Eric Mountjoy Fellowship

2019 | MCGILL UNIVERSITY

SUPPORTING GRADUATE STUDENTS

Commemorating five years of graduate student support in memory of Professor Eric Mountjoy
Dear Friends,

2018 marks the five year anniversary of the Eric Mountjoy Fellowship. I am so grateful to have been a part of it, along with all of you – Eric’s colleagues, friends, and our family. Your support has meant the world to me and to the students who are following in Eric’s footsteps. It has been a real privilege to have seen how this support has helped them work towards their goals, and it has enriched my life immensely to have seen how they have utilized these funds and to have been a presence in their lives.

When Eric was a PhD student, his supervisor Frank Beales made sure to create a welcoming community for the students. The impact on Eric was immeasurable and we dedicated ourselves to creating a similar environment in the field and at McGill. Looking back on the past five years, the fellowships have created a community for the students and it has extended to the rest of the department. The students have joined me, and continue to join me, for Thanksgiving, New Year’s, Easter and summer barbecue celebrations and invite their friends to join us, even meeting their families and significant others.

When I look at what we have created together, I can only think how much Eric would have enjoyed knowing these students and following their careers. Thank you all for your help.

Anita Mountjoy
My name is Pascale Daoust and I am currently enrolled in the doctorate program in Earth and Planetary Sciences at McGill University; where my PhD work is supervised by Galen Halverson and Alfonso Mucci and focuses on ocean acidification (OA).

I was recently awarded the Eric Mountjoy Fellowship for this year and I would like to express my gratitude for your support of the sedimentary geology component of the Fellowship. It is an honour to be awarded this fellowship this year. I would like to thank Anita Mountjoy and everyone involved in the creation, funding and inner workings of these scholarships. As a Ph.D. student, such recognition is deeply appreciated and feeds my passion for my research knowing that my work is recognized. I will keep doing my utmost best to move my project forward and contribute to the scientific community and more specifically to the geology field.

My interest in sedimentary geology was sparked even before I joined McGill University as a Ph.D. student. I did both my master’s and bachelor’s degrees at the University of Ottawa in geology. In my third year of BSc., I received the UROP scholarship and worked on carbonate rocks on Anticosti Island with André Desrochers and Ian Clark. As I really liked what I was working on, I requested to do my honours project with the same teacher on the same project. Wishing to continue in the same field of research for my master’s project but with a little less of environmental studies, I decided to do a stratigraphic project from Anticosti Island with André Desrochers again but in partnership with colleagues in Belgium. I realised a stratigraphic curve based on isotopic analyses, so it can be used as a stratigraphic tool. I also characterized the Beccscie Formation for the lithostratigraphy, cyclostratigraphy, chemostatigraphy. In this sense, the goal was to develop an integrated high resolution stratigraphic framework and to examine the earth systems during those deeper times.

Ultimately, this research path and background led me to my current project, which is focused on OA. In the context of climate change, OA is seen as the other carbon dioxide (CO2) problem (Andersson and Mackenzie, 2012). The ocean’s chemistry is changing and constitutes a potential threat to the health of marine ecosystems, particularly to calcifying organisms whose ability to secrete calcium carbonate (CaCO3) skeletons and tests might be hindered. The objective of my project is to experimentally simulate the progressive impact of OA on the mineralogy of modern platform carbonate sediments and compare these results with the mineralogy of ancient carbonates from key greenhouse periods such as those deposited at the Cretaceous-Paleogene boundary and following the Paleocene- Eocene Thermal Maximum. Their stratigraphy, sedimentology and geochemistry will be analysed to better understand their formation and alteration through OA and afterwards, compared them to modern carbonate deposits. In doing so, ancient carbonate deposits could provide us with insights on how much post-depositional dissolution they may have been subjected to during an acidification event and a more realistic representation of the mineralogical evolution of these. Therefore, this research will characterize better the present OA phenomenon in all the possible angles given by oceanography, geology and geochemistry with the help of ancient carbonate deposits. Thus, by comparing several ancient OA events to modern ones, we could try to find solutions and provide advice to relevant authorities.

I would like to reiterate my gratitude and thanks to all involved in the Eric Mountjoy Fellowship; and while I anxiously await the results of my research and what implications they may bring, this recognition comes as a pleasant surprise and a justification to keep working hard.

"As a Ph.D. student, such recognition is deeply appreciated and feeds my passion for my research"

Pascale Daoust
I am working in Canada’s northeastern Arctic Archipelago and northwestern Greenland on multiple thick successions of sedimentary rocks that would have been deposited around 1 billion-years-ago. These rocks represent one of the best geologic records of this time period, but are relatively under-explored (understandable given their remoteness). This period in Earth history is interesting both because it spans the formation of an ancient supercontinent (Rodinia) and the early radiation of complex life (early eukaryotes). My research interests are both in reconstructing the tectonic history and in analyzing the microfossils hosted in these rocks (1 billion year old microfossils). I also use radiometric dating to try to get a better grasp on precisely how old these rocks are and use multiple geochemical techniques to try to understand the chemistry of the oceans. This project is a very multidisciplinary and we have collaborators from UQAM, Laurentian, Dartmouth College, the Canada Nunavut Geoscience Office, and I’m getting help from professors at Yale University, and Cambridge University so I am really part of a large group trying to get to the bottom of the evolution of early life in the wake of a tectonically interesting period on Earth!

Proposed Research
J. Wilder Greenman

Beautifully preserved assemblages of fossilized microbes (microfossils) are hosted in sedimentary rocks of the Fury and Hecla Group on Baffin Island, Nunavut (1.2-1.0 billion-years-old) that represent tangible evidence about the development of early complex life on Earth. New data from rocks elsewhere in northeastern Canada inferred to be broadly the same age provide evidence that photosynthesis emerged within Eukarya (organisms with a nucleus and membrane-bound organelles) shortly before the rocks of the Fury and Hecla Group were deposited (Gibson et al., 2017). Organic-walled microfossils isolated from rocks collected in northwestern Canada suggest that eukaryovory (when a eukaryote eats another eukaryote) evolved among Eukarya shortly afterwards (Loron et al., 2018). The evolution of algae and early animals are inferred by some to have triggered massive shifts in the cycling of carbon and a net release of oxygen, fundamentally altering global ocean chemistry (Greenman, 2017; Lenton et al., 2014). On the other hand, recent molecular fossil data suggest eukaryotes did not contribute significantly to global primary productivity until 650 Ma (Brocks et al., 2017). I seek to establish further microfossil constraints on early algal photosynthesis and evaluate the extent to which emergence of algae influenced global biogeochemical cycles during the critical interval of ca. 1.2-1.0 Ga.

This project includes three field seasons. During the first two (2018, 2019), I will focus on the Fury and Hecla Strait region of Nunavut and intend to develop a detailed sedimentological and stratigraphic framework of these rocks and collect samples for paleobiological, paleoenvironmental, and geochronological analysis. I will spend a third field season (2020) in two equivalent-aged and tectonically linked sedimentary basins, the Borden Basin (Baffin Island) and the Thule Basin (NW Greenland), to develop a more comprehensive timeline for this critical interval and collect additional samples for micropaleontological and geochemical analysis.

Three principal analytical techniques will be employed for this project. First, to develop the biological evidence on early algal photosynthesis, I will extract organic-walled microfossils from their host rock via acid maceration and image them using multiple techniques, including standard microscopy and scanning electron microscopy. Characteristics about their size, shape and overall complexity will reveal the behaviour and habitat of the original microorganisms, and for some, their taxonomic affinity. I will perform the microfossil analysis at the University of Cambridge under the supervision of Prof. Nick Butterfield, a leading expert in Precambrian paleontology. Secondly, to establish radiometric age dates critical for constraining the otherwise poorly calibrated 1.2-1.0 Ga microfossil record, I plan to complete initial Rhenium-Osmium geochronology on samples collected during the 2018 field season at Yale University during the winter term of 2019 under the supervision of Prof. Alan Rooney. I will also employ Uranium-Lead geochronology to date a volcanic-ash layer sampled during the 2018 field season at the Geotop Research Centre in Montreal in 2019. Finally, to understand the influences that algae had on changes in carbon cycling and evolution of ocean chemistry, I will assess carbon and oxygen stable isotope data on carbonate rocks and a host of redox proxies on organic-rich at Geotop on samples collected from 2018-2020 field seasons. Collectively, this interdisciplinary approach will shed light on how oceans and the atmosphere responded as eukaryotes were gaining a foothold in global environments, and crucially, reconstruct the timeline over which these observed phenomena occurred in the geologic record.
I am writing to thank you for making it possible for me to receive a Mountjoy Fellowship. I have had so much fun over the past two years and a lot of that has come from being part of the community that Anita has built. As an international student I am limited in the funding that I can apply for, so to be awarded the fellowship has been a great financial help. I am looking at how the Ancient Maya responded to climate change, using a variety of biomarkers and proxies. In fact it is thought that the Ancient Maya experienced droughts and were constantly battling to conserve water, coming up with ingenious water management strategies to do so. We have a lot to learn about ancient civilizations, how they lived and how they dealt with their changing environment. This knowledge could be very useful in modern day places such as Mexico City and Cape Town, which are both struggling with similar problems when it comes to water shortages. Originally I was focused on reconstructing how wet or dry it was in the past using the isotopic composition of plant waxes. Now my research is taking a slightly different direction and in addition these plant waxes I am now developing a proxy for determining population size in the past using faecal stanols. These are chemicals that are produced in the digestive system of humans and animals and are preserved in lake sediments. I am extracting these compounds from sediments collected in Guatemala, and after lengthy procedures in the lab (months), I am able to analyse and quantify them. This has proved to be very exciting and I have my first data set which I presented in Washington D.C. in December 2018. I am looking forward to continuing with this project and testing it in the modern day. My idea is to collect samples from recent sediments and tie them with modern day population estimates, in order to see what kind of population numbers would have created the faecal stanol concentrations we see in the sediments. The ways in which archaeologists estimate populations in the past is through a system of counting dwellings but of course many buildings can be obscured by vegetation, and a significant number of people might have lived in wooden structures that are no longer present. We will therefore contribute to archaeological knowledge and methods as well as the response of the Maya to climate change. If the climate was inhospitable and people were dying or migrating, this should be reflected in the history of the faecal stanols i.e. decreased concentrations because there were less people eating and producing waste. This is proving to be exciting research and I want to thank you for helping to support it.

Using faecal stanols from a tropical lake core to reconstruct human population dynamics in the southwestern Maya Lowlands

Keenan, B., Douglas, P.M.J., Breckenridge, A., Johnston, K.

To understand patterns of human response to climate change it is valuable to have indicators of human population dynamics that can be directly linked to palaeoclimate proxies. Coprostanol, the main 5β-stanol found in human faeces, is a potential useful proxy for human populations that can be analysed alongside other palaeoenvironmental proxies in lake sediments. The coprostanol proxy relies on the premise that the ratio of coprostanol to cholesterol, a more widely produced bacterial stanol, correlates with the amount of human waste transported to the lake, and that the amount of human waste correlates with population size. I will present initial results of faecal stanol analyses from sediment cores from Laguna Itzán in Guatemala, as a proxy for the population of Itzán, an ancient Maya population centre. The faecal stanol proxy has been used recently in sediment cores from Norway and from Illinois (USA), but has not been applied as a palaeo-proxy in tropical lake sediment cores. We find quantifiable and variable amounts of faecal stanols throughout the Laguna Itzán sediment core, potentially implying changes in human population through time. We see a peak in the coprostanol/cholesterol ratio at about 639 BCE, with substantially lower ratios in later Maya archaeological periods. This is in contrast to archaeological estimates indicating peak local populations during the Late Classic period (~600 to 800 CE). We also see evidence for settlement in the area by at least 1350 BCE, which is earlier than has been inferred from the archaeological record. These discrepancies with the archaeological record will require further exploration, and may indicate that the coprostanol record is strongly influenced by factors such as waste management or the distribution of human residences. We plan to compare the faecal stanol data with the isotopic composition of plant waxes and the abundance of polycyclic aromatic hydrocarbons (PAHs) in the same sediment core, which will allow us to evaluate how Maya populations coevolved with changes in climate, vegetation type, and biomass burning. These data indicate that faecal stanols could be a powerful tool for tracing human population dynamics in tropical lake watersheds that can be used to complement archaeological datasets, and to link human populations with environmental change.
The Eric Mountjoy Fellowship has provided me the means to focus on my PhD, while enabling many opportunities to progress my research that wouldn’t otherwise be possible. I am honoured to carry on Eric’s tradition of geological fieldwork in wild and rugged areas. It is this style of research that led me to become a geologist, and this fellowship has contributed to the four seasons of arctic field expeditions I’ve undertaken for my thesis. In fact, without the Mountjoy Fellowship, I may not have had the chance to work with my PhD supervisor Professor Galen Halverson, whose broad interests in Proterozoic sedimentology, stratigraphy, and geochemistry brought me to McGill.

Since starting my program, I’ve conducted fieldwork in Yukon, Northwest Territories, Nunavut, Namibia, and Siberia, and have visited laboratories for geochemical studies at the University of Alberta, Université du Québec à Montréal, and Harvard University. Through these ventures, I’ve amassed invaluable skills and experiences that I hope to integrate in the future as part of my own academic research group. Furthermore, thanks to the support of the Mountjoy Fellowship, McGill’s Department of Earth and Planetary Science, and numerous grants awarded to Professor Halverson, I’ve been able to teach and mentor other students in various capacities in the classroom, field, and laboratory.

The overarching goal of my research is to understand links between Earth’s Proterozoic biological, climatic, and tectonic histories through the global carbon cycle. More specifically, I am interested in the interplay between eukaryotic diversification, the tectonic evolution of the ancient supercontinent Rodinia, and the onset of environmental perturbations to geochemical cycles from 1,200 to 800 million years ago. The basis of this research is founded in constructing a geological framework for various Proterozoic sedimentary basins across Arctic Canada by integrating geological mapping, sedimentological and sequence stratigraphic analysis, and geochronology. Then, once this framework is established, these ancient sedimentary rocks act as “natural laboratories” for me to investigate more specific questions regarding the interplay between global tectonic regimes and biological and geochemical innovations during this time period.
I am very honoured to receive this award and wanted to share my thanks. It has been a privilege to work in a scientific field where I get to travel and learn constantly.

From a young age, I wanted to explore and learn about the earth through science, and when it comes to curiosity-based research, awards like this make such endeavors a possibility.

I will strive to maintain the high standards of research set by Dr. Mountjoy and the whole Earth and Planetary Sciences Department here at McGill as I progress through my career.

Best,
Wilder Greenman