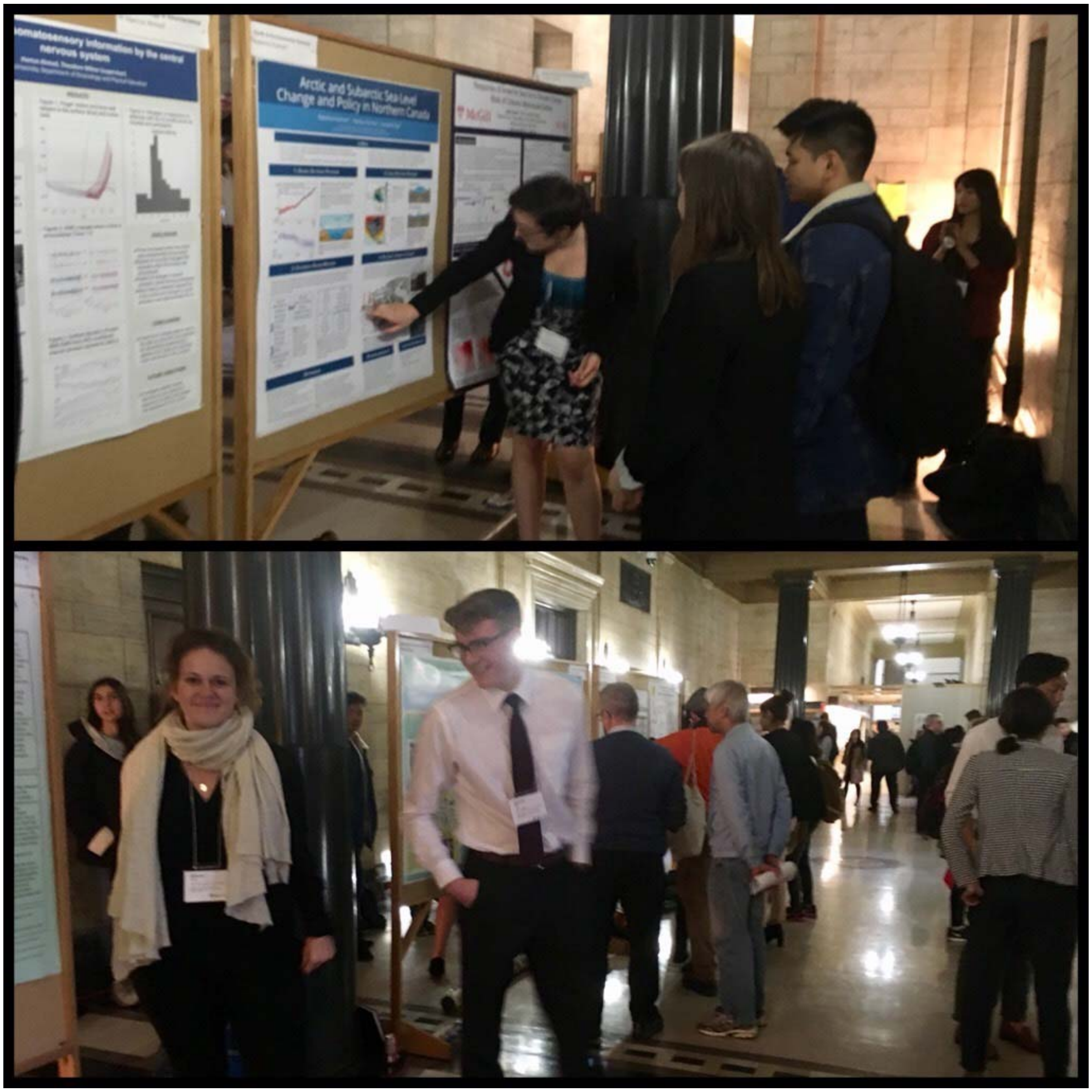
- Practical guides to the ore elements, minerals, and fluids
- Orogenic gold and porphyry-related systems
- Epithermal systems and iron oxide-copper-gold deposits
- Volcanogenic massive sulfides and ore deposits in surficial environments
- Applications to exploration

The course is open to graduate students from any university as well as professionals in industry. Graduate students may be eligible for credit toward their degree programs. Industry participants may receive credit toward professional training requirements.

Faculty of Science

Undergraduate Research Conference

26 October 2017



Earth & Planetary Sciences undergraduate students **Mitchell May, Eleanor Seery**, **Emerald Stratigopoulos**, and **Katarina Kuhnert** ***(2nd Prize Winner (tie) – Earth & Environmental Sciences)*** presenting their research at the Faculty of Science Undergraduate Research Conference – Arts Building Lobby

Open House

29 October 2017

Many thanks and appreciation to faculty *(Nick Cowan, Natalya Gomez, James Kirkpatrick, and Bill Minarik)* and students *(Anna Hayden and Dana Silerova)* for their involvement in this year's EPS and ESS Open House despite Sunday's inclement weather!

LIBS in Geoscience

The applications of Laser-Induced Breakdown Spectroscopy in Earth & Planetary Sciences

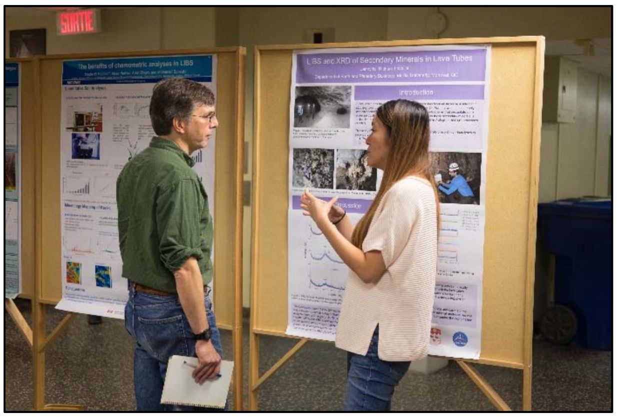
2-3 November 2017

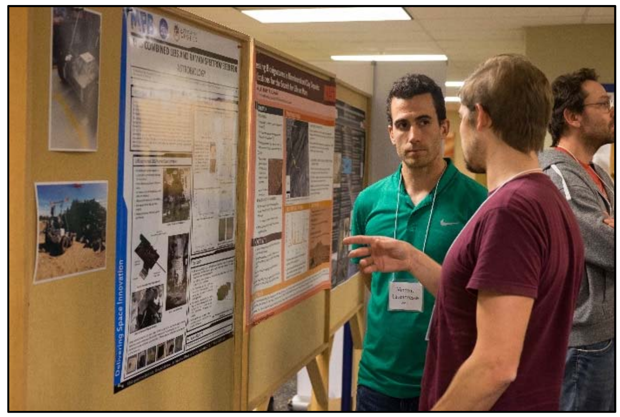
Laser-Induced Breakdown Spectroscopy (LIBS) is an emerging elemental analysis technique in the geosciences. Although the method has been around for some years and a LIBS instrument is currently active on the Mars rover *Curiosity*, the use of LIBS in geoscience is still in development. LIBS uses a short laser pulse to ablate a small amount of target material, creating a plasma with the combined characteristics atomic emission of elements present in the target.

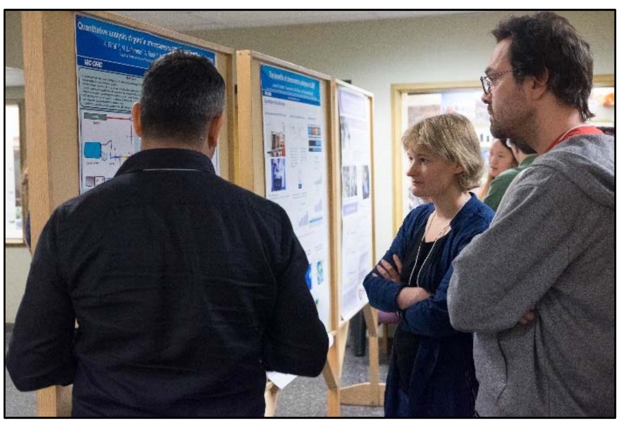
A workshop was held in the Department of Earth and Planetary Sciences at McGill University on November 2-3, 2017. Over 40 people participated in the workshop. A series of oral presentations were accompanied by a poster session as well as demonstrations of two commercial LIBS-based instruments by Applied Spectra Inc.(USA) and Elemission (Canada). Presentations covered the history and development of the LIBS technique, instrumentation, data analysis, and application in mining and the fossil fuels, gem provenance, geotechnical materials, Mars geochemistry, and medical microbiology and cellular biology. Presentations included a summary of the LIBS technique by pioneering researcher Mohammed Sabsabi (NRC), ChemCam LIBS instrument on Curiosity by Richard Léveillé (McGill U.), LIBS fingerprinting of rocks and gems by Nancy

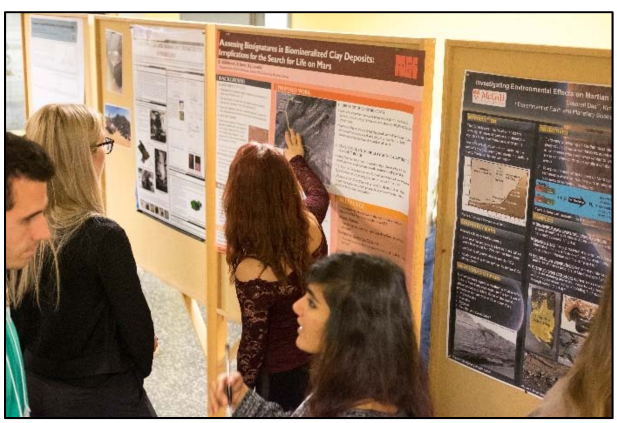
McMillan (New Mexico State U.), microbiology applications by Steve Rehse (U. Windsor) and even the detection of cancer cells using LIBS by Noureddine Melikechi (U. Mass-Lowell). Several students and postdocs also participated, in some cases presenting their own LIBS research, and the McGill LIBS lab, led by Kim Berlo, featured prominently.

The meeting was a resounding success. One of the participants (Dany Savard, UQAC) has created an email LISTSERV dedicated to LIBS. Participants were also invited to participate in the NASLIBS conference at SciX this coming November (Atlanta, GA) and it seems likely that there will be a follow-on workshop in the Fall of 2018 in the Montreal area.





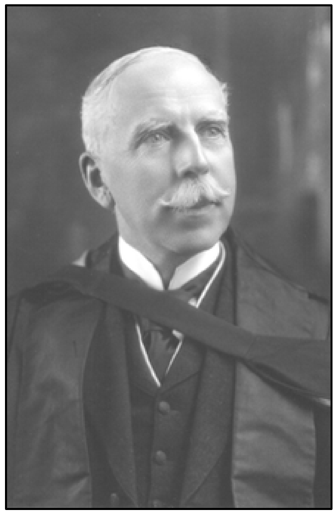




Photos courtesy of Richard Leveille

About Frank Dawson Adams

by Thomas H. Clark (1893-1996)



Frank Dawson Adams

Born in Montreal on 17 September 1859; and died in Montreal on 26 December 1942

Adams' father, Noah Adams, belonged to the distinguished Adams family of New England; his mother, Frances Tait Dawson, was a United Empire Loyalist from Northern Ireland. At nineteen he graduated with first rank honors in natural science from McGill University, where he came under the influence of the scholarly principal, J. W. Dawson (no relation), and the versatile and magnetic B. J. Harrington of the department of chemistry and mineralogy. Comfortable family financial circumstances allowed Adams to study chemistry and mineralogy at Yale University (1878-1879), and later to attend several sessions at Heidelberg University.

After spending 1880 to 1889 in government service, Adams joined the staff at McGill as lecturer (1890-1893); he followed Dawson as holder of the Logan chair of geology in 1893. Adams became dean of the Faculty of Applied Science in 1908 and dean of the Faculty of Graduate Studies in 1922. He retired in 1924, after thirty-five years of arduous service. He was deeply but quietly religious. His History of Christ Church Cathedral (1941) was a tribute to the church to which he was devoted and to his wife, Mary Stuart Finley, to whom the book was dedicated. Adams also found time to devote to many philanthropic arid social benevolences.

Adams belonged to numerous scientific societies, including the Royal Society of London, the Geological Society of America (of which he was president in 1918), the Royal Society of Canada (president in 1913; Flavelle Gold Medal in 1937), and the Geological Society of London (Lyell Medal in 1906; Woll as ton Medal in 1939). He was also president of the Twelfth International Geological Congress (Montreal, 1913). He received honorary degrees from McGill, Toronto, Queen's, and Mount Allison universities, and Bishop's College.

In 1880 Adams joined the Geological Survey of Canada as assistant chemist and lithologist. One of the first tasks given him by the director, A. R. C. Selwyn, was to determine the nature and origin of certain rocks from southern Quebec. In order to work out these derivations and associations, Adams requested, and was granted, leave of absence to master the new petrographic technique being developed by H. Rosenbusch at Heidelberg. He completed this work to Sclwyn's satisfaction and was next assigned to o study areas of partly foliated anorthosites in south- western Quebec that William Logan had considered to be the upper and stratified portion of the Laurentian series. To this difficult task he applied his newly won skill in the use of the petrographic microscope, an instrument with which he had become familiar in Heidelberg and which he was probably the first in Canada to use. He was able to demonstrate conclusively not only the igneous origin of the anorthosites but also the sedimentary origin of some of the Grenville crystalline rocks upon which Logan had supposed the anorthosites rested. The presentation of the results of this study gained him the Ph.D. summa cum laude at Heidelberg. The publication of his thesis (1893) established Adams as one of the North American experts in the use of the petrographic microscope. Several publications resulted from his work with the Geological Survey, among the more important being descriptions of Precambrian rocks north of Montreal and St. Jerome (1896), based on field work carried out from 1885 to 1891.

The Laurentian system had been considered by Logan to consist of two divisions, the lower a complex of metamorphosed sedimentary rocks, which he named Grenville and Ottawa, and an upper, or Norian, division, made up largely of anorthosite, which was considered to be an altered and crystallized sediment. This anorthosite, well exposed around Morin, Quebec, was very· carefully inspected by Adams, who showed that it was composed largely of plagioclase feldspar, with few accessories. He established its igneous nature both by his petrographic determinations in the laboratory and by the intrusive contacts with the Grenville rocks that he was able to demonstrate in the field. He attributed the marked differences in grain size to crystal fracturing, which in places was carried to granulation. He also recognized that the Laurentian granites, then supposed to be the oldest rocks of the Canadian shield and possibly part of the original crust, were intrusive into metamorphic rocks, which therefore must have pre- ceded them in time and space. These conclusions were among the foundations upon which the modern classification of the Precambrian series rests.

After leaving the Geological Survey and joining the staff of McGill, Adams devoted the summers of 1902 to 1908 to the mapping and description of the forbiddingly difficult Haliburton and Bancroft areas of southern Ontario. ln his report (1910), written with A. E. Barlow, who had collaborated with him during the later years of the project, he showed that the oldest rocks were highly metamorphosed sediments, now gneisses, schists, quartzites, and marbles, and assigned them to the Grenville series. He found widespread intrusions of granite, diorite, and gab bro penetrating the Grenville rocks, and correctly attributed most of the metamorphism to the thermal effects of the abundant granite bodies. Adams noted that the metamorphism of the stratified rocks became more intense and the sedimentary rocks were "fretted away and [ultimately] represented only by occasional shreds and patches of amphibolite," as the intrusive granites were approached. His discovery of nepheline syenite adjacent to granite and marble bodies was of great scientific importance, and paved the way for their later industrial exploitation. Because of the clarity of the writing, the painstaking carefulness of the descriptions, and the logical deductions, Adams' report has become one of the classics of Canadian geology.

At McGill, Adams could not fail to be impressed by the peculiar rocks of Mount Royal. He found that the same general rock types prevailed in the half-dozen prominent hills dotted across the Paleozoic plain between Montreal and the Appalachian front. He ·announced the occurrence of these remarkable rock types in his paper "The Monteregian Hills: A Canadian Petrographical Province" (1903):

Close study of the deformed foliated gneisses and schists of the Grenville area had stimulated Adams' curiosity concerning the causes of such structures and the possibility of their being duplicated in laboratory experiments. Aided by colleagues in the engineering laboratories at McGill, he started a sequence of experiments, spread over the first decade of the present century, utilizing a gigantic (for that time) press in which he could subject rocks to enormous pressures. High pressures had long been used to test the strength of cubes of rock to determine architectural suitability; but to duplicate the conditions within the earth's crust, Adams subjected cylinders of rock encased in metallic tubes to compression under high confining pressures - for the most part less than 20,000 pounds per square inch but on one occasion 296,725 pounds per square inch. Manipulation of the apparatus allowed Adams to develop differential stresses and presumably to imitate the conditions under which some of the foliated rocks may have originated; he was also able to correlate some of the experimentally developed structures with natural ones observed in the field. The influence of this work upon our understanding of metamorphic processes is profound, and it has contributed in no small measure to the development of modern ideas of mountain building.

Adams' first paper in this field, written with J. Nicholson concerned a thumb-size cylinder of Carrai marble that he exposed to a confining pressure of 18,000 pounds per square inch; after 124 days It column had shortened by 11.4 percent of its origin height. Examined microscopically, it showed many 1 the characteristics peculiar to the Grenville marble. Never before had properties of metamorphic rock been imitated in controlled experiments. Adams r, turned_ to this topic several times, and by using tr highest available pressure, 296,725 pounds per squa1 inch, he developed in his samples a schistose structu1 essentially similar to that of some highly metamorphic calcareous rocks. One interesting result was his discovery that quick-loading techniques caused calcium to yield to stress along intergranular slip plane giving a cataclastic structure, whereas slow increase in loading produced intracrystalline polysynthet twinning.

Other experiments were designed to record the plasticity of rocks under high pressures, up to 200,0C pounds per square inch. Most soft materials were easily deformed, but the harder rocks, such as granite failed along fracture lines, yielding zones of granulation; this corroborated Adams' own early ideas of the granulation of anorthosite by crystal fracturing. Other studies were directed to the determination of the depth at which pressure would close cavities in rock. In granite, one of the least plastic rocks, Adams determined that cavities could exist as deep as eleven miles below the surface. One of his last papers c experimentation (1917), written with J. A. Bancroft showed that the strength of rocks increases with pressure, and hence with depth in the crust, the conclusion being that rocks at great depth have great strength. To Adams must go the credit for establishing this phase of geological investigation upon a solid engineering foundation. His reputation as a pioneer, in the field is secure.

In the decade following his retirement from active participation in university affairs, he and Mrs. Adams traveled widely, and following their third visit to Ceylon, he published the first complete geologic report and map of that island (1929). Adams has always been intrigued by the beginnings of geologic thinking, and during his travels he visited most of the Old World universities whose libraries held wealth of early geological treatises. Wherever he could, he acquired early writings and amassed what was certainly the greatest such collection in private hands (now kept, intact, at McGill). This formed the basis for his scholarly work Birth and Development of the Geological Sciences (1938), a text that will long remain a standard treatment of the subject.

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II. SECONDARY LITERATURE. Of the many biographies the following are selected: H. M. Tory, "Frank Dawson Adams (1859-1942)," in Royal Society of Canada Proceedings, ser. 3, 37 (1943), 69-71; J. A. Dresser, "Memorial to Frank Dawson Adams," in Geological Society of America Proceedings 1944 (1945), 143-150; and J. W. Flett, "Frank Dawson Adams 1859-1942," in Royal Society of London, Obituary Notices of Fellows, 4, no. 12 (1943), 381-393.

Campus-side entrance to the Frank Dawson Adams Building

ADAMSITE-(Y)

Adamsite-(Y), a new mineral discovered in the Poudrette quarry on Mont Saint-Hilaire, **was named in honor of Frank Dawson Adams in 2000**. With the ideal formula $NaY(CO_3)_2C6H_2O$, it occurs as groups of colorless to white and pale pink, and rarely pale purple, acicular to fibrous crystals up to 2.5 cm in length. It is triclinic, with the space group *P* 1bar. Adamsite has a layered crystal structure consisting of slabs of $Na(H_2O)_6$ and (CO_3) polyhedra bonded to Y atoms. The weak H-bonding between the slabs gives rise to a perfect {001} cleavage.

Adamsite-(Y) is a very late-stage, low-temperature, hydrothermal phase occurring in cavities in an alkaline pegmatite dike in nepheline syenite in the East Hill suite of the Mont Saint-Hilaire intrusion. This dike, known as the Poudrette pegmatite, is remarkable for a mineral assemblage of over 150 mineral species, including 25 carbonates. In addition to adamsite-(Y), five other new mineral species have been described from the pegmatite, including thomasclarkite-(Y) named after Thomas Henry Clark (1893-1996), a past chairman of the Department of Earth and Planetary Science. Notably abundant in the pegmatite is dawsonite, named after Sir William Dawson.

BLAST FROM THE PAST …

BANCROFT – October 1990

Participants included: Dan Ahmad, Sherry Becker, Anne Charland, Pat Cerri, Luc Chouinard, Eva Drivet, Don Francis, Stephen Grasby, Jackie Hestrin, Francois Legault, Anne Kosowski, Robert F. Martin, Bruce Mountain, Eric Munro, Gary Nassif, Christine Petch, Glenn Poirier, Isabelle Robillard, Stefano Salvi and Peter Thiersch

MINEX – 1983-1984

Back Row: Jackie Chan, Pat, Mike Stanley, Steve Pigeon, Dan Walker, and Reno Pressaco

Front Row: Klaus Bunder, Peter Cashin, Bruce Mountain, Chris Davis, Francois, John Gravel and Isabelle Cadieux

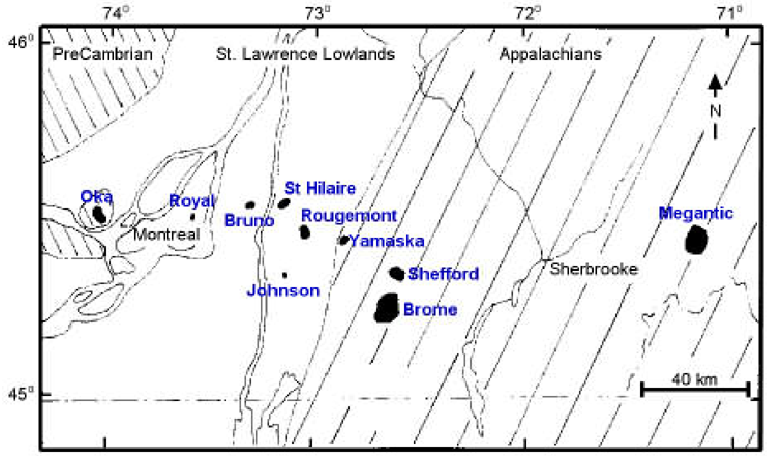
The Monteregian Hills

The Monteregian Hills is a linear chain of isolated hills in Montreal and Montérégie, between the Laurentians and the Appalachians. The first definition of the Monteregian Hills came about in 1903 when Montreal geologist Frank Dawson Adams began referring to Mount Royal and hills of similar geology in the Saint Lawrence Lowlands as the "Royal Mountains". Other hills in the chain included Mont Saint-Bruno, Mont Saint-Hilaire, Mont Saint-Grégoire, Mont Rougemont, Mont Yamaska, Mont Shefford, and Mont Brome. It was only later that Mont Mégantic, the Oka Hills, as well as the Saint-André and d'Iberville formations, were added to the list. The hills extend eastward for about 50 miles (80 km) from Île de Montréal to the Appalachian Highlands. Each hill in the chain consists of an erosional remnant of Cretaceous intrusive igneous rock and associated hornfels, which are more resistant to weathering than the surrounding sedimentary rock. All of the hills have dark-coloured mafic rock such as gabbro and essexite; some also have large areas of pulaskite, syenite, and other light-coloured rock.

The Monteregian Hills are part of the Great Meteor hotspot track, formed as a result of the North American Plate sliding westward over the long-lived New England hotspot,[4] and are the eroded remnants of intrusive stocks. These intrusive stocks have been variously interpreted as the feeder intrusions of long extinct volcanoes, which would have been active about 125 million years ago,[5][6] or as intrusives that never breached the surface in volcanic activity.[7] The lack of an obvious track west of the Monteregian Hills may be due either to failure of the plume to penetrate the Canadian Shield, to the lack of recognizable intrusions, or to strengthening of the plume when it approached the Monteregian Hills region. However, there is evidence the hotspot track extends northwestwards, including epeirogenic uplift, mantle velocity anomalies and kimberlitic volcanic features (e.g. the Attawapiskat, Kirkland Lake and Lake Timiskaming kimberlite fields) that become older away from the Monteregian Hills.[8]

The shallow, rocky sandy loam soils of the summits are mostly covered in forest. Where the underlying rock is rich in olivine, as over large areas of Mont Saint-Bruno and Mont Rougemont, these soils are classed as dystric brunisol. Podzol tends to develop over rock which lacks olivine, although many of these podzols lack an eluvial (Ae) horizon. Lower slopes are covered with aprons of gravel or sand. The sandy soils are usually podzols with classic Ae development; they often have subsoil hardpan and are undesirable for agriculture. The free-draining gravels are preferred for apple orchards, which grow in thermal belts where cold air can drain to the valley floor.

Best known is Mont-Royal, on Île de Montréal, which actually consists of three peaks—Mont-Royal (763 feet [233 m]), Westmount, and Côte-des-Neiges. Extending into Montérégie and Estrie are the mountains of Saint-Bruno, Saint-Hilaire (Beloeil), Saint-Grégoire (Johnson), Brome, Rougemont, Yamaska, and Shefford.



Name	Height	Age	Coordinates	Location
Oka Hills	249 metres (817 ft)[9]	n/a	45°28'N, 74°5'W	Oka
Mount Royal	233 metres (764 ft)	118-138 myr	45°30'23"N, 73°35'20"W	Montreal
Mont Saint-Bruno	218 metres (715 ft)	118-136 myr	45°33'1"N, 73°19'09"W	Saint-Bruno-de-Montarville
Mont Saint-Hilaire	411 metres (1,348 ft)	135 myr	45°33'8"N, 73°9'3"W	Mont-Saint-Hilaire
Mont Saint-Grégoire	251 metres (823 ft)	119 myr	45°21'29"N, 73°09'08"W	Mont-Saint-Grégoire
Mont Rougemont	381 metres (1,250 ft)	137 myr	45°28'36"N, 73°03'17"W	Rougemont
Mont Yamaska	416 metres (1,365 ft)	120-140 myr	45°27'25"N, 72°52'19"W	Saint-Paul-d'Abbotsford
Mont Shefford	526 metres (1,726 ft)	120-130 myr	45°21'49"N, 72°37'33"W	Shefford
Mont Brome	553 metres (1,814 ft)	118-138 myr	45°16'59"N, 72°37'59"W	Bromont
Mont Mégantic	1,105 metres (3,625 ft)	128-133 myr	45°27'20.5"N, 71°9'7.6"W	Notre-Dame-des-Bois

Outreach

By Robert F. Martin

This rock is igneous, not metamorphic! Bob Martin explains what to look for to Paul Martin, his wife Sheila, and Alysia. Photo by Vicki Martin. A profusion of Martins on that glorious day!

A call came in to Bill Minarik last Fall from Alysia, who had a novel idea for a gift to the man who has everything... her father-in-law in fact, whose 79th birthday was coming up. Was there anyone available to lead a field trip on Paul Martin's property, referred to as "The Farm", near Cowansville. She was talking about Paul Martin, Canada's 21st Prime Minister! It turns out that Paul had burning questions about a low cliff on his property, now located at a sand trap on his private nine-hole golf course. Every guest golfer would be told that the rocks at that exposure had been thrust up as a result of mountain building that had affected the area. Having participated in the former second field school in the Sutton area, I considered myself able to say something intelligent.

Vicki and I had a great afternoon visit in mid-October. We hopped on golf carts, Vicki with Alysia, Sheila with Paul Jr., and me with Paul. On our tour around the golf course, I asked to stop at a couple of low exposures, to see what kind of rocks were exposed; I noticed a few large boulders that had nothing to do with the rocks in the outcrop. I explained the concept of glacial erratics, much to the amazement of my driver. Then we came to THE cliff, the focal point. I told Paul that he had to revise his working hypothesis. This small cliff was created by removal of part of a major exposure by blasting in order to create the golf course, which must have been quite a challenge in this hilly countryside. It turns out that the rocks are not those I was expecting, but rather syenitic rocks. We were in the margin of the Brome complex, one of the Monteregian Hills, of Cretaceous age! Vicki and I had a great time, Paul, his wife Sheila, Alysia and Paul Jr. served us lunch, and subjected me to a barrage of long-unanswered questions! A memorable afternoon!

In The News

A misty morning at the researchers' study location above Tremblay Sound, northern Baffin Island.

Photo Credit: (Photo Tim Gibson)

Arctic rocks yield answers to billion-year-old mystery

By Levon Sevunts | english@rcinet.ca - Wednesday 3 January, 2018

A billion-year-old fossilized algae found in sediment rock deposits in the Canadian Arctic is believed to be the oldest known direct ancestor of modern plants and animals, according to a new study by scientists at McGill University published in the journal Geology.

The analysis of the fossil organism, identified as a red algae called *Bangiomorpha pubescens,* has also led the researchers to estimate that the basis for photosynthesis in today's plants was set in place 1.25 billion years ago.

The findings might help unlock a mystery that had puzzled earth scientists for over two decades following the discovery of the fossils encased in sedimentary rocks found in 1990 on Baffin Island in Canada's Arctic territory of Nunavut.

With the dating techniques available at the time researchers had estimated the fossils to be between 720 million and 1.2 billion years old, leaving a margin of error of nearly half a billion years.

What 'young' Arctic rocks tell us about origins of the Earth and Moon

However, using the relatively new Rhenium-Osmium dating technique researchers determined that the rocks are 1.047 billion years old, said Timothy Gibson, a PhD student at McGill University and the lead author of the study.

"They preserve, in my opinion, one of the most remarkable early fossils that we see in the rock record," Gibson said in a phone interview from New York City.

"What's particularly special about this fossil is that it looks almost identical to modern algae and it's really the first and oldest fossil that looks similar to a modern-day complex organism that we see today."

Field camp above Elwin Inlet, northern Baffin Island. © (Photo Tim Gibson)

Gibson and his research team spent the last four summers collecting their samples in northern Baffin Island, between the hamlets of Pond Inlet and Arctic Bay.

They were flown by helicopters and dropped off in remote campsites, spending a few days or a week at each site to do their field work.

"We were in complete wilderness," Gibson said.

And the ever-changing Arctic weather presented the geologists with its own set of challenges.

“We had seasons when we got a metre of snow in the beginning of August, which sort of shut down our field season because it’s hard to look into the rocks through the snow,” Gibson said. “We had really-really strong winds; a week of living in complete fog but we’ve also had conditions that were two or three weeks of 15 C, sunshine, no wind and working in t-shirts.”

The group had to take polar bear precautions and was fortunate enough not to have any encounters with these majestic but extremely dangerous Arctic predators, Gibson said.

Timothy Gibson at his field location on Tremblay Sound in northern Baffin Island. © (Photo Sarah Wörndle)

Gibson said he is finishing writing his PhD thesis and hopes to expand his research to other areas of the Canadian Arctic, Greenland and even Svalbard which have similar geological features.

“My future plans are sort of connecting the dots and making connections between the field area we worked in northern Baffin Island and lots of other areas in the Canadian Arctic,” Gibson said. “This coming summer I’ll be in the Yukon and Svalbard.”

Scientists from the Lawrence Berkeley National Laboratory, the California Institute of Technology, the University of Alberta, and the Geological Survey of Canada contributed to this study.

Funding for the research was provided by the Agouron Institute, the Natural Sciences and Engineering Research Council of Canada, the Polar Continental Shelf Program, the Geological Association of Canada, and the Geological Society of America.

2017 Thomson House

Christmas Party Photos



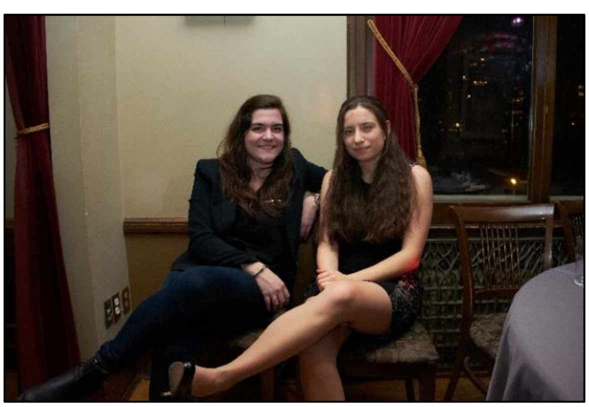











Photos courtesy of Ying Ran Lin (M.Sc. ’17)

Sedimentary Field Trip 2018

Sedimentary Basins and Sequence Stratigraphy

This year EPSC has run a sedimentary geology field trip to Spain led by Galen Halverson. Ten undergraduate students enrolled in EPSC 423 (Sediments to Sequences), 8 graduate students in Sedimentary Basins graduate seminar, and Professor Al Mucci joined me for this edition, which was somewhat longer than previous trips (9 days in the field) and covered more ground. This year, we successfully visited the Maestrat basin near Aliaga in the Iberian Ranges fold-and-thrust belt, then continued north across the Ebro foreland and into the foothills of the Pyrenees. We finished the trip at the work-class K-Pg and PETM deepwater (flysch) sections at Zumaia, between Bilbao and San Sebastian. The trip was extraordinary and highly educational for all, and it would not have been possible without the generous support of McGill donors and funding from Shell Canada.

Day 1. On March 2 the group met at the Madrid Airport, with only one casualty (non-arrival) from inclement weather in Ireland and the UK. Having rented our three vans, we set off for the town of Guadix, on the north flank of the Sierra Nevada and a 45-minute drive from Granada. Heavy doses of caffeine and the buzz of being back in Spain propelled us as we pushed through rain storms and jet lag to our destination: the Hotel Mulhacén. Following a brief rest, we made our way to the Bodega Calatravas, one of my favourite tapas places in the world. The Spain 2018 was officially underway!

Day 2. As per tradition, Fernando García-García of the University of Granada met us in Guadix and led us through the instructive outcrops of the Guadix Basin. Despite significant recent rain (the first in five years), perilously low water levels in the Francisco Abellán Reservoir permitted us to see lower in the stratigraphy of the Tortonian marine deposits than we had previously witnessed. As always, it was a great day in and around Guadix, and we enjoyed visiting both the usual outcrops and new ones, including massive travertine deposits and the Acequia Toril near Villaneuva de las Torres (I always enjoy visiting this area, too, because there is a nearby town called 'Pedro Martinez,' the name of a legendary former Expos and Red Sox pitcher).

Fernando makes his case that these sediments were deposited on a delta slope, rather than in deepwaters as previous sedimentologists had hypothesized. He convinced most of us!

Day 3. We spent most of the day looking at the Gilbert delta cycles in the Tabernas basin, near Alboloduy and suffered only a brief rainstorm during lunch. Here, a series of Gilbert deltas were deposited during interglacial-glacial cycles at a time of overall transgression, resulting in particularly well preserved bottomset, foreset, and topset deposits. This is the perfect location to demonstrate the basic principles of sequence stratigraphy (not to mention lots of sedimentology), and I would like to think that the many weeks in the classroom spent on sequence stratigraphy theory earlier in the semester paid off. We all enjoyed a scramble around the hills, trying to find a neat outcrop of rhodophyte grainstone that Fernando had previously shown me. We didn't find the outcrop, but we did enjoy an unplanned exercise in team-building as we explored new and unexpected terrain that required forging a new and adventurous route back to the vans.

Later in the day we continued to the deepwater deposits of the Tabernas basin near Little Hollywood. Our final stop of the day was at the classic 'Solitary Channel Complex' in which low and high density turbidites fill an east-west submarine channel that had been carved into deepwater marls of the basin. We then continued to the town of Tabernas where we stayed the night. Unfortunately, our favourite tapas place in town was closed for renovations, but we did find an excellent alternative for the evening.

Undergraduate student Arvid Gonzalez admires a high density turbidite in the 'Solitary Channel Complex' of the Tabernas basin.

The famous 'gypsum cones' in the Rio Agua, near the Sorbas Caves. As I tell the students, this is a one-of-a-kind outcrop that can only be seen in person to be appreciated.

Day 4. We continued into the Sorbas basin, where we first visited the classic Abad carbonate-marl and gypsum-marl cycles and contemplated how orbitally forcing generated these cycles. It was a generally cloudy and periodically rainy day, and it required some creative driving to wrestle our vans back to the main road following our first stop. We then continued out to the coast to chase down the strike-slip Carboneras Fault in outcrop, then the linked Palomeras Fault from a panoramic view in Mojácar. After a stroll about the ancient walled, moorish city, we returned to our hotel in Cariatiz and discovered wonderful tapas at the bar across the street.

A gratuitous group photo with the Mediterranean in the background. But don't let the blue sky or Pascale's shorts fool you—it was chilly and blustery!

The colourful Carboneras Fault Zone elicited significant and impasssioned discussion on the outcrop.

Day 5. We continued in the Sorbas basin, spending the morning at the Cantona Hill overlook, where the students can take in the whole of the basin and the basement uplifts that bound it. We never take the same track when we go to that site, and this time we took a slightly more challenging route that involved a long, uphill slog. But it was worth it for the views and a bit of exercise. After lunch, we spent the afternoon in Sorbas, admiring shoreface parasequences which include beautiful barrier island and lagoon deposits and sandy stromatolites. Most of the group finished off the day with a tour of the Sorbas caves, carved into the gypsum deposits.

The view behind (to the northeast of) the village of Sorbas. The cliffs below are made up of foreshore sandstone, and the recessive beds above are lagoonal mudstone. The upward continuity of sandstone on the right side of the photo (basinward) reveals the location of the ancient barrier island, and the tongue of sand in the middle of the photo shows spill-over of those sands in a flood-tidal delta.

Day 6. Driving day... we relocated from the Neogene basins in Almería Province to the Cretaceous Maestrat basin in Teruel Province. The drive took most of the day, but delivered us to the Albergue de Aliaga before nightfall. This is a wondeful, mountainous area in the Iberian Ranges that is off the radar for most tourists. It is part of an Alpine fold and thrust belt that inverted Cretaceous strata deposited during and following rifting coeval with the opening of the Atlantic Ocean. The last time I took students to Aliaga (in 2016), it snowed 30 cm on us, preventing any useful fieldwork. This time, even though not balmy, the weather was acceptable and we enjoyed two days of limited precipitation and lots of time outdoors.

Day 7. Section day! We began this day my favourite way to spend a day in a new area with unfamiliar stratigraphy. We took a long walk through the Cretaceous stratigraphy west of Miravete de la Sierra, finishing up on a rudist carbonate platform with spectacular outcrops revealing its sequence stratigraphic evolution. After the walk, we visited nearby dinosaur tracks on the other side of Miravete, where Robert Bourque, our own dinosaur expert, dispelled skeptism about the tracks' origins and gave the class a lesson on the differences between ornithscan, therapod, and sauropod tracks.

Highstand clinoforms pinching out basinward (to the left in the photo) of the Benassal Formation on the western limb of the Miravete Anticline.

The view of Miravete de la Sierra and the Miravete Anticline from the dinosaur track site. It was a cool, grey day, but this village was nevertheless lovely. Must return during the summer some time.

Day 8. We spent another day in the Aliaga area, first visiting the more developed dinosaur track site at Las Ceradillas, then hunkering down to log some section and trace sequence stratigraphic surfaces near Camarillas. We wrapped up the day surveying the geology, landscape, and architecture around Aliaga, including a crumbling 12th century castle built into the vertically dipping strata.

Al enjoys the scenery and a bit of much appreciated sunshine near the broken nose of the Miravete Anticline, outside Aliaga.

Day 9. We left Aliaga for the Pyrenees in the morning, driving across the Ebro Foreland basin, replete with gyspum deposits, and skirting Zaragoza. As we climbed out of the Ebro River valley into the edge of the Pyrenean fold and thrust belt, we crossed through progressively older and more deformed rocks—just as tectonics class tells us we should. On a whim, we pulled into the town of Olvena, which advertises a 'mirador' (lookout). It was a harrowing drive to this town perched on a peak of Paleogene carbonate conglomerates, but it would have been much worse had we tried to drive through the town towards the lookout. Fortunately, we made the right decision and reversed to the parking lot on the outskirts of town and walked up the steep, narrow, and winding streets and trails to the lookout. It was an excellent lunch spot, affording views across the Pyrenean foothills and down onto steeply dipping, folded and faulted rocks.

After lunch, we continued to Campo, where we had hoped to spend an entire afternoon investigating a platformal section spanning the K-Pg and PETM boundaries. Between some confusion about how to get to the outcrops and downpours, it turned into a brief stop on the outcrop, where we did just manage to find the PETM and identify some of the abundant Alveolina forams. We then drove through intense rains to the town of Ainsa, which was only chosen on this trip as a stopover for the night. However, next time, we will spend some more time there to check out the delta front and slope deposits, confined laterally by the Boltaña and Mediano anticlines in a piggyback basin.

A view from the mirador at Olvena. A fine lunch stop it was.

Day 10. This was our last day, but it was a very full day. First, we drove west through the axis of the Jaca basin (and along the Camino de Santiago) to Pamplona, then we made our way to Lizarraga pass, where the PETM is exposed on the edge of a carbonate platform in the high, sheep-grazing terrain of Basque Country. It was foggy and intermittenly rainy with a biting wind—not inspring weather. But it was great to get out of the vans and hike around, and in the end we not only walked through a prograding carbonate reef system, but also picked out the impressive 'Andia incision' (paleovalley carved into the platform) and tracked down the PETM. Pascale, Wilder, and Will would return the next day to measure and sample the section properly.

A high plateau in Basque country, where Paleocene to Eocene carbonate platform rocks are well exposed in a bucolic setting.

The group takes in the K-Pg section from above. Because it was high tide, we coudldn't descend to the exposures of the boundary, but we were hardly in a position to complain.

From Lizarraga, we dropped down to the Atlantic coast to see the famous K-Pg and PETM boundary sections in the deep-water part of the basin. I had previously visited the K-Pg section on a field trip while a graduate student (back in 1999), and although impressed, had not fully appreciated how wonderful this site is (nor had we gone to visit the PETM section). This was the last stop of the field trip, and it was some kind of idyllic, not only because of the stunning geology and views, but also because the sun emerged and bathed us in the warmest temperatures of the trip. The contrasting and steeply dipping flysch made for superb photography, and the temptation of the beach was too much for the students to pass up. We left begrudgingly, but appreciated our last night in Spain, comfortably lodged in the beach town of Zarautz.

*The group straddles the PETM boundary section. Al helpfully points out where Will is stand*ing.

Hard to resist the temptations of cooling their dogs in the Atlantic ocean on this brilliant spring evening in Basque country.

The juxtaposition of steeply dipping flysch, sand, ocean, and sky made for easy photography.

The End. And then the trip was over. Most of us awoke obscenely early because many of the students had 6:30 flights out of Bilbao, an hour's drive away. Al and I also had to clean the vans and turn them in, which is always the most stressful part of a fieldtrip, after the abuses geologists heap upon their vehicles. By a miracle, we escaped any costs for damages or cleaning and happily exchanged the car keys for boarding passes back to Montreal.

Photos courtesy of Galen Halverson

Willy Trip – March 2018

Guatemala

This year the students of the Willy trip travelled to Guatemala, El Salvador and a little bit of Belize. The trip started off strong with a hike up Pacaya, where the students witnessed a strombolian-type eruption. Next, they met with a local geologist who showed them around an ophiolite sequence belonging to the Motagua fault. The students got the chance to visit Tikal in northern Guatemala, go snorkeling in the Belize reef and learn about its structure as well as visit a gold mine near the capital city.

Itinerary

24-02-2018 - Arrival in Guatemala City late in the night

25-02-2018 - Drive to Antigua, Visit of a jade museum and polishing workshop

26-02-2018 - Hike of Pacaya Volcano, Pahoehoe flows, scoria and strombolian activity, Drive up to Guatemala City outskirts

27-02-2018 - Meet Mauricio, a local geologist, Exploring the Motagua fault outcrops of serpentinites, albities, pillow basalts and isolated blocks of jadeitites, all part of an ophiolite sequence, Drive down closer to the El Salvador border

28-02-2018 - Crossing the border to El Salvador, Afternoon on the Pacific coast of El Salvador for a swim and some seafood

01-03-2018 - Driving around lake Coatepeque, in a caldera, We saw rhyolite domes with fumarolic activity, outcrops of scoria showing preserved soil horizons and andesitic lava flows, Drive to the town of Conception de Ataco

02-03-2018 - Visit of LaGeo geothermal plant, the installations and working principles, Drive back to Guatemala to the town of Zacapa

03-03-2018 - Drive to Puerto Barrios, Look at red beds and serpentinite breccias, Stay at Hotel El Norte

04-03-2018 - Snorkeling in the Belize reef

05-03-2018 - Drive up to Tikal, Stay in the town of El Ramate

06-03-2018 - Visit the archeological site of Tikal and the six temples, Bought a guide to learn about Mayan ways of life

07-03-2018 - Drive back to Guatemala City, Stop at Las Conchas for some swimming and cliff jumping, a river carved in limestone

08-03-2018 - Meet with Hector from EXMINGUA, a Guatemalan gold mining company, Tour of the mine installations, Look at some outcrops of saccharoidal quartz, which contained the gold, as well as overview of the overall geology, Look at the exploration core logs

09-03-2018 - We needed to do some car repairs. And we did.

Willy's 40th Willy Trip!

GAC 2018 Jack Henderson Award for Best M.Sc. Thesis

We are pleased to announce that **Kelian Dascher-Cousineau** *(M.Sc. 2017)* has been selected to receive the Jack Henderson Award for Best MSc Thesis of 2017 for the thesis entitled: *"The Evolution of Fault Slip Surfaces with Displacement"* (Supervisor = James Kirkpatrick). The Jack Henderson award for best MSc thesis is given by the Canadian Tectonics Group division of GAC. It is an award that is open to any MSc thesis submitted to a Canadian university on the subject of structural geology or tectonics.

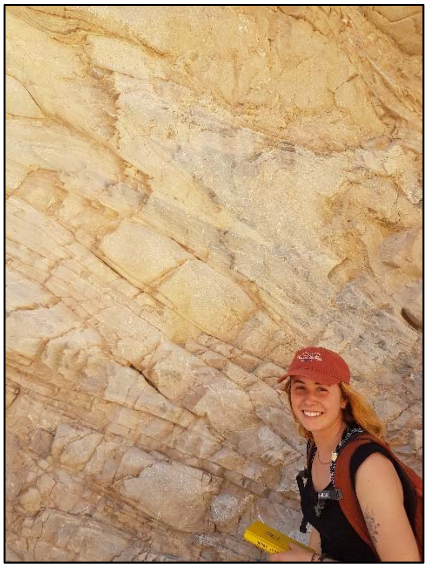
Field School I

3-17 May 2018

The 2018 Field School 1 ran from May 3rd to May 17th. Seven undergraduates, one instructor(Noah Phillips), and one teaching assistant (Alexander Timofeev) spent 2 weeks making maps, cross sections, and stratigraphic logs of units and structures in the Basin and Range geologic province of southwestern USA. They examined units and structures formed in a wide range of settings reflecting the changing geological environment through time, from a passive margin during the Proterozoic, to contraction during the Sevier and Laramide Orogenies, through to present day extension. Students examined faults, volcanoes, and sedimentary sequences, each of which told a small piece of the geologic history of the Basin and Range province. In addition to the main lecturer, students were able to interact with a number of visiting scholars including Dr. Joe White (University of New Brunswick), Dr. Lori Kennedy (University of British Columbia), and Paul Schiarizza (British Columbia Geological Survey). McGill alumni Mikaella Rough (BSc 2007), who now works for Barrick Gold Corp joined the group for an informal fireside discussion on working in industry. This year's students were hardworking and excelled in their studies. The students also quickly became adept in the practical aspects of field work, including making and breaking up camp, camp cooking and cleaning, and the logistics of operating remote field camps. The group is thankful for the opportunity to map and learn outside of the classroom setting. Having two field schools is a wonderful way to prepare students for working in industry or continuing in academia.

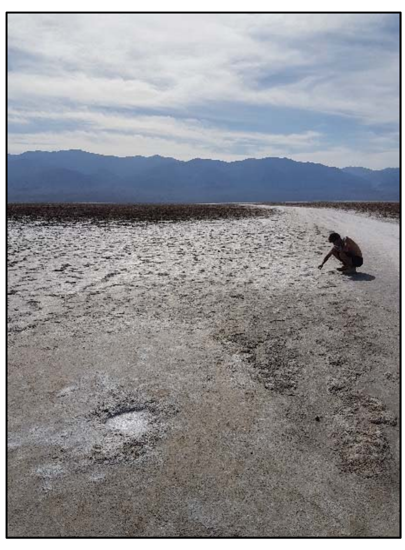
Undergraduate Participants: Alexandra Mayor del Aguila, Ty Amorosano, Yusuff Giwa, Melanie King, Shanshan Li, Jenna Randazzo, William Wong







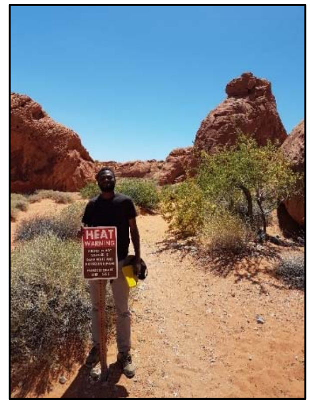












HEAT



Field School II & III

Massif Central - France

5 May – 4 June 2018

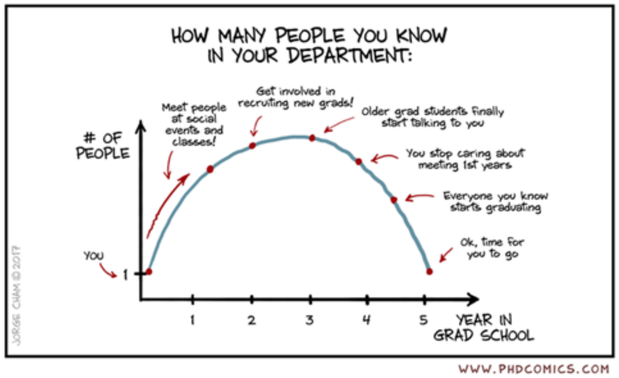
Located in the Variscan orogeny of central France, this fieldschool explores the high-grade metamorphic rocks of this mountain belt, the ore deposits within it, and the volcanoes that erupted onto this basement. Using a variety of geological and geochemical tools, student will learnt to reconstruct the geological history of the mountain belt and how its rocks, soils, sediments and waters interact on the Earth's surface.

This fieldschool teaches careful observation at a wide range of scales, synthesis of the observations into accurate notes, and the ability to transform diverse, and sometimes contradictory observations into a consistent interpretation. It teaches students to collect the raw data that our models of the Earth are based on, and illustrates the challenges and uncertainties involved. Students gain skills in geological mapping of a high-grade metamorphic and volcanic terrane, geochemical sampling of waters, soils and sediments, their analysis by XRF, colorimetry and various wet chemical techniques, spatial visualization of these data using GIS tools, and how to combine all this information into a consistent geological history.

McGill and Utrecht students make sense of a non-conformity in Chanteuges on the second day of Field School.

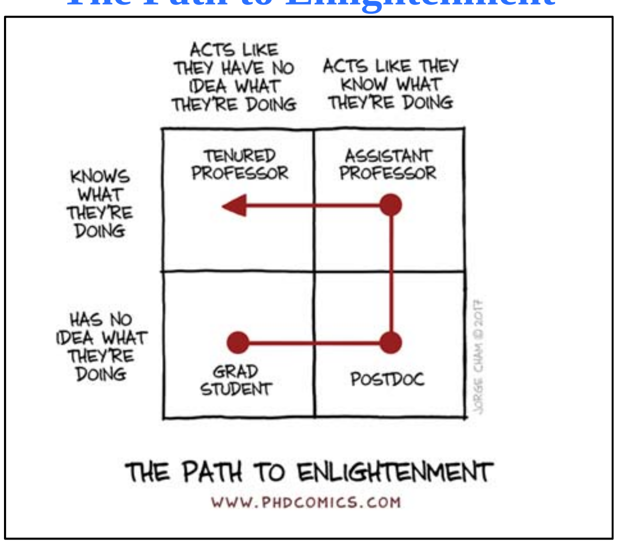

TORONTO

When is it time to go?



Volcanoes and Cats

The Path to Enlightenment



In Memoriam

Ron Doig (1939 - 2017)

Retired Professor Ron Doig *(B.Sc.'60, M.Sc.'61, Ph.D.'64)* passed away in his sleep after a long and difficult illness – inability to walk, dementia, and post-polio syndrome - at the age of 78 in a nursing home in Duncan, BC on Thursday, August 3rd, 2017. He is survived by Sandra Tait-Doig *(M.Sc.'65),* and daughters Alexa and Frances Doig *(B.Sc.'92).*

THE MONTREAL STAR, SATURDAY, MAY 15, 1965

Margin of Error— 150 Million Years

By D. B. MACFARLANE

If McGill researcher Dr. Ronald Doig is out 150,000,000 years in his estimate of "time," he is still within allowable error.

Dr. Doig is setting up an isotope laboratory in the department of geological sciences. He is allowed an error up to five per cent in arriving at the age of rocks 3,000,000,000 years old.

He uses the isotopes of rubidium and potassium, which decay to strontium and argon, in his calculation of ages of rock samples.

The amount of strontium and argon produced in rocks is a function of age. By measuring the per cent of "parent" and "daughter" it is possible to arrive at the age of rocks — within an error limit of five per cent.

The method used by Dr. Doig in his new laboratory is only good with rock samples at least 1,000,000, years old.

The new laboratory at McGill will enable researchers to arrive at more accurate determination of rock ages in geological mapping, and will be especially useful in the case of Canada's pre-Cambrian shield.

Laurentian rocks may be as much as 1,000,000,000 years old. North of Val d'Or they may be 2,500,000,000 years old. Certain granites at various spots in the Laurentians may be a mere 600,000,000 years old.

For more precise determination of "time," particularly with biological materials or remains, carbon dating is used. This method is satisfactory for ages up to 50,000 years.

Dr. Doig's research, using the rubidium-strontium and potassium-argon methods, is supported by grants from the National Research Council of Canada.

Staff Photo by Mac Juster

...ill researcher Dr. Ronald Doig makes adjustments to mass spectrometer ...h will be used to determine the age of rocks up to 3,000,000,000 years old.

...DAY, FEBRUARY 11, 1966

Dr. and Mrs. Ronald Doig whose wedding took place recently at the McGill University Chapel. The bride is the former Miss Sandra Elizabeth Tait, daughter of Mr. and Mrs. Alexander Hunter Tait, of St. Andrews, N.B. Dr. Doig is the son of Mr. and Mrs. W. J. Doig, of Montreal.

Married

Sandra E. Tait
Dr. Ronald Doig

The marriage of Miss Sandra Elizabeth Tait, of Montreal, daughter of Mr. and Mrs. Alexander Hunter Tait of St. Andrews, N.B., to Dr. Ronald Doig, son of Mr. and Mrs. W. J. Doig, of Montreal, took place recently at the McGill University Chapel. Rev. Reginald Hollis officiated. Miss Mary Blaikie was at the organ. An arrangement of gladioli and starburst chrysanthemums was used as decoration.

The bride, who was given away by her father was in a sleeveless Calais lace gown designed on Princess lines, having a high neckline, worn under a floor length coat of white peau de soie having elbow length sleeves. Her shoulder length veil of tulle illusion was held by a flower of satin peau de soie. She carried a bouquet of gladioli and hyacinth blossoms.

Mrs. Milton D'Ganigian, sister of the groom, as matron of honor, and Miss Catherine Tait, sister of the bride, as bridesmaid, were in floor length gowns of jade green peau de soie, worn with white accessories. They carried bouquets of yellow starburst chrysanthemums.

Mr. Douglas McClure, of Toronto, was best man. The ushers were, Mr. Gordon Tait and Mr. Milton D'Ganigian.

Mrs. Tait, mother of the bride, was in a two-piece suit of beige guipure lace worn with a corsage of pink sweethearts roses.

Mrs. Doig, mother of the groom, was in black brocade dress trimmed with a green taffeta bow, worn with a corsage of white sweetheart roses.

Following the ceremony, a reception was held at the Faculty Club, McGill University. Later Dr. and Mrs. Doig left for Lac Beauport, the bride travelling in a moss green homespun wool suit worn with a golden wide brimmed hat, and dark brown accessories.

Lloyd A. Clark

Lloyd A. Clark passed away at home on December 30, 2017. He was a St. Patrick's Day baby born on March 17th, 1932, to Clyde W & Gertrude (Stoughton) Clark, and was raised on a farm in the Prince District, near North Battleford, SK.

Lloyd was the youngest of three children. His brother George was 10 years older than him, and his sister Marjorie was 8 years older. Lloyd spent a lot of his young life on his own exploring the prairie.

His father Clyde Clark raised Clydesdale and Percheron horses, and Lloyd travelled with him to exhibit them. Sometimes they took the horses on trains in boxcars designed to accommodate the horses on one side while they slept on the other. They traveled as far as the Canadian National Exhibition in Toronto.

At the University of Saskatchewan, Lloyd obtained a Bachelor of Science in Engineering (Geological), and near the completion of his Masters, he met the love of his life, Isabelle Forcier, on a blind date. They were married on September 17, 1955 in Saskatoon.

In August of this past year, Lloyd began writing a journal. He wrote, "Engineering students were encouraged, even commanded, to work at summer jobs in their specialization." He was in geological engineering, so he worked in the forested, unmapped regions of Northern Saskatchewan.

During the summer of his marriage, at the age of 25, he worked all summer in North. He returned to Saskatoon two days before his marriage to Isabelle. The day after the ceremony, he met with all his geology professors for his comprehensive exams for his Masters' degree. He told Isabelle at the time that he smiled throughout the entire ordeal. The newlyweds moved to Montreal, where Lloyd pursued a PhD in Geology, and taught at McGill for 10 years.

In his journal, Lloyd wrote about his time teaching at McGill, where his very first job was to teach Optical Mineralogy. He wrote, "I didn't know much about the subject, so I used to read the appropriate pages in the textbook before teaching it the next day."

As part of his PhD, Lloyd and Isabelle moved to Washington DC, where he did research at the Carnegie Institute of Washington Geophysical Laboratory. It was here that Lloyd discovered what he describes as "a way to define the pressure inside a reaction vessel. This involved the reaction of some minerals with molten iron and arsenic liquid." This work involved a specially designed lab, and eventually he brought this technology back to McGill, where he wrote that he continued research "with frequent support of the National Research Council of Canada."

Lloyd and Isabelle survived the Cuban revolutionary uprising in 1959. They had been visiting Lloyd's cousin in Cuba. One day, Lloyd wore his McGill sweater, and he found people waving enthusiastically to him, and he waved back. His cousin quickly told him to take it off because red and black were the colors of the revolution and a counter-revolutionary might shoot him.

In 1966, Lloyd took a sabbatical and the entire family spent 6 months in Tokyo, and 6 months in Florence, Italy. Lloyd wanted to study Precambrian green-stone belts, but in Canada they are highly altered and deformed, so he went to Japan, where deposits are not overprinted by subsequent alteration and metamorphic events. He published this research in the *Canadian Institute of Mining and Metallurgy Bulletin*.

In 1970, they moved to Salt Lake City, where Lloyd worked for Kennecott Exploration as Senior Research Geologist and Head of Geochemical Research. There are many beautiful ski areas near SLC, and skiing became a large part of their life.

In 1976, Lloyd went to work as Exploration Manager and Chief Geologist for Saskatchewan Mining and Development Corporation, now called Cameco, in Regina, and later, in Saskatoon.

In 1990 when Lloyd retired, the couple moved to Surrey, BC. Living on the prairies always leaves its imprint, and Lloyd became a curling enthusiast. He also played recreational slow pitch softball for many years.

After 5 years, Lloyd and Isabelle moved to their acreage in Langley, to garden to their hearts content!

Lloyd is remembered for his great diplomacy and kindness as a husband, and parent to Dave and Laurel Clark, Lyle Clark and Fred Heerema, Susan and David Hughes, and Leslie and Hans Hussmann. He was also a grandfather to Ilyes Daoudi, Danielle and Alex Clark, & Pearl Hughes.

Lloyd was a passionate geologist. He did countless miles of exploration on foot throughout northern Canada and the world, including many far-flung trips to places such as Australia and South Africa.

Lloyd volunteered with the McGill Alumni, the Fraser Valley Dahlia Soc., Surrey Crime Prevention and several professional societies. Lloyd and Isabelle volunteered for the Heart & Stroke Foundation.

Lloyd was an avid gardener; his pride & joy were the gorgeous dahlias he cultivated and exhibited. Lloyd and Isabelle's acreage garden in Langley was incredible. They had an Empress Paulownia tree, a monkey puzzle tree, a silk tassel or honey locust tree, many fruit trees, Saskatoon berries, raspberries, grapes, and much more. Lloyd was true to his farm heritage, and grew all their vegetables. Sometimes the harvest was too much, so they shared some with the Food Bank.

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

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DAWSON FIELD STUDY SUPPORT

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

Jennifer Abbott or Robert Davis, University Advancement, Faculty of Science, 3450 University Street, Montreal, QC H3A 0E8, (514) 398-4607, jennifer.abbott@mcgill.ca or rob.davis@mcgill.ca

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Leonard Cohen mural inaugurated in time for the one-year anniversary of Cohen's death - The mural is located at 1420 Crescent Street, Montreal, QC