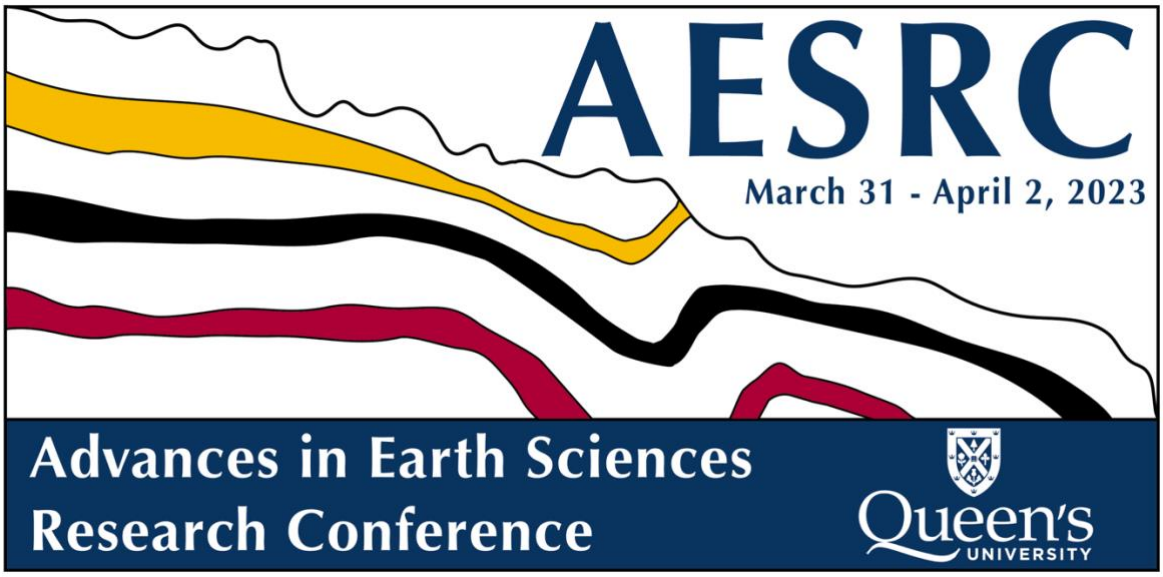
Conference Abstracts



Session 1: Environmental & Quaternary Geoscience (Sponsored by Canadian Geophysical Union)

Saturday, April 1st, 2023

Understanding the Big Creek Watershed: Watershed modelling and retrospective analyses to determine long- and short-term trends in flow regime and phosphorus loading

Sophia Zamaria and George B. Arhonditsis (University of Toronto)

Lake Erie has experienced an extensive history of eutrophication and harmful algal blooms (HABs) due to anthropogenic activity in adjacent watersheds since Euro-American settlement. Non-point pollution of phosphorus (P), and specifically its more bioavailable form soluble reactive P, to tributaries in adjacent watersheds has been linked to the re-emergence of HABs in the region since the 1990s. Watershed models are used as tools to better understand these ongoing environmental issues through integrating monitoring data, knowledge of the system that is continuously updating, and different targets and goals of diverse stakeholders. To this end, watershed models can provide flexible and evidence-based suggestions to policymakers and define key uncertainties that require further research. Owing to its extensive agricultural history, sand-dominated soils, recent restoration efforts and lack of research attention, The Big Creek Watershed (BCWS) provides a valuable opportunity to use a watershed model to investigate anthropogenically forced trends in flow regime and P loading over the past two centuries. We use the Soil and Water Assessment Tool (SWAT) to establish the present-day influence of land use and climate changes on flow regime and P loading of the watershed at a daily resolution. Given the lack of attention into the impacts of snow hydrology on modelled flow regime, we also calibrate the snow submodel of SWAT and couple it with a modification of the source code to include a rain-on-snow (ROS) melting process common to the Great Lakes Basin. Consistent with the literature, our preliminary results show that the modified ROS process improves characterization of the spring freshet and summer baseflow and improves model performance. Further, we found that a significant amount of annual P loading coincides with infrequent and brief but intense high-flow events. Lastly, we found that the most sensitive parameters of the watershed model are those that control infiltration, runoff, groundwater, and channel processes in the watershed, which has implications for determining the most effective agricultural best management practices and watershed management strategies. We intend to force the SWAT model with land use and meteorological data from historical records and compare results with diatom-inferred P concentrations from a sediment core to assess anthropogenic impact on trends in the long-term variability of flow regime and P concentrations over the past two hundred years, resulting in a rigorous assessment of natural variability and anthropogenic impact on the BCWS.

Investigating the impacts of land use on water quality in the Halton Region

Nathan Beckner-Stetson, Maddy Estabrooks and Bas Vriens (Queen's University)

Disentangling the natural and anthropogenic drivers of surface water quality and stream health is important to manage and mitigate stresses on watersheds imposed by climate- and land use changes. However, the effects of shifting precipitation patterns, temperature, and changes in land-use, including associated effects of diffuse- and point-sourced human emissions, are spatiotemporally variable and remain challenging to quantify. Lacking consistent long-term surveillance data on solute concentrations in parallel to ecological parameters in rivers and creeks is adding to this challenge.

In a collaboration with the Halton Region and Conservation Halton, we are characterizing stream health in a uniquely high resolution and interdisciplinary context. Halton Region is one of the fastest growing regions in Southern Ontario, with an expected 482,000 people coming to the region by 2051 (Halton Region, 2021). The region encompasses strongly contrasting types of (sub-)watersheds, ranging from the pristine upper reaches of Bronte and Sixteen Mile Creek, to the heavily impacted urban creeks near the shores of Lake Ontario. In 2022, we collected samples from >40 sites at biweekly intervals that were analyzed for major water quality parameters, nutrient levels, concentrations of trace elements and select emerging contaminants.

We found that water quality was generally in line with previous long-term monitoring, with parameters such as conductivity, turbidity, phosphate and chloride levels distinctively differing between sub-catchments while remaining relatively stable within. Parameters such as conductivity and chloride tended to not change wildly within their own sub-catchments, unlike parameters such as phosphate and turbidity which changed significantly within the urban (2 orders-of-magnitude) and 16 Mile Creeks (3 orders-of-magnitude), respectively. Comparing the sub-catchments, conductivity was an order of magnitude smaller in the Bronte Creek than the other creeks while chloride values were twice to three times as high in Grindstone and the Urban creeks compared to Bronte and Sixteen Mile Creek. Provincial and regional stream health indicators suggest select locations being more vulnerable to variability in water quality, salinification or nutrient levels.

We are assessing concentration-discharge dynamics and performing geospatial modelling to further interpret the observed water quality trends in parallel to field-based hydrological, climatological and ecological surveillance data. Our work will help build a more refined understanding of surface water conditions upstream, downstream and within Halton's regional Natural Heritage Systems and serve as a pilot to show how enhanced environmental monitoring and watershed planning can deliver actionable information to help watershed practitioners make better decisions.

Modelling ground water pollution using the spectral element method

Riley Wells and Hom Nath Gharti (Queen's University)

The aim of the present work is to use and assess the performance of a spectral element computer simulated model to predict the leakage of contaminants from a tailings site into the surrounding media. Using the newly developed software package SEMDIFFUSION, based on open-source SPECFEM3D, a real tailings site is modelled in both time and 3-dimensional space based on the surrounding structure and physical characteristics. A 3D mesh model is first created in Coreform Cubit and then, based on input parameters such as initial concentrations, diffusivity, density, flow rate, and reaction processes, the time evolution of the concentration over the modelled structure is calculated in time using the SEMDIFFUSION package. The final files are visualized using Paraview software to create a 3D movie for analysis. The SEMDIFFUSION package uses the spectral element method to calculated solutions to the time dependant diffusion-advection-reaction equation. The spectral element method (SEM) is a variation of the finite element method (FEM) that employs higher order basis functions, providing high order solutions. The process is very computationally heavy and requires the use of supercomputing clusters to return a result in a timely manner. The resulting simulation is compared to measured results at the site to determine the effectiveness of modelling in predicting concentration movement behaviour. Preliminary modelling of simple tailings pond geometry has shown that the evolution of concentration distribution can be accurately predicted. This project will assess the applicability of the new SEMDIFFUSION package to this type of geological problem, potentially providing a new tool to mitigate environmental risk in the designing and managing of tailings sites.

Session 2: Economic Geology (Sponsored by the Society of Economic Geologists Canadian Foundation Prospectors and Developers Association of Canada)

Saturday, April 1st, 2023

The role of machine learning in exploration and mining: Turning real-time data acquisition into actionable information

McLean Trott, Matthew Leybourne and Dan Layton-Matthews (Queen's University)

Exploration vectoring and enhancing ore body knowledge can be improved by the rapid incorporation of real time geologic data. Inconsistent geological logging, especially on projects that are long-lived or historic, is commonplace in the mineral exploration and mining industry. Advancements in portable data acquisition hardware are providing real-time data on active drilling projects, but there are still gaps in the workflow between acquisition of real time data and utilizing it effectively to inform active drilling decisions. We can improve our exploration models and increase ore body knowledge through the use of machine learning processes to utilize real-time data, while still underpinning our interpretation with human geological insight.

An inside scoop into the mining industry

Liam Blackie (Carleton University Alumnus)

The presentation will take a look at my experience throughout the mining industry touching on greenfield operations to a developing staged mining operation I have advanced. These deposits include SEDEX styled Pb-Ag-Zn, Polymetallic intrusion related As-Au and Greenstone belt Au mineralization spanning from the heart of the Yukon to Northwestern Ontario. The methodology of exploration for each of these deposits will be talked about briefly to give insight into how Geologist in the industry develop a discovery into a resource. I will also be touching on how to promote yourself as a Geologist and jumpstart your Geoscience career.

Session 3: Geophysics (Sponsored by Canadian Society of Exploration Geophysicists)

Saturday, April 1st, 2023

On the evolution of thermal structures in 4.5-billion-year mantle convection models

Fadhli Atarita, Petar Glišović, and Alexander Braun (Queen's University)

Seismic tomography models indicate the presence of multi-scale structural heterogeneity in the lower mantle as a result of mantle convection. While instantaneous mantle convection models derived from present-day geophysical observations provide insight into current processes, recently developed long-term convection models offer a new perspective on structural evolution and its influence on the mantle's current state. This study aims to understand how thermal structures evolve over 4.5 billion years of Earth's history. It further aims at determining the necessary spatial resolution to accurately depict mantle flow and resolve small-scale structures while keeping the numerical modelling to be computationally stable. Here we present the results of a preliminary test using a pseudo-spectral mantle convection code to simulate 4.5-billion-year whole-mantle convection using random initial thermal anomalies with varying levels of heterogeneity using spherical harmonic degrees 32 and 64 spatial resolutions. The results reveal that spatial resolution affects convection significantly and that higher resolution allows for faster convection rates with smaller structures evolving and stabilizing between degrees 32 and 64. Furthermore, the present-day models show reasonable agreement with present-day observations. Given that the heterogeneity in the lower mantle is believed to be controlled by complex thermo-chemical processes, we recognize the current limitations of our model. Despite this, understanding the thermal processes involved is a step forward in understanding long-term mantle structure evolution. Further studies are needed to fully comprehend the implications of these preliminary results on the current and past states of the Earth's mantle and its geological consequences.

Terrestrial water storage derived from the Gravity Recovery and Climate Experiment and Follow-On Missions

Stephanie Bringeland and Georgia Fotopoulos (Queens University)

Since its launch in 2002, data from the Gravity Recovery and Climate Experiment (GRACE) and its 2018 follow-on mission (GRACE-FO) have become indispensable for monitoring terrestrial water storage. GRACE-derived terrestrial water storage anomalies (TWSA), especially when used in conjunction with other water budget datasets (i.e., precipitation, evapotranspiration, surface runoff), provide insight into water storage components such as groundwater and glacier mass. In this presentation, analysis of two decades of TWSA observations within Canada is presented providing a proxy for using GRACE-derived TWSA to infer long-term water storage trends within Canada. This includes examples of mass fluctuations over glaciated regions that demonstrate the decline in overall ice mass as climate change accelerates melting in northern regions. The evidence of unprecedented high lake levels in the Mackenzie River Basin beginning in the summer 2020 is also assessed. Future research is aimed at understanding terrestrial water dynamics which is a critical component linked to the impact of a changing climate in the decades to come.

Session 4: Sedimentology, Paleoenvironments, & Paleontology, Oh My! (Sponsored by Canadian Geophysical Union)

Sunday, April 2nd, 2023

The Ediacaran Mall Bay Formation, Newfoundland, Canada, and protracted onset of the Gaskiers Glaciation

Danielle Fitzgerald, Peir Pufhal and Guy Narbonne (Queen's University)

The Mall Bay Formation (ca. 600-580 Ma) in eastern Newfoundland is a kilometre-thick succession of mainly fine-grained deep-water siliciclastics. This study focuses on the coastal outcrops of the southwestern Avalon Peninsula, including the formerly unstudied Colinet Islands, and provides sedimentologic insight into the conditions immediately predating those coinciding with the deposition of the glacial Gaskiers Diamictite (580 Ma), above which occur the abundant soft-bodied fossils of the Mistaken Point Biota (ca. 575-560 Ma). The Mall Bay Formation is dominated by interbedded mudstones and sandstones interpreted as an intermixed deep-water turbidite, glacial contourite, and rainout (pelagic and glacial debris) system deposited in the axial sub-basin of the Avalon Basin. While the Mall Bay diamictites are also thought to be part of this intermixed system, they are only observed interbedded with mudstones and sandstones in the upper portion of the formation. In contrast, thin beds of volcanic ash are sporadically dispersed throughout the succession. Paleocurrent data and the orientation of slump fold crests support a NE-SW elongate Avalon Basin model consisting of a main axial basin and axial sub-basin, partially separated by a topographic barrier known as the Harbour Main high. Interpreted ice-rafted debris, in the form of dispersed outsized clasts (some of which show dropstone features including penetration of underlying laminae and onlapping of overlying sediment) and coarse lags, as well as glendonites (stellate crystals interpreted as pseudomorphs after the cold-water carbonate ikaite), provide robust evidence for prolonged cold climate conditions preceding the stratigraphically defined onset of the Gaskiers Glaciation. The stratigraphic coarsening upward trend in the Mall Bay strata suggests progradation associated with the protracted onset of the Gaskiers Glaciation. The sedimentological data we present herein disagrees with the previously interpreted short-lived nature of the well-known regional Gaskiers Glaciation event and advances what is known about Ediacaran cold periods. Our proposal of a protracted onset to the Gaskiers Glaciation, grounded in new paleoclimatic data, may have broader implications for understanding the evolution of Ediacaran glacial systems between the well-known global “Snowball” glaciations of the Cryogenian and the equally well-known Paleozoic glaciations of Gondwana.

Evaluating backwater versus upstream tectonic controls on the gravel-sand transition, Cretaceous Dunvegan Formation, Western Canada Sedimentary Basin

Aneesa Ijaz Rabbani, Janok Bhattacharya, Beth Parker and Julie Zettl (McMaster University)

The Cretaceous Dunvegan Formation in the Western Canada Sedimentary Basin is a well-characterized source-to sink system that extends for about 1000 km from proximal gravelly alluvial systems in the Liard Basin, Northwest Territories, to well-developed sandy deltaic and prodelta muddy shelf systems in Alberta. The mud to sand transition has been well-documented and the sandy deltas have been shown to be fed by tributive incised valley systems driven by cycles of high frequency sea-level change. These incised valleys in turn pass landward into the conglomerate alluvial systems, but the nature of these conglomerates and the controls on the gravel-sand transition have not been well examined. Dunvegan conglomerates in outcrops in the Liard Basin are moderately-sorted and well- rounded reaching up to small cobbles in size. These have previously been interpreted as alluvial fans; however, our investigations show a domination of sharp to scoured based meters-thick fining upward facies successions consisting of dune- and bar- scale cross stratification. The conglomeratic units comprise highly amalgamated channel belt deposits that form cliff exposures that are about 70 m high. There is an absence of debris flows or of sedimentary structures characteristic of supercritical flows, and we thus interpret these as likely deposited by meters-deep lower-gradient gravel-bed streams, rather than steep-gradient, sheet-flood dominated alluvial fans. Trunk channels in the sink area, farther to the southeast are associated with incised valleys and have a mean bankfull depth of 10-15 m, carry medium sand (< 200 microns) with slopes estimated to be on the order of 6x 10-5. Source to sink calculations indicate a back-water length of around 200 kilometers. Based on paleogeographic reconstructions, the conglomerates appear to have been deposited 300 to 500 km from the mapped deltaic shorelines, indicating that the gravel sand transition is not related to the back water and is likely not controlled by sea-level changes, thought to be important in generating the incised valleys in the sink area. The conglomerates appear to be confined within the Liard Basin, which is bounded to the east by the Bovie Fault, expressed as a major kilometer-throw normal fault. The Bovie structure was long-lived and may have been active throughout Dunvegan time. Hence, excess accommodation, driven by movement on the Bovie Fault may have prevented gravel from escaping into the more distal parts of the Western Canada Sedimentary basin. This is in contrast to other clastic wedges in the Cretaceous Interior Seaway, such as the Frontier and Cardium formations, that contain conglomeratic shoreline and shelf deposits and may indicate steeper gradient S2S systems. Tectonics and climate in the Dunvegan drainage basin may not have been linked to processes downstream because of the Bovie Fault. Despite clear evidence of downstream sea-level controls in the Dunvegan sink, it does not appear that these signals were able to propagate upstream.

Impacts of wave action and salinity on insect sinking and fossilization

Johnathan Afheldt Sorrentino, Paul A. E. Piunno and Marc Laflamme (University of Toronto)

Making accurate reconstructions of ancient ecosystems and organisms requires an understanding of the biases inherent in the fossil record. Soft tissues, such as chitin and muscle, are rarely preserved in the fossil record because they are highly susceptible to decay; there is only a short time (weeks) to preserve these tissues before they are lost. Realistic controls on the timing and modes of soft-tissue fossilization can be determined by monitoring the early stages of extant organism decay under varying environmental conditions. Burial is essential for fossilization, and it is thus surprising to find that naturally buoyant organisms such as insects are fossilized with exquisite detail in offshore deep-lake depositional environments. Experiments have been designed to analyze how water salinity and wave action influences the initial stages of decay and sinking rates of insects. Greater water salinity should improve buoyancy increasing the time the insects will decay pre-burial; however, it will also reduce decay rate by inhibiting the growth of bacteria. Wave action has the potential to increase insect disarticulation while also decreasing the time before sinking by breaking water surface tension. Decay experiments with crickets (Telogryllus oceanicus) were conducted to determine how water salinity and wave action impact the preservation potential of insects. The crickets were euthanized by rapid freezing in a -86°C freezer and placed in individual containers filled with either artificial freshwater or artificial seawater. Periodic photography (once every four hours) recorded the timing of feature loss (e.g., deformation and limb loss), bacterial growth, and sinking. A second set of experiments was conducted with the individual containers placed on an oscillating platform simulating wave motion. Decay progress was compared across wave-salinity conditions to place realistic bounds on the biases exhibited by fossilized insect collections in deep time.

Tracking Indian monsoon through different lenses: Tectono-sedimentary sequences to molecular fossils

Arijit Chattopadhyay (Queen's University)

The South-west Indian monsoon is a critical climatic pattern that uniquely influences the Indian subcontinent. In the past scores of geoscientific studies tried to unravel the onset of the Indian monsoon using different tools. The current research has tracked Indian monsoon through different lenses: the importance of tectonosedimentary sequences and signatures of molecular fossils/ biomarkers. The Himalayan orogeny during the Tertiary epoch is unique to the Indian subcontinent that moulded South Asia's overall climatic pattern. The relationship between the rise of the Himalayas and the south-west monsoon's onset is complex. The Ganges and Indus are two major river systems stemming from the Himalayas. Detailed studies of tectono-sedimentary fabrics of deltaic to offshore basins corresponding to the Ganges, Indus, and other peninsular India rivers give a clear idea of extra-basinal influences on basin fill. The Himalayan orogeny and onset of SW monsoon had led to the deposition of disproportionately thick sedimentary sequences in east and western Indian margin basins since the early Oligocene, as evidenced from seismic data. The exploration of fluvio-deltaic and deepwater clastic systems led to the discovery of regional petroleum systems in the 20th Century.

Identification of the Bicadinane group of biomarkers from Tertiary oils and sediments from South/SE Asia in the 1980s, holds the key to track the evolutionary trail of the Dipterocarpaceae family of angiosperms, an integral part of the evergreen tropical rain forest of South Asia. The present study has identified Bicadinane in coal-bearing outcrop sections of early-mid Eocene Lakadong Sandstone member in Meghalaya state and oils from Lakadong Sandstone reservoirs of Assam basin in NE India. The present study, in combination with the literature review, reveals a unique trend. The sequential appearance of Bicadinane and common angiospermous biomarker Oleanane in Late-Pliocene to early-mid Eocene sediments from present-day equatorial SE Asian basins to tropical Indian basins, respectively, have a close linkage with the evolutionary spread of Dipterocarpaceae family of plants, elemental to South Asian rain forests. This reporting of Bicadinane in early-mid Eocene sediments in Meghalaya, indicates the onset of the Indian monsoon, by sofar the oldest record through molecular fossil signature in the Indian subcontinent, when the Indian plate collided with the Eurasian plate triggering the rise of Himalayas.

Geological control on modern nearshore flow dynamics

Laura Szczyrba, Ryan Mulligan, Peir Pufahl (Queen's University), Josh Humberston (Sandia National Laboratories, USA) and Jesse McNinch (United States Army Corps of Engineers)

During the Last Glacial Maximum and eustatic sea level lowstand period (23,000 - 19,000 years ago), paleo-river systems incised channels in the present-day coastal nearshore region. Near Kitty Hawk, North Carolina, a series of shore-oblique troughs and bars (SOB's) were inherited from these antecedent geological processes. The SOB's connect to the upper shoreface, feature sorted bedforms in fine-gravel-lined troughs, are stable even during stormy conditions, and have been statistically correlated with hotspots of severe beach erosion. However, the physical mechanisms linking these complex bathymetric features to accelerated shoreline change have not been fully explored. In this study, we combine data from an X-band radar system, a phase-resolving numerical model, and LiDAR beach elevation surveys to determine how SOB's alter nearshore flow dynamics and contribute to erosional hotspots. A high-resolution X-band radar unit was deployed in the field to measure surface waves for 3 months in 2017 and the data are compared with simulated hindcasts of severe storm events. In addition, a set of idealized simulations representing a range of bathymetric conditions are performed to further explore how SOB's influence nearshore hydrodynamics. Results are contextualized with measurements of LiDAR beach elevation surveys to discuss how underlying geological features may exacerbate nearshore hotspots of erosion. Preliminary results indicate that the bathymetric framework creates localized zones of higher wave energy fluxes, causes flow accelerations, divergences, and meanders, funnels offshore flows down channel, and causes acute wave refraction.

Session 5: Mineralogy & Geochemistry (Sponsored by Isomass Scientific Inc.)

Sunday, April 2nd, 2023

Classifying ordinary chondrite M60363

Josephine Di Maurizio, Sarah Mount and Emily McDonald (University of Toronto)

Newly discovered meteorites must be analysed and classified by composition, petrologic type, weathering class, and shock class in order to be instated into the Meteorological Bulletin of Meteoritics and Planetary Science (MAPS) and given an official name. Meteorite M60364, an ordinary chondrite found in North-West Africa and purchased by the ROM in 2010, has now been classified using these parameters. The total known weight of M60363 is 112.5 g, divided into a whole-rock sample (102.49 g) and a thin section (9.62 g). The sample is primarily composed of chondrules, clearly defined by fine-grained opaque and metallic rims, within a fine grained matrix. The modal mineralogy consists of 70% olivine present as mainly barred olivine chondrules and porphyritic olivine chondrules, 15% pyroxene present as radial pyroxene chondrules, and 15% troilite and Fe-Ni-metals, present rimming chondrules and as disseminated blebs throughout the matrix. The fusion crust is ≤200 μm and varies in thickness, suggesting it has been removed through weathering. The sample is a petrologic type 4 ordinary chondrite, based on the clearly defined chondrules, opaque to transparent matrix, and presence of mesostatic material. This suggests it has experienced thermal metamorphism up to 700°C. The shock class is S3 to S4, based on the presence of weak mosaicism and undulatory extinction in olivine grains, planar fractures, and opaque shock veins with minor melt pockets interconnected. This suggests it has experienced 10 to 30 GPa of pressure. The weathering class is W2, with 30-40 vol% Fe-Ni metal converted to Fe-oxide, Fe-oxide veining permeating chondrules, and a weathered fusion crust with macroscopic Fe-oxide staining. The magnetic susceptibility of the sample was between 4.2 - 4.0 log 10-9 m3/kg, which correlates with the LL group of ordinary chondrites when plotted against petrologic classification level 4. Based on the range of shock features and thermal metamorphism, it is likely that this meteorite is a breccia formed from chondrules that experienced a variety of conditions prior to aggregation. Classifying and analysing meteorites, particularly ordinary chondrites that are made up of some of the oldest materials in the solar system, allow for the furthering of our limited understanding of the solar system, its contents, and the geologic processes that occur within it. By looking at as many different samples as we can, we can further constrain our knowledge about different asteroid chemistries, petrogenesis, and overall geologic history.

Constraining the metamorphic history of the Saglek-Hebron Gneiss Complex in northern Labrador through Lu-Hf garnet geochronology

Allison Howes (Queen's University), Hanika Rizo (Carleton University) and Jonathon O'Neil (University of Ottawa)

The Saglek-Hebron Gneiss Complex (SHGC) located in Northern Labrador, Canada, hosts some of the oldest rocks in the world with ages as old as 3.9 billion years (Ga) and is composed of garnet-bearing metavolcanics and metasediments of high-grade metamorphism. Little is known regarding the timing of metamorphic events that caused these garnets to form, however, these rare crustal remnants, and the minerals they contain provide direct evidence of Earth's early geological processes. Inclusion-free garnet fragments, hand-picked from crushed samples, and whole-rock powders were dissolved with various reagents in order to extract Lu and Hf through ion exchange chromatography protocols. ^{176}Lu-^{176}Hf compositions were measured for each of the whole-rock and pure garnet fraction samples using the Neptune multi-collector inductively coupled mass spectrometer (MC-ICP-MS) within the Department of Earth Sciences. Previous studies used ^{147}Sm-^{143}Nd isotopic analyses to determine that peak metamorphism occurred between 2.5 and 2.7 Ga (Sole, 2017). Here we found that Lu-Hf whole-rock–garnet isochrons suggest that a garnet growth episode occurred at 3.76 Ga. This corresponds with garnet growth ages of 3.7 Ga from samples of the Isua Supracrustal Belt (Southwest Greenland) which are thought to be connected with the SHGC (Blichert-Toft & Frei, 2001). Laser ablation rim-to-core-to-rim transects of in- situ garnets allowed for geochemical characterization which suggests that elements such as Lu were mobile in some of the samples that yielded isochron ages between 3.29 Ga and 2.92 Ga. These isochrons also showed a high data scatter which could be associated with a variable degree of resetting of the Lu-Hf system and likely caused by major thermal events. The results of this thesis indicate a metamorphic history that is more complex than originally hypothesized. However, this Lu-Hf garnet geochronology study allows for a stride in deciphering the thermal evolution of the SHGC and for a deeper understanding of Earth's early history.

Session 6: Geoengineering (Sponsored by BGC Engineering)

Sunday, April 2nd, 2023

Innovations in indirect tensile strength testing of low porosity rocks

Timothy Packulak, Jennifer Day and Mark Diederichs (Queen's University)

The tensile strength of rock and rock-like materials is a critical material property in rock engineering design and the prediction of rockmass behaviour to mitigate any potential failure that may affect personnel safety or damage property. The Brazilian Indirect Tensile Strength (BTS) Test is a relatively easy method to measure the tensile strength of rock materials. The method was originally developed for testing the tensile strength of concrete, a "homogenous" material and the material physics associated with the test assumes the material is "homogenous" and "isotropic". Through further understanding of the test method, improvements can be made to the test setup, instrumentation, and data processing. This body of work dives into how isotropic and anisotropic geological material behaves during the BTS test and how practitioners should interpret test results. Furthermore techniques that are not common to geomechanics, such as Digital Image Correlation, is going to be discussed and how they can be incorporated and used to further increase the understanding of how geological materials behave under tension.

Understanding the micromechanics of strainbursting through discontinuum numerical models

Fedilberto Gonzalez and Mark Diederichs; Peter K. Kaiser (Queen's University)

The intrinsically anthropogenic need for human development can ultimately only be satisfied by underground mining operations. The transition from open pits to underground operations such as at Chuquicamata is a vivid example of this. Greater depths and higher production rates just increase the challenges of providing a safe and productive environment. Environments at greater depths are inherently more fragile due to the increase in the stress gradient, which leads to higher differential stress. Higher production rates increase the loading rate of excavations, which might increase the frequency and severity of self-induced strainbursts and cause costly disruptions in the underground mining operation. In burstprone ground, sudden and violent failure of hard brittle rock dynamically loads and deforms ground support. Current numerical codes and computational power allow for creating thought experiments that would be otherwise very difficult to carry out in laboratory or in-situ. Discrete element methods such as the Particle Flow Code provide emergent behaviors that perfectly match macroscopic rock rupture observed in deep underground infrastructures as well as well-formulated laboratory experiments. As soon as an excavation is made in active mines at great depths, sudden and violent release of stored strain energy becomes almost inevitable due to the self-destructive nature of strainbursts. We highlight significant micromechanical characteristics of brittle hard rock at different stress levels allowing for a differentiation between spalling and strainbursting. The cracking process leading to rock brittle fracture is evident and consistent with in-situ observations, which indicates that the pervasive behaviour of rock-like material is successfully modeled. This study allows to have a profound understanding of the crack nucleation, growth and coalescence of tensile and shear cracks previous to rock brittle fracture.

Poster Session 1

Saturday, April 1st, 2023

Using trace element analysis to determine the petrogenetic history of kyanites

Richard Barrette and Christopher Spencer (Queen's University)

Kyanite plays an important role as an index mineral used to constrain P-T conditions of metamorphism. Moreover, modern methods for trace element analysis have enabled the indepth analysis of individual crystals. However, there are some disagreements within the literature as to the nature of trace element signatures in kyanites, and very little work has been done within the Grenville province. The purpose of this project is to test these methods on a set of kyanites from Fernleigh, a locality of the Grenville province. The aim is to see whether differences in trace element compositions can be found between the distinct kyanite groups and if these can be used to decipher their petrogenetic history. To explore this question, seven kyanite samples representing five distinct populations were analyzed using LA-ICP-MS and electron probe microanalysis for trace element concentrations, and cathodoluminescence and scanning electron microscopy for internal crystal structures. Early results show appreciable differences in trace element concentration between the kyanites from each group, with samples 2 and 4 diverging the most from the rest. This points towards different conditions of formation. The cathodoluminescence images also show varying levels of alteration and inclusions between the groups and there is some link between cathodoluminescence brightness and trace element concentrations, indicating spatial variations within the samples. This may indicate a history of multiple metamorphic, hydrothermal, and partial melting events. In the context of the Fernleigh occurrence, the results may be used to refine orogenic models for the Grenville province.

Orogenic gold mineralization associated with crustal deformation during the rapid uplift in Himalayan orogen: case study from the Buzhu

Chaoyi Dong (China University of Geosciences, Beijing, and University of Toronto), Qingfei Wang, (China University of Geosciences, Beijing), Daniel D. Gregory (University of Toronto), and Huajian Li (China University of Geosciences, Beijing)

Orogenic gold deposits are widely distributed within the Himalayan orogen. However, the control of rapid uplifting on gold mineralization is not clear. The newly discovered sub-greenschist-hosted Buzhu gold deposit, as a typical example, hosts gold veins controlled by an extensional fault system developed in the margins of the dome, providing an opportunity to address this issue.

The extensional fault system controlled the vein system that experienced three deformation stages, including hydraulic brecciation during stage I, crack-sealing processes in stage II during the ductile-brittle transition, and crosscutting by veins in newly-formed normal faults during stage III. Stages I and II have quartz-pyrite-chlorite-muscovite ± arsenopyrite ± base metal sulfides assemblage. In stage III, native gold and pyrrhotite formed. In stage I, quartz exhibited oscillatory and sector zoning cathodoluminescence patterns. Pyrite in stage I veins showed a correlation between gold and arsenic, as well as restricted δ34S values, implying that fluid-rock interaction caused gold precipitation. Quartz from stage II had bright and dark cathodoluminescence bands with corresponding high and low Al-Li concentrations, indicating fluctuating fluid pressure. Pyrite from stage II showed a negative correlation between gold and δ34S values (decreasing values from cores to rims), consistent with fluid oxidation associated with a fluid pressure drop. Late minor quartz in open spaces transected earlier quartz, implying the hydrothermal system dropped to near-hydrostatic conditions. The partial replacement textures of pyrite and arsenopyrite from stage III, with varied δ34S values, and the existence of micro-inclusions and visible gold along the contact, suggest a fluid-mediated dissolution-reprecipitation process. These findings indicate that Buzhu gold mineralization is controlled by crustal uplift, and the gold precipitation mechanisms vary from fluid-rock interaction and fluid oxidation to remobilization during the hydrothermal system's transition from the ductile to brittle domain. This study presents a comprehensive genetic model for the formation of gold deposits in the Himalayan orogen, which can serve as a reference for understanding other orogenic gold systems that formed during the development of crustal domes.

Spectral-element simulations of 3D advection-diffusion-reaction processes in complex geological models

Maxwell Milchberg, Eric deKemp and Hom Nath Gharti (Queen's University)

We present the development of a versatile open-source numerical tool to solve the generalized advection-diffusion-reaction equations in 3D heterogeneous models based on the spectral element method (SEM). The SEM uses higher-order polynomials, and the mass matrix is diagonal by construction, leading to a highly accurate and efficient explicit time domain solver. The new solver is implemented on the existing open-source software package SPECFEM3D, initially developed for forward and adjoint simulations of seismic wave propagation. The software package is parallelized using MPI and ported to modern GPU platforms, enabling simulations over a wide range of scales. We benchmark our tool against analytical solutions to various advection-diffusion-reaction examples. Finally, we demonstrate the simulation of a complex model with 3D heterogeneities. Our comprehensive numerical experiment shows that the method is accurate and efficient. The new tool will facilitate the simulations of advection-diffusion- reaction processes in complex geological models.

Controls on lateral migration rates of rivers in a delta depositional system

Geila Uzeda, Elisabeth Steel (Queen's University) and Austin Chadwick (University of California, Santa Barbara)

Lateral migration rates of rivers are largely controlled by their sediment supply, meaning that higher suspended sediment load is expected to correspond to higher rates of lateral migration. River migration rates have a direct impact on stacking and connectivity of sand bodies, and we aim to better understand the complex fluvio-deltaic sand bodies that commonly serve as aquifers and hydrocarbon reservoirs.

The aim of this research is to determine if lateral migration rates of rivers are controlled by local sediment load and discharge or if they are more strongly influenced by migration rates of their upstream reaches. A large-scale flume experiment was conducted in a 4 m x 4 m x 1 m basin at the Queen's University Coastal Lab in which a delta was allowed to build under constant sea-level for 80 hours. Topographic scans and time-lapse photography were collected throughout the experiment. These experimental channels offer the opportunity to explore several fundamental questions surrounding river morphodynamics. Channel migration rates will be carefully tracked using a novel application of Particle Image Velocimetry (PIV). The amount of sediment extracted along the system will be estimated to investigate the controls of sediment supply, local suspended sediment load, and upstream migration rates on the migration of rivers along the network.

Currently, this research is in the analysis and processing data stage, which consists of image preparation for applying PIV methodology. Principal Component Analysis (PCA) is performed on all images to identify land-water boundaries on the delta surface. Thresholds are used to create binary images of the wet-dry surfaces in each image. Both processes are being developed in Python. Once the image preparation process is completed, PIV methodology is applied to all binary images using PIVlab, an open-source MATLAB Application that successfully tracks channel motion in a delta surface. This presentation will show preliminary work performed on the image preparation process for PIV and, subsequently the Implementation of Particle Image Velocimetry (PIV).

Autoliths in the Parisien Lake Zone of the East Bull Lake Intrusion, Ontario, Canada: Implications for mineralization genesis and mineral exploration

Marc Rochette, Daniel Layton-Matthews (Queen's University), Dave Peck (Grid Metals Corp, Toronto, ON, Canada,) and Reid Keays (Monash University, Australia)

The East Bull Lake intrusion occurs approximately 80 km west of Sudbury, Ontario and hosts a widespread, disseminated sulfide mineralization that has been classified as contact-type PGE-Cu-Ni mineralization. Contact-type mineralizations occur at the base and margins of most of the co-eval mafic-ultramafic intrusions in the greater Sudbury region, though none of these occurrences have proven to be currently economically viable. The lowermost stratigraphic units of the East Bull Lake intrusion hosts Pd grades in the range of 1 - 10 g/t. The Pd mineralization is associated with poorly characterized epidote rich, sulfide-bearing autoliths in a gabbronorite matrix and a chalcopyrite-dominated disseminated sulfide mineralization. Narrowing the source and mechanisms of Pd enrichment in the mineralized autoliths will help develop a better understanding of the mineralization-forming processes and improve the potential for higher grade targets. Core samples were taken from seven DDH with >1.0 g/t Pd at the Central Parisien Lake Zone, which is >1.0 km2. DDH were quartered with half used for whole rock geochemistry and the remaining material was billeted for 54 thin sections. Optical mineralogy and automated mineralogy scanning electron microscopy (MLA-SEM) were used to analyze mineralogical and textural characteristics of the samples for in-situ trace element analyses. Laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was used to define trace element chemistry of sulfides and platinum group minerals (PGMs). The aim of these analyses is to identify PGE mineral hosts and to compare mineralogy of autoliths, host magmas and occurring lower in the stratigraphy. Initial findings indicate that Pd occurs mostly as a stoichiometric replacement in sulfides such as (in order of highest Pd concentration to lowest) pentlandite, chalcopyrite, pyrrhotite, bornite, and pyrite. Palladium also occurs as a major element in platinum group minerals which occur near sulfides within the autoliths such as kotulskite (Pd(Te,Bi)), merenskyite (PdTe2), and other palladium tellurides and arsenides. LA-ICP-MS targeted sulfide minerals and PGMs near and within the mineralized autoliths, and from lower in the stratigraphy where sulfides occur as interstitial phases. The targets from lower in the stratigraphy are currently being analyzed, and the new data will help determine what, if any relationship exists between the mineralized autoliths and their host rocks. By further characterizing the mineralization-forming processes within the Parisien Lake Zone of the East Bull Lake we hope to develop more robust techniques for future exploration.

Modelling noise propagation in urban environments generated by trains and church bells using the spectral element method

Pedro Lapietra Garcia and Hom Nath Gharti (Queen's University)

Urbanization has caused a growing concern over noise pollution in densely populated areas. The limited space for development has led to urban infrastructure being built upwards or closer to noisy areas such as airways, railways, and highways. This study aims to investigate the propagation of noise in urban environments generated by train horns and church bells, which are sources of noise that contribute significantly to the overall noise levels in the city. The study employs the spectral element method to accurately model noise propagation in an urban environment. The spectral element method is chosen due to its ability to handle complex geometries typical of urban environments. The study constructs a detailed representation of the city's physical features, including buildings, roads, and other structures, using real-world GIS data of the area surrounding the signal sources. The study models the train horns and church bells as moving and stationary point sources, respectively. Results are validated by comparing them with real-world measurements. Chronic exposure to high noise levels has been shown to negatively impact human health and well-being, making it a pressing issue for urban environments. This study's contribution is critical in characterizing noise pollution in urban environments. The study provides a comprehensive understanding of noise interaction with the existing physical features such as buildings and open areas in urban environments. The research's findings have significant implications for urban planning and decision-making, potentially providing a reliable basis for effective mitigation strategies against noise pollution.

Meteorite classification of a new ordinary chondrite

Kathryn Cheng, M. Sengupta, J. Li, R. Hui, and K.T. Tait (University of Toronto)

Ordinary chondrites account for the majority of the described meteorites on Earth. To better understand their origin, meteorite classification is used to sort extraterrestrial rocks into similar types of geological material. Classifying meteorites is important to allow scientists to communicate with a standardized terminology. The purpose of this study is to classify a new ordinary chondrite specimen using macroscopic, microscopic, and magnetic susceptibility analyses. The sample is NWA XXX from Northwestern Africa succession number M60360 at the Royal Ontario Museum and was purchased in Tucson, Arizona. It weighs 2668.48 g with dimensions 12.5 cm by 10 cm. It has a smooth outer surface with light pink, white, and weathered concretions of unknown origin on the exterior; surficial cracks and shock veins are also present.

Microscopic observations under cross-polarized light (XPL) show that this sample is rich in silicate minerals, specifically olivine and pyroxene with fewer Fe-metal and Fe-sulfides. Microscopic analyses and magnetic susceptibility were used to classify the meteorite as an H chondrite (high in iron and other metals, low in iron oxides and silicates). After accounting for weathering, the magnetic susceptibility was 5.251, further classifying the sample as H. The microscopic observations also allowed identification of the shock stage as S2 (very weakly shocked), which results from a shock pressure of 5 to 10 GPa. Moreover, the olivine crystals underwent undulatory extinction under XPL and had irregular fractures – both indicative of S2 or S3 shock classification. However, there were no shock veins or melt pockets visible in the thin section, determining the shock stage as S2.

Lastly, a weathering class of W1 was determined using both macroscopic and microscopic observations. Meanwhile within the thin section, the metal had Fe-oxide rims of various thicknesses, along with minor sulfide veins along the matrix. However, the volume of metal affected by the weathering rims was less than 20% on average; since 20–60% of the metal needs to be replaced by oxidation rims to be classified as weathering class W2, the meteorite was given a weathering classification of W1. Microscopic observations were used to classify the rock as a petrologic type 4. Multiple well-defined, porphyritic, and spherical chondrules were visible within a glassy, fine-grained recrystallized matrix. This suggested that the meteorite has undergone some thermal metamorphism, but not enough to create poorly defined chondrules or a coarse-grained matrix.

Characterization of the sequence stratigraphy and facies architecture of the Upper Cretaceous Dunvegan Formation, Northwest Territories, Canada and its hydrogeological implications

Aneesa Ijaz Rabbani, Janok Bhattacharya, Beth Parker, and Julie Zettl (McMaster University)

Contamination of groundwater aquifers from gas wells in the Liard Basin, Northwest Territories present a serious concern for First Nations Communities dependent on these resources. Our project examines the main aquifers and aquitards in the basin to decipher the geologic controls on fluid flow. Previous work shows that the main aquifer; the 100 meters thick Cretaceous Dunvegan Formation, consists of interbedded sandstones, shales and conglomerates, that coarsen upward. It is uncertain how continuous the coarsest sandstones and conglomerates are in the upper part of this unit. We tested this via photographs of continuous cliff outcrops that expose the Dunvegan along the banks of the Petitot River. The new data reveal that the Upper Dunvegan consists of highly amalgamated sandstones and conglomerates, likely deposited in a braided river plain. The Lower Dunvegan showcases evidence of meandering river deposits, interbedded with muddy floodplains that overlie upward coarsening and more sheet-like delta sandstones. The next phase of the study will consist of drilling monitoring wells to measure ground-water flow and deduce possible contaminant pathways. The outcrop data provide a continuous view of the stratigraphic layering that can be used to better interpret and correlate subsurface well data. Geophysical resistivity surveys also provide images of the subsurface layers. Interpretation will be aided by the ground-truth outcrop data collected in this study.

Poster Session 2

Sunday, April 2nd, 2023

Influence of lithospheric scale basement faults on seismicity in the Himalayan orogenic system: A numerical modelling approach

Michelle Pearce, Laurent Godin, and Hom Nath Gharti (Queen's University)

The seismically active Himalayan orogen is the product of the Cenozoic collision between the Indian and Eurasian plates. Both plates record complex geological histories that have generated pre-orogenic (inherited) lithospheric-scale faults. Inherited Indian Precambrian basement faults have been identified via geophysical methods and have been linked to Himalayan along-strike spatial variations in seismicity, basal thrust geometry, metamorphism, foreland basin thickness, and exhumation. Recent Himalayan research focuses on these spatial variations to understand how basement structures influence the evolution of the Himalaya. These basement faults bound Indian Precambrian basement topographic highs (ridges) that are interpreted to continue beneath the Himalayan orogenic front and the orogenic wedge. Recent research suggests the basement faults control the distribution and magnitude of seismicity along the Himalaya.

The Himalayan system serves as a prototype for novel three-dimensional numerical modelling to understand if and how inherited basement structures influence seismicity in orogenic settings. Models are generated using the Coreform Cubit meshing software and are run on the Digital Research Alliance of Canada's Advanced Research supercomputer platform hosted at the University of Toronto. The initial model contains three crustal blocks: the Indian crust, a deformed orogenic wedge, and the Asian crust, all cut at a high angle by a lithospheric scale basement fault. The 2015 7.9 MW Gorkha earthquake is simulated, and slip is generated along the Himalayan basal detachment. Seismograms, shear wave potential, and compressional wave potential movies are created to understand if and how the inherited basement faults influence seismicity within orogenic systems. Understanding how these regionally significant basement faults influence seismicity in the densely populated regions of northern India and Nepal is of utmost societal importance. This research is also applicable to other orogenic systems that have identified inherited basement structures in the underthrusted plate, such as the Apennine Mountains in Italy and the Canadian Cordillera in Alberta and British Columbia.

Variability of facies, neoichnology and sedimentation rates on the Waipāoa Continental Margin, New Zealand

Angelina Abi Daoud and Janok Bhattacharya (McMaster University)

Major paradigm shifts in the study of sedimentology have revolutionized the way fine-grained sediments are studied on continental margins. Although muds are the most abundant natural material on the Earth's surface by volume, the fundamental mechanisms of their transport, dispersal, and deposition are still debated. To better interpret ancient cores from shallow marine environments, observing how transport and depositional mechanisms are preserved in the stratigraphic record of modern continental shelves is essential. This study provides a facies analysis of six modern box cores collected in the Tūranganui-a-Kiwa/Poverty Bay and on the distal Poverty Shelf in New Zealand, where the Waipāoa River delivers sediment directly into the bay. These short cores were collected by the Kaharoa Research Vessel in May 2010 and are oriented in a northwest to southeast transect from Tūranganui-a-Kiwa/Poverty Bay to the Outer Poverty Shelf, through the Poverty Gap. The cores were X-radiographed on-site and enhanced using Adobe Photoshop. Grain sizes vary from clay to very fine sand, with the majority of the cores rich in clay and silt. Five facies were identified: 1. laminated very fine sand (LVFS); 2. normally graded sands and silts (NGSS); 3. structureless mud (SM); 4. laminated silty mud (LSM); and 5. biogenically mottled silty mud (BMSM). The main trace fossil suite present was the recently defined Phycosiphon ichnofacies, with identified species such as Phycosiphon, Helminthopsis, Thalassinoides, Schaubcylindrichnus, Asterosoma, Scolicia, and Chondrites. Members of the Skolithos ichnofacies were also present, such as Skolithos and Arenicolites. Abundant body fossils, such as gastropods and bivalves, occur alongside these trace fossil suites expressed within the defined facies. An inverse relationship was found between sedimentation rate and bioturbation intensity, where organisms are able to outpace the formation of primary strata when sedimentation rates are low on the distal shelf, but do not have a long enough colonization window with high sediment input near the river mouth. Wave reworking processes dominate the sediment proximal to the Waipāoa River mouth, while suspension settling and biogenic reworking dominates the lower energy Outer Poverty Shelf.

Characterization of the Holleford impact crater

Emer McConnell-Radford and Christopher Spencer (Queen's University)

Impact cratering is a ubiquitous geological process affecting all planetary bodies with a solid surface. However, unlike most other planetary bodies, Earth's surface undergoes a much faster resurfacing due to erosion and active tectonics that actively removes impact structures from the geologic record. Small craters tend to be removed quicker by erosive forces due to the limited depth to which they can be recognized and small volume of shocked material.

In particular, the Holleford crater, just north of Kingston Ontario, being roughly 2.35km in diameter, is part of an enigma of small but old impact craters in the geologic record. The characterization of this impact crater is limited to the identification of a circular depression in the 1950s from aerial photographs, and a single study in the 1960s which discovered coesite, as confirmed with x-ray powder diffraction. Previous studies have estimated an age of around 550 million years old for this crater, based on the deposition time of the undisturbed Potsdam formation which fills the crater.

Detailed logging of the Holleford crater core and modern analytical techniques are used to identify shocked minerals from the Holleford crater, providing a more robust characterization of an impact feature and the possibility of determining an accurate age through dating neoblastic accessory minerals.

Comparing measured and perceived productivity of Earth scientists during COVID-19 work-from-home initiatives

Sarah Hatherly and Christopher Spencer (Queen's University & Traveling Geologist)

Work-from-home initiatives have led to disproportionate impact among different genders. Bibliometric and survey-based data are used to evaluate and compare the productivity of Earth scientists. An individual's perception of their own productivity is significant in understanding how equity-deserving groups are affected by disruptions to normal routines. Additionally, peer-reviewed publications are a key metric of academic productivity, as they are a vital component of career advancement. Using sex- (female vs. male) and gender-based (women vs. men) methods, this study investigates how both the perceived and measured productivity of women and men was impacted by global COVID-19 work-from-home initiatives. Here we show that in a normal year females publish proportionally to males, and that the proportion of female first authors increased between the 2019-2020 ("pre-pandemic") and 2020-2021 ("during pandemic") years. This finding is contrary to the perceived productivity between women and men and indicates that our perceptions may not always match reality. Although women and men are publishing at nearly identical rates based on their proportions within our field, women are harder on themselves. Support structures should be focused on women and early-career researchers as their more negative perception of self-productivity can lead to mental health issues and a lack of confidence.

Temperature dependency of particulate transport by wind

Christopher Schweighofer and Cheryl McKenna Neuman (Trent University, Trent Environmental Wind Tunnel)

A key knowledge gap in aeolian transport research concerns the adjustment of saltation processes to the extreme conditions found within high-latitude regions. Three hypotheses were tested in order address this knowledge gap: 1) Increasing pore ice will result in an increase in the mean sand particle velocity and trajectory height within the transport cloud, and a decrease in the proportion of particles travelling in creep. 2) Fewer particles will be ejected during a collision with a frozen surface, relative to a dry surface. 3) Vertical dust fluxes will increase with decreasing temperature.

To address these hypotheses, a series of experiments were carried out in the Trent Environmental Wind Tunnel, which can operate under full temperature control and over a wide range in humidity. Particle entrainment and transport within shearing flows of varied wind speed and turbulence intensity were monitored over beds of varied temperature, and ice content. Hypothesis (1) was addressed through the sampling of particle velocities using a two-component Dantec Laser Doppler Anemometer and a vertical array of laser sheet sensors for particle flux assessment. Hypothesis (2) involved the upwind introduction of a red, tracer sand into the flow and an isokinetic sand trap at the downwind end, allowing us to quantify the proportion of sand ejected from the bed surface relative to the feed particles. Hypothesis (3) used DustTrak Aerosol Monitors to measure PM10 concentrations in a vertical profile at varying temperatures.

LDA data confirm that the coefficient of restitution for particles saltating over frozen surfaces is significantly greater than over dry surfaces. Further, sand trap data show that transport rates decrease with increasing surface moisture content. Although more energy is conserved within the saltation cloud, more surface ice results in fewer particle ejections from the bed. This was confirmed through the trapping of higher proportions of red, tracer sand over surfaces of high moisture content than surfaces of low moisture content. Finally, as temperatures drop from 30°C to 5°C, the dust flux increases. Sand trap and laser sheet data both confirm that mass transport rates increase as temperatures decrease.

It is anticipated that the results from this study will support the parameterization and calibration of existing models of the mass transport rate and dust emission, developed for hot deserts, so that they may be extended to sites within cold/polar regions on Earth, inclusive of northern mines and glacio-fluvial outwash systems.

Simulations of implosion and explosion in an underground mine using the spectral-element method

Marie-Hélène Lapointe, Lilli Taviss, Dan Martin, Hom Nath Gharti (Queen's University), and Doug Angus (ESG Solutions)

We perform a forward modelling of an Mw 1.2 microearthquake event caused by the rock burst that occurred near an excavation void of a copper mine. We compute the seismic wavefield using the spectral-element method for both explosive and implosive sources. We compare the synthetic waveforms with the real data observed by the in-mine seismic network of 39 three-component receivers. Rock burst is a spontaneous and complex phenomenon, and determining its source mechanism is challenging. Comprehensive simulations of seismic wave propagation in the mine will help to characterize these events and to understand the failure mechanism. Consequently, these simulations can provide valuable information for mining hazards and the designing support systems in the mines.

Vanadium speciation in hyper-enriched black shales of the Selwyn Basin and its implications for the burial path of Vanadium

Ozgur Can Tekin[1], Daniel David Gregory[1], Anthony Chappaz[2], Danielle McGill[1], Daryll Bien C Concepcion[1], Merilie A Reynolds[3], Chelsey Merrick[1] and Stefanie M Brueckner[4]

1. University of Toronto, 2. STARLAB - Earth and Atmospheric Sciences - Central Michigan University, 3. Northwest Territories Geological Survey, 4. University of Manitoba

Vanadium (V) is an essential metal that plays a crucial role in both the green energy revolution and steel production. One of the main drivers of its increasing demand is its use in Vanadium Redox Flow Batteries (VRFBs), which are necessary for the integration of renewable energy sources into the electrical grid. In addition to its application in VRFBs, V is also utilized as a steel alloy to improve durability and reduce energy consumption. This highlights the importance of a deeper understanding of V enrichment, which would aid in the exploration of additional V resources and contribute to the green energy revolution. As a result, ongoing exploration for new vanadium deposits is taking place worldwide and targeting various geologic settings. The urgent and strategic need to identify new sources of V has led to the exploration of hyper-enriched black shales (HEBS), which are potential V resources. The Selwyn Basin, located in northwest Canada, is a sedimentary basin with relatively high V enrichments of approximately 0.3 wt%. The deposition of V in HEBS is still debated, with two possible scenarios: direct precipitation from seawater (top-down) or seafloor hydrothermal activity (bottom-up). The speciation of V in HEBS, including a recent discovery of a new species of V, bound to sulphur atoms associated with organic phases, can provide crucial information about the conditions and source of fluids transporting V. Therefore, this study focuses on characterizing the speciation of V in HEBS from two sites in the Selwyn Basin to contribute to the exploration of new V resources. The use of synchrotron-based spectroscopy techniques such as micro-focused X-ray absorption near edge spectroscopy (μ-XANES) can provide precise information about the speciation of V in metal-enriched shale samples. This includes its oxidation state, coordination, molecular environments, and hosting phases. The application of μ-XANES was used to analyze a selection of samples in the Advanced Photon Source (BL-13-IDE), and preliminary results showed the presence of two predominant V species: V(+IV) bound to sulphur atoms and V(+III) bound to oxygen atoms. These results suggest that the top-down scenario might control V's burial. The study is still ongoing and will incorporate additional geochemical analyses such as isotope chemistry, whole-rock analyses, and SEM.

Spectral-infinite-element simulations of induced polarization anomalies

Kiana Damavandi and Hom Nath Gharti (Queen's University)

The induced polarization (IP) method is an important geophysical technique used to investigate the electrical properties of the subsurface. It is widely used in mineral exploration, environmental studies, groundwater exploration, and engineering geophysics. The method involves measuring the electrical response of the subsurface to an applied electric field. The IP method is particularly useful in areas where traditional resistivity surveys may be less effective, such as in areas with high clay content or in the presence of conductive minerals. A fast and efficient numerical simulation algorithm is required to design an effective IP survey and to interpret data from the IP method. We developed a versatile open-source numerical tool to simulate the IP in complex heterogeneous media based on a spectral-infinite-element method. The spectral-infinite-element method (SIEM) is a numerical technique that combines the spectral-element method with the mapped infinite-element method and was initially developed to solve unbounded geophysical problems, including gravity perturbations, gravity anomalies, and magnetic anomalies. The SIEM discretizes the unbounded domain into the spectral elements within the finite domain and the infinite elements in the outer domain to mimic the infinite boundary conditions. Numerical integration is performed via Gauss–Legendre–Lobatto and Gauss–Radau quadratures in the spectral and infinite elements, respectively.