2025 ATLAS Research Symposium
9th-11th April 2025

The Earth and Atmospheric Sciences Department is invited to attend the 2025 ATLAS Research Symposium Annual Meeting, taking place at the University of Alberta, Edmonton, from April 9–11, 2025.

Organized by ATLAS, the graduate student society of the Earth and Atmospheric Sciences Department, the ATLAS Symposium is an annual student-led event. It features a series of academic talks and a poster session presented by graduate and undergraduate students. The symposium covers a diverse range of topics, including geoscience, paleontology, environmental studies, human geography, and urban planning.

As a valued department tradition, the ATLAS Symposium fosters a strong academic community of over 180 graduate students and 50 faculty members, providing an opportunity for students to share their research, learn from peers and invited speakers, and develop essential presentation and time management skills for their future careers.

1. Hosts and Sponsors

The 2025 ATLAS Symposium is made possible through the generous support of the Faculty of Science, Undergraduate Research Initiative (URI), PS Warren, Grace Anne Stewart Initiative (GASI), Dr. Stephen Johnston, APEX Geoscience Ltd., APEGA, Dahrouge Geological Consulting Ltd., Edmonton Geological Society (EGS), Enverus and Imperial Oil. We extend our sincere gratitude to our sponsors for their support.

2. Meeting Format

The event schedule is as follows:

- **Oral Presentations**
  Location: Earth Sciences Building, Room 1-39
  Time: 9:00 AM – 4:00 PM, April 9–11, 2025
- **Poster Session**
  Location: Earth Sciences Building, Room 1-39
  Time: 4:00 – 5:30 PM, April 9, 2025
- **Keynote Speakers**
  Location: Earth Sciences Building, Room 3-27
  Time: 1:00 – 2:00 PM, April 9–11, 2025

In addition to the research presentations, ATLAS will host a **“**Runaway Research: Miscommunication and misinformation in research” panel on Thursday, April 10th from 5:00 to 7:00pm, and an industry panel “From Classroom to Career: Finding Your Place in Industry” on Friday, April 11th from 2:30 pm to 4:00 pm**,** and a banquet on Friday**,** April 11, at the University Club, offering students the opportunity to network with peers, faculty, and deligates from industry

and academia. Even more, ATLAS will provide breakfast and lunch for all participants and attendees.

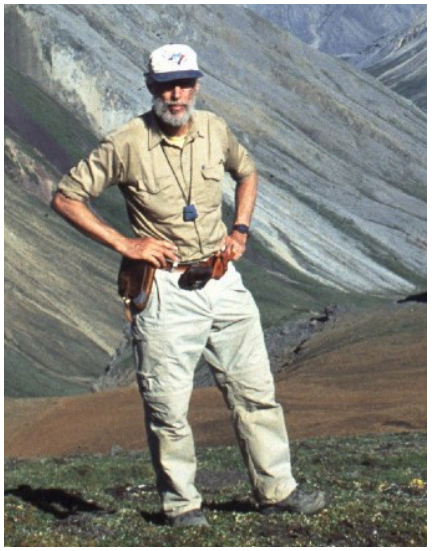
3. Keynote speakers

Dr. Nick Falvo

Nick Falvo has a PhD in Public Policy and spent 10 years working on the front line with persons experiencing homelessness. He is internationally recognized as one of Canada's most prominent researchers in affordable housing and homelessness. Prior to pursuing his PhD, he spent 10 years working on the front line with persons experiencing homelessness. While at Carleton, Nick developed and taught one of Canada's only university-level courses on affordable housing and homelessness. He also led two research projects in Canada's North. He is Editor-in-Chief, North America, of the International Journal on Homelessness, and is the 2021 winner of the CMHC President's Medal for Outstanding Housing Research.

Dr. Cynthia Whaley

Cynthia (Cyndi) Whaley got her PhD in atmospheric physics from the University of Toronto. She joined ECCC in 2014 in the air quality modelling group, and in 2017 she transitioned to climate modelling at the Canadian centre for climate modelling and analysis in Victoria, BC. Her research is focused on short-lived climate pollutants and climate-air quality interactions. She is one of the Steering committee member for the International Global Atmospheric Chemistry (IGAC) activity.



Dr. Paul Hoffman

A native of Toronto, Paul Hoffman is a former Senior Research Scientist with the Geological Survey of Canada (1969−1992), where he was an early proponent of Precambrian plate tectonics, and a Sturgis Hooper Professor of Geology at Harvard University (1994−2008), where he was a leading advocate of the Cryogenian Snowball Earth hypothesis, based on field work in northern Namibia (1993−2023) and independent projects by graduate students across the globe.

4. Additional Events

Panels

The Grace Anne Stewart Initiative (GASI) and ATLAS present the panel "*Runaway Research: Miscommunication and misinformation in research*" where panelists Anne Hicks, Dr. Cynthia Whaley, Dr. Josh Evans, and Marlin Schmidt will discuss the challenges when presenting information to the public and their techniques to avoid misinformation.

Additionally, ATLAS presents the industry panel "*From Classroom to Career: Finding Your Place in Industry*" with Alexander Partsch (Canadian Institute of Mining, Metallurgy, and Petroleum, Mining), Rebecca Funk (Edmonton Geological Society), Jared Kugler (Principal Consultant - Enverus, Oil and Gas), Erik Backstrom (Alberta Professional Planners Institute/Senior Planner - City of Edmonton, Urban Planning), and Rob L'Heureux (CEO - Metalero, Mineral Exploration). This panel aims to bridge the gap between academia and industry and redefine what it means to have a job "in your field". Panelists will guide students on the transferability of their skills, the interdisciplinary realities of the workplace, and how to leverage your knowledge and expertise.

Poster Presentation and Social Program

There will be a late-afternoon Poster Session on April 9th, from 4:00 pm – 5:30 pm; and a closing banquet on the evening of April 11th, from 5:00 pm – 7:00 pm in the Windermere Room of the University Club.

5. Program

5.1 Graduate Student Talks Summary (April 9-11th, 10:00am - 4:00 pm)

All events are held in ESB 1-39 unless otherwise stated

Time	**Wed 9th April**	**Thurs 10th April**	**Fri 11th April**
9:30-10:00		Breakfast	Breakfast
10:00-10:15		Daniela Gutierrez-Rueda	Ahmad B. Aulia
10:15-10:30		Cody Lazowski	Veronica Rosa
10:30-10:45	Ice Breaker with Breakfast	Brette Harris	Jonathan Spence
10:45-11:00		Break	Break
11:00-11:15	Julian-Marie Jones	Kelly Rozanitis	Michelle Woje
11:15-11:30	Jenna Maccagno	Sanaa Mughal	Ankita Mukherjee
11:30-11:45	Emma Braun	Alex Baxter	Megan Athey
11:45-12:00	Javeria Khalid	Sara Biddle	Tatiana Mijajlovic
12.00-12.15	Poorva Jain		
12:15-13:00	Lunch	Lunch	Lunch
13:00-14:00	**Dr. Nick Falvo ESB 3-27**	**Cynthia Whalley ESB 3-27**	**Dr. Paul Hoffman ESB 3-27**
14:00-14:30	Break	Break	Break

14:30-14:45	Andre Truksa	Michelle landry	**Industry Panel ESB 3-27**
14:45-15:00	Mohammed Abdaki	Cameron Poole	
15:00-15:15	Patrick O'Brien	Break	
15:15-15:30	Paula S. Moreno-Pina	Hanaa Yousif	
15:30-15:45	Break	Tahya Weiss-Gibbons	
15:45-16:00		Mukulika Pahari	
16:00-17:30	**Posters session ESB 1-39**		
17:00-19:00		**Panel Discussion: Science Miscommunication ESB 3-27**	**Banquet (17.00 to 21.00) Winspear Room, University Club**

Hydrogeology

- **Julian-Marie Jones:** *"Effectiveness of LIDs on urban creek flow regimes within a cold climate context: A Case study on the Whitemud Creek Watershed, Edmonton, Alberta".*
- **Jenna Maccagno:** *"Geochemical and hydrogeological characterization of local buried valley aquifers to improve Edmonton's water security".*
- **Emma Braun:** *"Characterizing the urban hydro(geo)logy of the Edmonton Area using a 3D flow simulator".*

Urban Planning ang Human Geography

- **Javeria Khalid:** *"Beyond the Basics: Designing Future-Ready Bus Stops that Prioritize Equity, Safety, and Sustainability".*
- **Poorva Jain:** *"Understanding the impacts of Public Transit Intervention on various demographic groups: A systematic review of methodological approaches and data sources*

Remote Sensing Studies

- **Andre Truksa:** "Classification of lianas from tropical dry forest point clouds".
- **Mohammed Abdaki:** *"A Machine learning approach for filling long gaps in Eddy Covariance time series data in a Tropical Dry Forest".*
- **Patrick O'Brien:** *"Predicting environmental DNA-derived soil biodiversity in forests with orbital hyperspectral data".*
- **Paula Sofia Moreno-Pina:** *"Environmental Droughts In Tropical Dry Forests".*

Sedimentology

- **Daniela Gutierrez-Rueda:** *"A drying protocol to minimize water interference in the analysis of silica gels by FTIR".*
- **Cody Lazowski:** *"Lithium isotopes of the Peace River Arch in the Western Canada Sedimentary Basin: A framework for resolving deep basin lithium sources".*

- **Brette Harris:** *"Spatial interactions between microbial mats and intertidal organisms, Willapa Bay, Washington, USA".*

Paleontology

- **Kelly Rozanitis:** *"Surviving the Depths: metazoan resilience in sulfidic aquaria environments".*
- **Sanaa Mughal:** *"Understanding the early biosphere through the lens of the microfossil record".*
- **Alex Baxter:** *"The Role of Temporal Scope in the Identification of Palaeoecological Signals".*
- **Sara Biddle:** *"A Quantitative Ichnological Approach to Relative Deoxygenation Across the Cenomanian-Turonian Boundary Oceanic Anoxic Event 2 in the Alberta Portion of Western Interior Seaway (west-central Alberta)".*

An Exploration of Oceans, Ice, and Permafrost

- **Michelle Landry:** *"Assessment of Drilling-Waste Sumps in the Discontinuous Permafrost Zone of the Sahtú Region, NWT".*
- **Cameron Poole:** *"Preliminary insights into peatland initiation and lateral expansion in the interdunal peatlands of the Smoky River dune field, Grande Prairie, Alberta. Implications for archaeological prospection and paleoenvironmental reconstruction.".*
- **Hanaa Yousif:** *"Volcanic Aerosol and Ash Deposition in Mount Logan Ice Cores".*
- **Tahya Weiss-Gibbons:** *"The Role of River Runoff in Arctic Freshwater Inflow Across Bering Strait".*
- **Mukulika Pahari:** *"Mechanisms Behind Irminger Water Bifurcation into the Northern Labrador Sea and Baffin Bay".*

Economic and Environmental Geochemistry

- **Ahmad Brahmanta Aulia:** *"CO_2 Injection and Storage in the Suboptimal Depleted Oil Reservoir of the Hugin Formation, Volve Field, North Sea".*
- **Veronica Rosa:** *"Microbial CDR: Investigating Cyanobacteria-Mediated Alkalinity and Carbonate Precipitation on Fe- and Mg-Bearing Substrates".*
- **Jonathan Spence:** *"Strategizing the deployment of enhanced rock weathering for CO_2 removal across North America. ".*
- **Michelle Woje:** *"Investigating Critical Metal Enrichment at Pine Point".*
- **Ankita Mukherjee:** *"Leveraging partitioning coefficients of REEs in calcite and apatite to unravel the origins of IOA deposits.".*
- ***Megan Athey**: "Carbon and Nitrogen within Diamonds: Relationships and Expanded Limits".*

Planetary

- **Tatiana Mijajlovic:** *"Constraining Lunar Source Craters Through Shock Metamorphism".*

5.2. Student Posters Summary (April 9th, 4-5:30pm, ESB 1-39)

Sedimentology

- **Aram Asmar Cruz:** *"Identifying Enigmatic Microbial Mats in Devonian Organic-Rich Mudstones from the Horn River Group, Northwest Territories".*
- **Ethan Woollett:** *"Lithium enrichment in the Granite Wash of the Western Canada Sedimentary Basin".*

Tectonics and Volcanology

- **Shamsoddin Damani Gol:** *"Paleomagnetic Study of the Crowsnest Volcanics".*
- **Jaimee Hodgson:** *"Determining Eruption Frequencies of the Mono-Inyo Craters in Eastern California".*

Paleontology

- **Connor Sievwright:** *"Investigating The Lack Of Cranial Material At The Danek Bonebed: A research study".*

Remote sensing

- **Katherine Bauer:** *"Advanced Machine Learning Tools for Multispectral Data".*

Oceans

- **Ostap Krynytskyy:** *"Observational Study on Physical Dynamics of Water Currents in Baffin Bay".*

Metamorphism

- **Josh Bugnet:** *"Reevaluating the origin and extent of the Taltson magmatic zone: Evidence from the Gray Lake area of the Western Rae craton".*

Book of Abstracts
2025 ATLAS Symposium

Contents

Keynote Talks

What lies ahead for community-level homelessness planning in Alberta?

Dr. Nick Falvo
Consultant on Homelessness and Housing Insecurity

For well over a decade, Alberta has had an international reputation for 'good governance' associated with the use of funding for homelessness. Communities have used much of this funding to support Housing First, good data practices and strong triage systems. A December 2024 provincial announcement threatens to disrupt this model. Dr. Falvo's presentation will discuss both the model and the recent provincial decision.

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Global modelling of lightning and wildfires in a changing climate

Dr. Cynthia Whaley
Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada

At the Canadian Centre for Climate Modelling and Analysis (CCCma), we work on development and application of the Canadian Earth System Model (CanESM). There has recently been a lot of effort on the subject of short-lived climate forcers – atmospheric species with radiative impacts that are shorter-lived than CO_2 – but a number of important atmospheric processes were missing to properly represent SLCFs in CanESM. This talk will focus on recent model development work in the areas of lightning and wildland fires and applications related to future projections of lightning and fire in a changing climate. I will also discuss upcoming international collaboration opportunities in the area of atmospheric modelling of fires.

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Crustal ‘eduction’ and slab-failure magmatism in a post-collisional orogen: linking the disparate Tu Cho (Great Slave) and Nonacho basins (1.89−1.87 Ga), NWT

Dr. Paul F. Hoffman
University of Victoria

From the first week of my PhD thesis field work in the east arm of Tu Cho (Great Slave Lake), I knew that the paleocurrents I was measuring were going in the wrong direction. I had predicted in advance that the lower clastics (Sosan Group) had been transported southeastward from sources in Slave craton. Instead, the flow was southwestward implying that the southeastern Slave margin was already blocked off. Detrital zircon dating later confirmed this inference—Sosan Group clastics were derived mainly from the Thelon−Taltson magmatic arcs, with which Slave craton collided at ~1.97 and ~1.93 Ga respectively. For the next 57 years the question raised by the paleocurrent directions remained unanswered. Why is there no passive-margin sequence on the southeastern (Taltson) margin of Slave craton, analogous to those on the northwestern (Wopmay) and northeastern (Thelon) Slave margins, the Epworth and Kimerot groups, respectively?

A second unanswered question emerged more gradually. Why did the southeastern Slave margin become a magmatically-active flexural foredeep (Tu Cho basin), coupled with an Alpine-style thrust belt, between 1.89 and 1.87 Ga, some 40−60 Myrs *after* the Slave−Taltson collision? If a back-arc basin had existed behind the Taltson magmatic arc, no trace of it remains where it should have closed. Instead, there are mainly nonmarine extensional basins filled by coarse-grained clastics (Nonacho Group).

‘Eduction’ is the upward and outward ejection of previously subducted crust. It forms regional-scale post-collisional crustal wedges (*e.g.*, High Himalayas) bounded by thrust systems below and normal-sense detachments above. Post-collisional eduction predicts that the lithologically dissimilar Tu Cho and Nonacho basins were contemporaneous (1.89−1.87 Ga) and mechanically coupled—Tu Cho basin a thrust-related deep marine footwall foredeep and Nonacho basin an extensional hanging-wall terrestrial basin. Speculatively, eduction was triggered by Slave slab failure, which removed the passive margin and gave rise to Seton volcanism in Tu Cho basin at 1889 Ma. The transfer of mass to the educted wedge and consequent loss of crustal buoyancy may have triggered Slave lithospheric delamination, giving rise to Compton diorite laccolith emplacement along the length of Tu Cho basin at 1867 Ma, just after thrusting ceased. A good thesis project is one that never ends.

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Graduate Student Talks

Effectiveness of LIDs on urban creek flow regimes within a cold climate context: A Case study on the Whitemud Creek Watershed, Edmonton, Alberta

JM Jones[1], M Faramarzi[1], B Smerdon[1]

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Urban streams can provide essential ecological and social benefits in a community, but often have altered hydrology, degraded water quality, and loss of biodiversity because of urbanization, a collection of symptoms known as Urban Stream Syndrome (USS). Low-impact developments (LIDs) have been widely implemented to mitigate these symptoms by enhancing infiltration, evapotranspiration, and stormwater retention. However, their effectiveness in cold climates, particularly if the winter season has rain-on-snow events, and the dynamic spring melt season, remains uncertain. Additionally, climate change is leading to warmer, wetter, and shorter winters, further altering urban watershed hydrology.

This research investigates the long-term hydrological impacts of LIDs within Whitemud Creek Watershed, a cold-region urban watershed in Alberta, Canada. Using a process-based hydrological model (PCSWMM), we are: (1) assessing historical hydrological trends, (2) evaluating seasonal and interannual LID effectiveness within an urban creek watershed, and (3) exploring adaptation strategies by integrating multiple LID designs. This model can then be used to quantify the impact of climate change on LID performance. Although LIDs can effectively restore hydrology during summer, their performance diminishes during winter and spring due to freeze-thaw cycles and altered snowmelt dynamics. Long-term projections help inform whether LIDs contribute to watershed-scale restoration or primarily affect localized runoff control. The findings will enhance understanding of LID resilience under future climate conditions, providing municipalities with data-driven strategies for sustainable urban water management in cold regions.

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Geochemical and hydrogeological characterization of local buried valley aquifers to improve Edmonton's water security

J Maccagno[1], DS Alessi[1], B Smerdon[1]

[1] *Department of Earth and Atmospheric Sciences University of Alberta*

Outside of Alberta's major centres, groundwater is often the primary source of potable water, which varies in quantity and quality. For groundwater users tapping into buried valley aquifers, sufficient water is available for rural acreages and small farms, but the quality depends on the framework of bedrock formations and overlying sediments. While the geometry of these aquifers is well known, their geochemistry, flow pathways, and connection with recharge areas remain poorly understood. This study aims to characterize groundwater mixing and evolution in Edmonton's buried valley aquifers, with focus on those beneath the Carvel Pitted Delta (CPD).

Publicly available groundwater data, including the Alberta Geological Survey (AGS) groundwater quality maps and the Domestic Well Water Quality in Alberta database, were analyzed using major ion chemistry and thermodynamic calculations to assess groundwater composition. Inorganic chemical mass balance techniques quantified major ions, visualized through Piper diagrams to illustrate the composition of buried valleys below the CPD. Chemical mass balance techniques were coupled to thermodynamics calculations to form activity-activity plots, further characterizing the geochemical types of water. These analyses will be compared with ongoing mineralogical assessments of CPD surficial sediments using X-ray diffraction (XRD) to better understand the controls on groundwater chemistry and evolution in aquifers in the CPD.

In the final phase of the study, geochemical modeling will identify spatial trends and processes governing groundwater chemical evolution, while a localized steady-state groundwater model will simulate groundwater flow paths, recharge/discharge areas, and water balance. By integrating geochemical analysis and groundwater modeling, this study will improve the understanding of Edmonton's buried valley aquifers, including their role in water security.

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Characterizing the urban hydro(geo)logy of the Edmonton Area using a 3D flow simulator

E Braun[1], DS Alessi[1], B Smerdon[1]

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Well informed management of urban groundwater resources is imperative for developing sustainable water use practices and fostering climate resilience. Urban development perturbs natural surface and subsurface hydrodynamics by altering topography and stream flow, disturbing shallow groundwater flow, and altering spatio-temporal patterns for groundwater recharge and discharge by increasing impervious surfaces. In Alberta, Canada, the City of Edmonton's complete surface and groundwater system has yet to be characterized at a scale that considers the dynamic hydrological processes of urban environments and the impacts of climate change on freshwater resources.

Here, we develop a physically-based 3D hydrogeological model of Edmonton's urban water cycle with the goal of providing spatio-temporal insights into groundwater recharge and discharge and the impacts of urban development on groundwater dynamics. We focus on urban creeks, using 3D modelling, flow measurements, and geochemical data to characterize the connection of creeks with groundwater. The model is being calibrated in three steps: first to a pseudo-steady-state with long-term climate conditions, secondly under dynamic equilibrium conditions with monthly averaged forcing data, and finally under fully transient conditions. The simulations define a high-resolution representation of Edmonton's groundwater that include recharge and discharge areas and the water table. Differential gauging measurements and geochemical sampling during low-flow conditions on five urban creeks help constrain the potential influence of groundwater. The model will be applied further to analyze the impacts of climate change for the mid-future period (e.g., 2040-2070) under climate scenarios SSP126 (strong mitigation efforts and decarbonization with warming of less than 2°C at the end of the century) and SSP585 (high radiative forcing and warming of 2.4-5.7°C). We look to apply the 3D model to provide insight into the future dynamics of Edmonton's water cycle under a changing climate.

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Beyond the Basics: Designing Future-Ready Bus Stops that Prioritize Equity, Safety, and Sustainability

J. Khalid[1] , E. Grise[1] , S. Wong[1]

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Edmonton's public transit (PT) system plays a prominent role in reducing transportation-related GHG emissions. Encouraging more people to use PT is not only a structural intervention but also behavioral, as individuals, especially those with access to other modes, have to make a conscious choice to travel by PT. This choice has become increasingly complex as we emerge from the COVID-19 pandemic with a heightened focus on personal health and growing concerns about social disorder in public spaces, including PT. Adding to this complexity, more frequent extreme weather events necessitate considering their effects in the design and provision of transit infrastructure, such as bus stops. Through this project we aim to understand the experience of transit riders at bus stops in Edmonton. This engagement effort will be complemented by a review of best practices and emerging designs of bus stop amenities globally that promote enhanced safety, health of riders, and protection from natural elements. We will respond to this information by developing an enhanced bus stop design guideline that involves best practices for climate adaptation, safety, and equity to achieve the underlying goal of this research which is to improve the safety and comfort of bus stops through enhanced design guidelines.

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Understanding the impacts of Public Transit Intervention on various demographic groups: A systematic review of methodological approaches and data sources

P. Jain and E. Grisè

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Public transit is crucial for promoting sustainable urban mobility, reducing car dependence, and easing traffic congestion. Factors like network connectivity, centrality of facilities, and network alignment with activity centers contribute to successful public transport systems. However, transit systems are grappling with challenges including rising operational costs, aging infrastructure, and fluctuating ridership levels. In response, transit agencies adjust service frequency, restructure fares, and improve operations to enhance ridership, service quality, and accessibility. Despite these efforts, the impact of these interventions, especially on travel behavior and demographic equity, remains uncertain. Transit interventions impact demographic groups differently as studies show that flat fare structures are inequitable, disproportionately burdening low-income, minority, and transit-dependent riders who make shorter, frequent trips. Similarly, policies removing transfers or passes negatively affect lower-income riders, youth, and minorities. These challenges emphasize the need to assess both the effectiveness of transit interventions and their varying impacts. However, significant gaps exist in understanding the best methods and data sources for evaluating these impacts. Many studies rely on aggregate data, such as overall ridership, which fail to account for variations in how different demographic groups are affected. This systematic literature review explores methodologies and data sources that capture the impacts of transit interventions across various demographic groups. It aims to identify the most effective data sources and analytical methods while examining how factors like data granularity and methodological design influence the interpretation of results.

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Classification of lianas from tropical dry forest point clouds

A Truksa[1]

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Accurate classification and mapping of forest components are critical in the understanding of forest dynamics, biodiversity, and the ecosystem. This includes different aspects of trees, particularly lianas, with which many plots are infested. This study presents a comprehensive pipeline for processing LiDAR-based Simultaneous Localization and Mapping (SLAM) data to classify forest structures, with a specific focus on lianas, using scans from the tropical dry forest of Santa Rosa National Park in Costa Rica. The workflow begins with the registration and cleaning of raw point cloud data to ensure high-quality input for subsequent analysis. Advanced point cloud techniques and labelling are then employed to segment and isolate forest structures, including trees, branches, and lianas. A deep learning model is then trained on annotated point cloud labels to classify and differentiate lianas from other forest components. Preliminary results show the effectiveness of the approach and the possibilities of advancing the research in terms of part segmentation of trees are explored.

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A Machine learning approach for filling long gaps in Eddy Covariance time series data in a Tropical Dry Forest

M Abdaki [1,3], A Sanchez-Azofeifa [1], HF Hamann [2]

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Long-term Eddy Covariance (EC) data is crucial for understanding the impact of global change impact ecosystem functions. However, EC data often contains long gaps, particularly in tropical dry forests (TDF) due to seasonality and El Niño–Southern Oscillation (ENSO) phases. These factors create high variability, complex dependencies, and dynamic flux footprints. No current gap-filling method adequately addresses long gaps in TDFs. This study introduces a novel framework for addressing this issue by: i) defining gap sizes by their relative percentages, ii) training, tuning, and evaluating two Machine Learning (ML) models: MissForest for short gaps and Prophet for intermediate and long gaps, and iii) predicting half-hourly EC data from 2013 to 2022 for six EC variables, where actual gaps dataset ranged from 26.6% to 28.4%, at TDF in Costa Rica. Results indicate that MissForest excelled at filling short gaps (≤5%, R^2=0.76 and Nash–Sutcliffe efficiency (NSE)=0.71), while Prophet performed exceptionally well for gaps between 5% and 10% (R^2=0.72 and NSE=0.67). However, both models struggled with gaps between 10% and 13%. Validation showed R^2 values of 0.79, 0.88, and 0.77 for CO_2 flux, sensible heat flux, and latent heat flux, respectively, with corresponding NSE values of 0.78, 0.86, and 0.72, and Normalized Root Mean Squared Error (NRMSE) around 2E-4. Additionally, to validate our results, we applied our approach at three EC sites with different ecological conditions, demonstrating robust performance. This study presents a reliable ML approach for imputing long gaps in EC data, which can be applied to sites with strong variability.

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Predicting environmental DNA-derived soil biodiversity in forests with orbital hyperspectral data

PB O'Brien[1], N Kasraee [2], K Buckingham [2], A Sanchez-Azofeifa [1]

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[2] *Veritree*

Forest restoration is necessary to counteract the effects of climate change and deforestation from human activity. Increases in wildfires, expansions for agricultural expansion, and the impact of pests in the boreal forest region have contributed to unprecedented forest loss. Planting projects designed to restore these forests consider the types of tree species being planted to match native communities, but the effects of the planted trees on the surrounding ecosystem must be considered. This includes the soil microbiome, the composition of which can be measured through the use of environmental DNA (eDNA) that has been extracted from the abiotic (i.e. soil) components. EDNA analysis remains expensive and costly, requiring the use of remote sensing for scalable predictions of below-ground biodiversity. Focusing on a partially restored forest near Cochrane, Alberta, Canada, spectral images measuring hundreds of unique wavelengths in the visible and infrared regions (known as hyperspectral images) at a 30 m resolution were collected concurrently with eDNA-containing soil samples from 36 plots in August 2024. RNA from the soil samples was then amplified with 16S and ITS2 primers before being sequenced, which were then corrected, filtered, and assigned taxonomic data. Machine learning techniques, including Linear Discriminant Analysis (LDA), Partial Least Squares Regression (PLSR), Support Vector Machine (SVM), and Random Forest (RF) were then utilized to identify significant wavelengths from the hyperspectral images that predicted indicator species from the eDNA-derived biodiversity. Results from these methods, along with comparisons for prediction accuracy, will be discussed. Recommendations are also made for the consideration of future forest restoration projects.

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Environmental Droughts In Tropical Dry Forests

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Ecosystems such as tropical dry forests (TDFs) are highly vulnerable to droughts, yet research approaches to drought in these ecosystems remain geographically and methodologically inconsistent. In TDFs, where human activities are closely linked to forest resources, environmental droughts exacerbate the fragile balance between ecosystem services and biodiversity conservation. This imbalance threatens the ability of these ecosystems to cope with the impacts of drought. To better understand the complex interactions of drought in ecosystems like TDFs, the environmental drought approach offers a promising framework for analyzing drought effects. This approach is critical for predicting ecosystems' future health and resilience under changing environmental conditions. Environmental drought is defined as water deficits that exceed the vulnerability thresholds of ecosystems, adversely affecting vegetation and other natural resources.

This research aims to apply the environmental drought approach by using remote sensing and reanalysis products to assess drought conditions across TDF sites in the Neotropics. To achieve this, we first define a set of metrics and data sources based on a systematic review of environmental drought research literature. Then, by integrating climatic, ecological, and landscape metrics, we evaluate the vulnerability of TDFs to environmental drought. Our findings underscore the need for a multidisciplinary approach to drought research that incorporates the role of ecosystems. Such an approach is essential for effectively monitoring and predicting the future of forests and their resilience to the growing frequency and intensity of drought events.

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A Drying Protocol to Minimize Water Interference in the Analysis of Silica Gels by FTIR

D Gutiérrez-Rueda[1], JPL Kenney[2], DS Alessi[1], KO Konhauser[1]

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Silica precipitation and crystallization play a fundamental role in geochemical processes, influencing both modern sinter deposits and ancient cherts. A critical aspect of this process is the transformation of silica gels as they initially precipitate from seawater and undergo structural evolution with aging. Fourier-transform infrared (FTIR) spectroscopy is a powerful tool for studying these transformations, providing molecular-scale insights into silica network development and mineralization. However, FTIR analysis of silica gels is often hindered by water interference, which distorts spectral features and obscures key vibrational modes. This study investigates the impact of drying conditions on FTIR spectra, aiming to establish a reproducible nitrogen-drying protocol that minimizes water-related spectral artifacts while preserving the intrinsic silica structure. Experiments were conducted across a range of silica concentrations, with spectral changes monitored over time. Our results demonstrate that while drying effectively removes interfering water, it also accelerates polymerization, altering the silica gel structure. Consequently, prolonged drying before analysis can induce polymerization and potentially misrepresent silica gel transformations. These findings emphasize the importance of standardized synthesis and characterization protocols in FTIR spectroscopy to enhance the accuracy and reproducibility of silica gel structural analysis.

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Lithium isotopes of the Peace River Arch in the Western Canada Sedimentary Basin: A framework for resolving deep basin lithium sources

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Lithium (Li) enrichment in the formational brines of deep sedimentary basins has emerged as a crucial component of global Li inventories. However, the processes driving the formation of Li-brines remain poorly understood. This study investigates the sources and emplacement mechanisms within weathered subcropping units and overlying detrital sediments of the Peace River Arch (PRA) in the Western Canada Sedimentary Basin (WCSB). Using lithofacies analysis and Li isotope geochemistry, we analyze data from three drill cores that traverse Precambrian basement and five overlying siliciclastic and carbonate units. Lithium concentrations are strongly facies dependant, ranging from 0.4 to 167.3 ppm, while δ7Li values range from 1.5 to 23.5‰. Our results show that coarse-grained lithologies are Li-depleted and δ7Li-enriched, whereas fine-grained facies with secondary clay minerals exhibit the highest Li concentrations and δ7Li depletion. Contrary to the prevailing model of post-depositional hydrothermal emplacement, we find no evidence of hydrothermal alteration. Instead, Li enrichment is attributed to weathering of the crystalline basement and syndepositional processes during basin evolution. This study is the first to directly trace Li from source to sink in an ancient sedimentary basin. It underscores the link between the nature and distribution of basin fill sediments and the formation of Li enriched brines. As formational brines gain prominence as future Li resources, the methodology presented here establishes a framework for characterizing Li genesis, with applications for sedimentary basins worldwide.

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Spatial interactions between microbial mats and intertidal organisms, Willapa Bay, Washington, USA

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The “agronomic revolution” marks the early Cambrian transition from matgrounds to mixgrounds, where microbial mats became confined to environments inhospitable to grazing and burrowing fauna. Early Cambrian and Ordovician evolutionary radiations introduced new feeding strategies, increasing bioturbation and altering sediment mixing, nutrient cycles, organic carbon transfer, and solute transport within burrows. While early animals primarily used microbial mats for food or oxygen, this study explores additional benefits of proximity to mats (e.g., porewater micronutrients) and reevaluates the assumption that bioturbation inhibits mat development.

To investigate these interactions, data were collected from the mesotidal, mesohaline intertidal flat of Willapa Bay, Washington, USA. A transect spanning heavily burrowed to heavily matted tidal flat zones was analyzed. Porewater samples were obtained using Rhizon samplers and analyzed for pH, salinity, and composition via ICP-MS. A 3D model of the tidal flat was generated using UAV imagery processed in Agisoft Metashape. Data on burrow density, microbial mat presence, and elevation were extracted from the model.

Preliminary results indicate the highest burrow densities occur 0.75–2.2 m from mat edges. Burrows extend up to mat margins, suggesting mat cohesiveness is the primary barrier to bioturbation, with potential benefits from mat adjacency such as access to porewater micronutrients unavailable in oxygenated sediments. For instance, iron was observed in relict burrows and porewater samples beneath mats but not in bioturbated zones. These findings challenge the notion that bioturbation simply reduced microbial mat extent; instead, mats may influence bioturbation distributions at intertidal margins in more complex ways.

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Surviving the Depths: metazoan resilience in sulfidic aquaria environments

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Hydrogen sulfide (H_2S) is widely acknowledged as a potent respiratory toxin for eukaryotic cells. However, some macrofauna have been observed in environments with elevated H_2S concentrations. Here we report on a saltwater aquarium hosting a community of invertebrates and inhabited by an epibenthic microbial mat. The aquarium was left undisturbed for the duration of the COVID-19 pandemic stay-at-home order, leading to the development of high concentrations of H_2S. Remarkably, the invertebrate community did not collapse. This success offers valuable insights into how invertebrates respond to physiochemical stressors at both individual and community levels.

We also observed sustained disequilibrium between H_2S and oxygen (O_2), exhibiting out-of-phase periodic cycles driven by a simulated solar cycle. During daylight, photosynthetic O_2 production increased, prompting more active behavior from the metazoan community. Conversely, H_2S production peaked during the dark cycle, causing a moribund animal community. Additionally, over time, overall community diversity in the tank decreased, while macrofaunal abundance appeared largely unaffected. Polychaete worms and cnidarians demonstrated resilience to the high-sulfide conditions for the entire duration of the experiment, whereas others experienced gradual declines in abundance until they perished. These findings challenge conventional expectations of eukaryotic tolerance to H_2S and underscore the significance of behavioral adaptations in withstanding high-sulfide environments. Our findings provide insights into how primitive metazoans may have survived in sulfidic to euxinic Ediacaran seas.

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Understanding the early biosphere through the lens of the microfossil record

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The fossil record is the most direct evidence of past biospheres, lending the best insight into the co-evolution of life and the Earth. Despite the richest record being towards the more recent Phanerozoic Eon (538 million-years- ago - present), molecular clocks and biosignatures suggest the biosphere has been active since as early as 4.3 billion- years-ago. However, both the fossil and geological record dwindle rapidly as they enter the Precambrian (>538 million-years-ago) due to the repeated recycling and destruction of older rocks with time, making inferences and interpretations about evolutionary change in early life increasingly difficult. Nonetheless, instances in which fossils are indeed preserved in the Precambrian are crucial to our understanding of the origin and diversification of life and major clades within. The most exceptionally preserved soft- bodied, or 'Lagerstätte', specimens enable both phylogenetic (relationship to other organisms) and ecological (relationship to their environment) inferences. My PhD research comprises three approaches that encompass both geological and experimental data to answer how, when, and why complex microbial life evolved in the Precambrian through the lens of organic-walled microfossil preservation, ultimately elevating our understanding of the earliest biospheres.

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The Role of Temporal Scope in the Identification of Palaeoecological Signals

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Scientists, including ecologists and palaeoecologists, commonly assume that signals from larger datasets are more robust. However, in the field of palaeoecology there is an inherent risk as one increases the scope (spatial or temporal range) of the data, that the signals from finer-scale processes may be overwhelmed by signals associated with larger-scale events or processes. Our study examines how temporal subsampling procedures can reveal finer-scale ecological signals that were previously overwhelmed and made unidentifiable by a signal associated with a regional extinction event. We make use of a collection of over 100,000 fossil brachiopods (248 total samples) that is broad in scope both spatially and temporally (22,000km2; 36.5mya). The data were collected at an exceptional temporal resolution (especially when considering the temporal scope) and thus, facilitates testing of the effects of temporal scope on signals. A sample-taxon matrix was constructed using these data and ordinated using non-metric multidimensional scaling (NMDS). The resulting ordination plot positions samples relative to one another based on similarities in taxon content. The samples formed two discrete clouds in ordination space. The two clouds contained only brachiopod fauna of Early and Middle Devonian affinity respectively. This separation recognizes a rapid fluctuation in sea-level that resulted in the extinction of 96% of brachiopod genera in the area. In contrast, NMDS ordinations restricted to samples exclusively of Early Devonian age contained a graded environmental signal, correlating brachiopod faunas with spatial and environmental positioning along the topographic slope from onshore to offshore. The ability to detect these different signals depended the temporal scope of sampling.

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A Quantitative Ichnological Approach to Relative Deoxygenation Across the Cenomanian-Turonian Boundary Oceanic Anoxic Event 2 in the Alberta Portion of Western Interior Seaway (west-central Alberta)

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Analyzing ichnological features in organic-rich mudstones is challenging. Low sediment shear strengths hinder the formation of well-formed burrows and lead to substantial post-depositional compaction for those that do form, while poor lithologic contrast masks the presence of bioturbation. Further, lowered bottom water oxygen conditions, which promote organic enrichment, lead to diminutive and impoverished trace fossil suites.

A well-preserved organic-rich mudstone core from the Cretaceous Oceanic Anoxic Event 2 in the Western Interior Seaway offers a unique opportunity for comprehensive ichnological analysis and ichnologically-based reconstruction of relative bottom-water oxygenation. Burrow Size-Diversity Index (SDI) has been used to assess relative oxygen changes in other deposits. We note two factors that impact interpretations of SDI: high bioturbation intensities lead to underestimations of diversity; and SDI can be influenced by stresses other than lowered oxygen (e.g., fluctuating salinity, rapid sedimentation). A semi-quantitative relative oxygen equation accounts for these complexities and better proxies bottom-water oxygenation over the interval. The equation combines diversity counts, burrow sizes, and bioturbation intensity (all indicators of high oxygenation), scaled with total organic carbon measurements (TOC, an indicator of low oxygenation). Integrating ichnological data with TOC accounts for the diminution and low diversity that may stem from several physicochemical factors. The proposed equation offers a repeatable approach to integrate ichnological and TOC data, providing a better ichnological-oxygen proxy for organic-rich mudstones.

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Assessment of Drilling-Waste Sumps in the Discontinuous Permafrost Zone of the Sahtú Region, NWT

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The Sahtú region of the Northwest Territories contains 191 former well and drilling sumps, remnants of petroleum exploration and extraction activities from 1921 to 2014. These sumps, predominantly constructed in warm, thin permafrost (≥ –2°C, 5-40 m thick), now present emerging environmental challenges as permafrost conditions change. Recent field observations reveal widespread physical changes at these drilling-waste sumps, including surface ponding, thaw-related subsidence, and the migration of high-chargeability fluids from containment areas. These indicators of permafrost degradation necessitate a more complete assessment of environmental risks across the region. This study presents progress on a systematic inventory of drilling-waste sumps by integrating multiple data sources: high-resolution LiDAR surveys, remote sensing imagery, historical drilling records, and regulatory inspection reports. The inventory assesses critical parameters including permafrost conditions, surface stability, proximity to water bodies, and site accessibility. While our findings establish an initial framework for risk assessment, significant knowledge gaps remain, including detailed ground temperature data, waste composition analyses, and site-specific assessments at high-priority sites. Additional resources and coordinated efforts between regulatory agencies, industry stakeholders, and local communities are essential to implement future monitoring programs and develop remediation strategies for these legacy sites in degrading permafrost environments.

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Preliminary insights into peatland initiation and lateral expansion in the interdunal peatlands of the Smoky River dune field, Grande Prairie, Alberta. Implications for archaeological prospection and paleoenvironmental reconstruction

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Alberta's boreal forest ecoregion contains thousands of archaeological sites, which are a testament to the continuous record of human occupation since the opening up of the ice-free corridor around 13,800 years ago. A high proportion of these sites are found on stabilized late-Pleistocene aeolian dunes that formed following the mass mobilization of glaciofluvial sediments left behind as the ice sheets retreated and pro-glacial lakes drained. Many of the archaeological sites found on these dunes are difficult to date and are often poorly understood due to a range of factors, leaving us with limited information about how ancestral indigenous populations lived in these areas.

During the Holocene, peatland formation began in interdunal basins, leading to the creation of elevated sandy islands in a sea of peat. The anaerobic conditions of peat are highly conducive to the preservation of archaeological material and preserved macrofossils can provide a limiting age through C14 dating. Peat can also preserve a long record of paleoenvironmental change, which can generate important context for archaeological sites.

This project is creating a spatio-temporal model for peatland initiation and expansion at an interdunal peatland in the Smoky River dune field, with the aim of evaluating the potential for archaeological sites to be preserved within or beneath the peat. Preliminary results show sand dune stabilization occurred ~12,000 years ago, while peatland initiation occurred at approximately ~6500 years ago. Therefore, it is highly likely that archaeological sites are buried within these basins. Early stratigraphic analysis of the collected peat cores provides interesting insights into paleoenvironmental change and potential dune instability.

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Volcanic Aerosol and Ash Deposition in Mount Logan Ice Cores

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Mount Logan, in the St. Elias Mountains of southwestern Yukon, is the only non-polar site reported to have pre-Holocene ice (Fisher et al., 2008). The 186 m Prospector-Russell core (PR Col) has a basal age estimate of ~20 kyr based on the $\delta^{18}O$ record, interpreted as the Last Glacial Maximum (Fisher et al., 2008). The PR Col ice core is an important record of abrupt climate variability and has been designated an auxiliary stratotype for the 4.2 ka climate event (Walker et al. 2019). A freezer failure resulted in the loss of a significant amount of the archived PR Col samples. A new 327 m ice core was recovered in 2022 from Logan's summit plateau ~1000 m from the previous drill site. An annual chronology for the 2022 ice core, based on seasonal variability in glaciochemical species, is established back to 1911 CE (256.3 m). Although the basal age is yet to be established, initial results suggest significantly younger ages than PR Col, a conclusion supported by tephra from eruptions of Augustine 1986 at ~125 m and Katmai-Novarupta 1912 at ~256 m. Given the proven utility of tephra in the upper 256 m, tephrochronology offers a promising method for establishing independent time markers in the deeper sections, where annual layer counts are no longer possible. At the same time, tephra from the PR Col record are being re-examined to test the existing age model. Archived major and minor geochemical analyses and remaining material that survived the freezer failure are being used to determine the position of additional potential marker horizons within the original PR Col ice core. Here, we present our initial findings from this exploratory work into whether nearby ice cores can exhibit such significant differences in age.

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The Role of River Runoff in Arctic Freshwater Inflow Across Bering Strait

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With climate change, and warming Arctic temperatures, there has been a large increase in freshwater sources into the Arctic Ocean. A large part of this increase has come from river runoff and inflow from the North Pacific across the Bering Strait, which has increased the surface freshwater observed in the central Arctic Ocean. Using the NEMO framework, version 4.2 run at ¼ degree resolution, I present a new regional configuration which aims to improve inflow across the Bering Strait and as well updates the river runoff forcing. Boundary locations in regional ocean model configurations can have a large impact on model results, and will be investigated. The impact and propagation of important river waters in the Arctic, such as the Yukon river off the coast of Alaska, will also be investigated. Understanding and development of improved regional ocean models is a crucial step in understanding the processes and mechanisms which drive changes in the Arctic.

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Mechanisms Behind Irminger Water Bifurcation into the Northern Labrador Sea and Baffin Bay

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Irminger Water (IW), originating in the Irminger Current, is an important water mass supplying heat and salinity to the western sub-polar region. As the warmest (4-6°C) and most saline (34.9 PSU) water mass entering the region at intermediate depths, it plays varied roles in stratification and sea ice and glacier melt. IW brings heat to the interior of the Labrador Sea and helps maintain its weak stratification, essential for deep convection. IW also reaches the marine-terminating glaciers at Greenland through fjords. The heat from this water mass melts the glaciers at depth and destabilizes them. This study aims to discover the processes that drive the flow of IW in the western subpolar North Atlantic and specifically the bifurcation near Fylla Bank that allows this water mass to enter Baffin Bay or the northern/western parts of the Labrador Sea. This region has limited observations, so a 1/60° horizontal resolution simulation (LAB60) run with the NEMO (Nucleus for European Modelling of the Ocean) model is used to conduct the study. The method of Lagrangian particle tracking is used to estimate the pathways of IW and to find the drivers of this flow. The results from this study will better explain the variability of heat and salinity transfer to the western Labrador Sea and Baffin Bay. It will help improve the representation of boundary currents and mixing processes in ocean models. It will also allow us to understand how this warm water mass will continue to affect the tidewater glaciers of Greenland in a warming climate.

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CO_2 Injection and Storage in the Suboptimal Depleted Oil Reservoir of the Hugin Formation, Volve Field, North Sea

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This study characterizes the suitability of converting the Middle Jurassic Hugin Formation at the depleted Volve Oil Field, North Sea into a CO_2 storage site. Hugin sandstone reservoir (10 – 30 m thick) is located at a depth of 2800-3100 m below sea level in a domal structure approximately 2 km x 3 km[WU1] in size, which is segmented and bounded by numerous normal faults. The reservoir is overlaid by thick (~10 m – >500 m) shale units of the Oxfordian to Ryazanian Draupne Fm.. One of the chapters of this study analyzes the sealing capacity of faults that cut through the Hugin Fm. in the Volve domal structure that helps to assess the potential for CO_2 retention and/or migration through faults and predict the compartmentalization and reservoir pressure buildup in the fault blocks of the field structure. The primary objective is to determine whether faults segmenting and bounding the reservoir can sustain sufficient capillary entry pressures to allow CO_2 lateral migration from the injection target.

Using petrophysical analysis of the reservoir interval validated by core testing results from exploration wells 15/9-19A and 15/9-19BT, we identified prospective injection intervals with an average porosity of 23%[WU2] and permeability ranging from 100 mD to over 1000 mD with relatively low (< 20%) shale content in sandy intervals. The overlying shales of the Draupne Fm. is the seal with >85% of shale content. The sandy and shaly units, locally with coal, of the Middle Jurassic Sleipner Fm. below the Hugin Fm. have shale volume ranging between 20% and 60%. The petrophysical analysis results were integrated into the 3D geological model that was build based on structural interpretation of 3D seismic data.

We calculated the Shale Gouge Ratio (SGR) for the faults in the domal structure of the Volve field. We then utilized established global empirical relationship[WU3] to derive the across fault pressure difference (AFPD) and maximum CO_2 column height (hmax) based on the calculated SGR. For the estimation, we used a CO_2 phase density of 660 kg/m³, a geothermal gradient of 30°C/km, and maximum burial depth of the Hugin Fm. of 3400 m, based on reservoir configuration and literature studies. We found that major normal faults bounding the domal structure at Volve exhibit large vertical throw (60 to >300 m) with SGR ranging from 0.3 to 0.7. Across these faults, The[WU4] Hugin reservoir is juxtaposed with shales of the Draupne Fm., creating significant sealing potential with CO_2 hmax ranging between 125 m and 200 m. The normal faults that segment the domal structure into blocks has lower vertical throw (5-30 m) which allows self-juxtaposition of the Hugin sandstone, and has lower SGR values (<0.2) indicating these faults being likely incapable of sustaining high AFPD.

We used the fault seal analysis result in 3D reservoir modeling to analyses injected CO_2 migration and associated reservoir pressure buildup. The analysed reservoir pressure changes are incorporated in 3D coupled reservoir geomechanical modeling to predict changes in principal stresses and risk of fault slip reactivation caused by CO_2 injection. Additionally, the results of fault seal analysis were used in the estimation of CO_2 storage capacity using Monte Carlo simulations. The simulation estimate a storage capacity between 2.3 Mt (P90) and 6.9 Mt (P10), with a P50 value of 4.2 Mt.

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Microbial CDR: Investigating Cyanobacteria-Mediated Alkalinity and Carbonate Precipitation on Fe- and Mg-Bearing Substrates

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Storing CO2 as alkalinity by dissolving silicate minerals is the most efficient form of carbon storage. Cyanobacteria can enhance alkalinity generation if provided with the correct nutrients to grow. This study investigates the potential for Mg- and Fe- rich minerals found in mine tailings to encourage alkalinity generation and cyanobacterial growth, aiming to quantify how Fe- and Mg-rich minerals can impact the growth of cyanobacterial mats. Eight bench-top experiments were conducted over 24 weeks using phlogopite (a mica), forsterite (olivine) and tailings from two mines containing up to 32% tetraferriphlogopite (a Fe-rich variety of phlogopite) and 22% forsterite respectively. Each substrate was tested under biotic and abiotic conditions. The experiments measured weekly changes in pH and alkalinity. At the end, aqueous samples were analyzed for cations and anions using ICP-MS, while solid samples were analyzed for carbonate content using TOC and TIC methods. Results showed that pH increased with biotic systems, showing a greater total alkalinity compared to abiotic setups and correlating with cyanobacterial photosynthesis. Alkalinity measurements indicated that cyanobacteria enhanced CO2 sequestration. Tetraferriphlogopite-rich tailings and phlogopite supported higher microbial activity than olivine-rich materials. This could be attributed to the higher availability of Fe as a micronutrient from those mineral substrates. This study demonstrates that the potential of cyanobacteria to remove CO2 from air can be enhanced in the presence of Fe-rich minerals as a source of micronutrients. These findings could inform strategies for utilizing a greater range of mine tailings that contain common minerals, such as micas, for carbon sequestration.

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Strategizing the deployment of enhanced rock weathering for CO2 removal across North America

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Enhanced rock weathering (ERW) is a promising carbon dioxide removal (CDR) technology that involves the spreading of silicate rock powder onto farmland, trapping CO_2 while providing ancillary agricultural benefits. ERW has gained traction largely due to its low barrier to entry; however, questions remain regarding the large-scale feasibility of ERW, and whether it can be used to efficiently reach the CDR rates needed to mitigate climate change.

North America has over 200 million hectares of farmland, and an abundance of mines with that could produce ERW feedstock, meaning that ERW has widespread potential to offset CO_2 emissions. However, the geographic separation between mines and farms introduces logistical questions. For example, how to strategically match mines producing ERW feedstocks to nearby farmland, minimizing the costs and emissions of deployment. This question must be addressed, as the net CDR potential of ERW is significantly reduced, and the costs significantly increased, if feedstock distribution is done inefficiently.

We have developed life cycle assessment (LCA) and techno-economic analysis (TEA) models for the extraction, comminution, transportation, and spreading of ERW feedstock in North America. Further, we have integrated these models with GIS to calculate the emissions and costs for feedstock deployment from any mine to any farm in North America. GIS modelling was completed using a network of roads, railways and shipping routes, and net CDR costs were calculated for four feedstock types, basalt, serpentinite, kimberlite, and wollastonite skarn. Overall, we found that while the net CDR costs for ERW vary greatly, the widespread distribution of rock sources across the continent keeps the CDR costs feasible for nearly all farmlands.

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Investigating Critical Metal Enrichment at Pine Point

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Critical metals have become indispensable in the transition towards clean and sustainable energy. The Pine Point Pb-Zn district, located in the North-west territories of Canada has been described as a low temperature MVT deposit. These are known to host significant concentrations of critical metals such as gallium (Ga), germanium (Ge), and indium (In). Previous studies recognized that In is enriched in the Pine Point Pb-Zn district, but the controls on its distribution remain unclear.

In recent years, the laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) has become an indispensable tool for the investigation of trace element concentrations. In this study, we employ the use of the electron microprobe and the LA-ICP-MS to quantify the concentration of critical metals at Pine Point and to identify the potential geological controls influencing their distribution. Sphalerite at Pine Point is enriched in Fe, Cd, Mn, Pb, Ga, and Ge, most of which show smooth ICP-MS signals, indicating their presence as solid solutions in the mineral. Elements such as Cu, Co, Ag, and Tl are most likely present as mineral inclusions, and little to no traces of In was found at Pine Point. Early, colloform sphalerite is generally enriched in gallium, while germanium shows a preference for later formed, iron-rich, coarse sphalerite. We posit that Ga prefers early, colloform sphalerite, possibly due to rapid sulphide deposition associated with this texture. Correlation plots show a slight positive correlation between Ge and Fe (0.26), suggesting a coupled substitution of $4Zn^{2+} \leftrightarrow 2Fe^{2+} + Ge^{4+}$.

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Leveraging partitioning coefficients of REEs in calcite and apatite to unravel the origins of IOA deposits

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The genesis of magnetite-apatite (IOA) deposits remains debated, with models ranging from purely magmatic to hydrothermal origins. Some IOA deposits contain carbonates and apatite, the latter hosting significant REEs. Understanding REE partitioning between apatite-melt and calcite-melt is crucial to deciphering their formation. Calcite-apatite (Cc/Ap) partition coefficients (D) have proven useful in distinguishing igneous from fluid-mediated processes in carbonatites.

This study calculates Cc/Ap partition coefficients (D) for 15 IOA samples from Kiruna, Humboldt, Buena Vista, Iron Springs, and Pea Ridge. Petrographic analysis, including BSE, CL imaging, EPMA, and LA-ICP-MS, was conducted to assess growth and alteration zones, P and Ca concentrations, and trace element distribution. The partitioning trends, particularly the flat to slightly U-shaped La-Lu pattern and absolute DREECc/Ap values in some samples, support a magmatic origin for carbonate minerals. Other samples, however, indicate secondary recrystallization.

Comparisons with Nooitgedacht carbonatites (Kaapvaal Craton, South Africa) further contextualize the results, as these rocks are considered magmatic. The study refines our understanding of IOA deposits, offering insights into the magmatic versus hydrothermal debate, with implications for REE enrichment mechanisms

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Carbon and Nitrogen within Diamonds: Relationships and Expanded Limits

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Nitrogen is the main impurity within diamonds, yet the relationship between carbon isotopes and both nitrogen abundance, and nitrogen isotopes are still not well understood. Using SIMS analysis, we investigated a suite of fifty-nine samples of diamond fragments from fourteen mines worldwide to add to the global database of diamond measurements in aims to better understand these relationships. Our goal was also to test a proposed 'limit sector' from Cartigny et al. (2001) that suggested a decrease in nitrogen abundance with decreasingly negative carbon isotopes. Between the over two hundred data points from our analysis, and the four and a half thousand relevant entries in the global database, we have over three times the data points than Cartigny et al (2001) had, and are currently investigating these relationships, discovering they are more complex than initially thought. Alongside this, one of our samples has found a new low in δ13 carbon, and high in δ15 nitrogen, expanding previously known limits and leading to more analysis being undertaken. While research is still in progress, we aim to provide an explanation for various patterns emerging in the data and suggest potential sources for these extreme isotope values.

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Constraining Lunar Source Craters Through Shock Metamorphism

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Northwest Africa (NWA) 10597, NWA 4898, NWA 8632, NWA 479, and Miller Range (MIL) 05035 are unbrecciated lunar basalts that were delivered to Earth by hypervelocity impact events. A comprehensive study of shock deformation and transformation effects constrains the upper and lower boundary limits of bulk shock pressures that would have been experienced during the ejection of each sample. Crystal nucleation within and adjacent to shock melt veins constrains localized shock pressures lower than those recorded by the shock effects in the bulk rock. The presence of plagioclase and its transformation to maskelynite in NWA 8632 was also confirmed in this study. As plagioclase is present in all the samples, the whole or partial transformation of plagioclase to maskelynite constrains the upper limit of the bulk shock pressures experienced by the samples as < 30 GPa and the lower limit of the bulk shock pressures as follows: NWA 479 and MIL 05035 to ~25-27 GPa, NWA 8632 to ~26-28 GPa, NWA 10597 to ~22-25 GPa and NWA 4898 to ~24-26 GPa. All the shock pressures correspond to post shock temperatures of <250 °C. High-pressure silica polymorphs present as mottled inclusion textures within silica glass combined with low pressure olivine and pyroxene suggest the melt remained liquid after pressure release. As the high temperatures during the impact event lasted longer than the length of the shock wave pulse, the rate of shock wave decay in these meteorites may be used to constrain dwell time through Finite Element Heat Transfer (FEHT) modelling. Once the dwell time is obtained, modelling can be used to estimate the crater diameters of the original launch sites on the moon and then used to further constrain the source craters of these meteorites and their paired stones.

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Undergraduate student posters

Identifying Enigmatic Microbial Mats in Devonian Organic-Rich Mudstones from the Horn River Group, Northwest Territories

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The Horn River Group, made up of the Hare Indian Formation and overlying Canol Formation, is a Devonian lithostratigraphic unit located in the Northwest Territories. The entire group consists primarily of organic-rich mudstones deposited in an oceanic basin, with characteristic features including pyrite framboids, silt-sized quartz grains, and fine-grained sediment intraclasts. The Hare Indian Formation is more calcareous, having common calcite tentaculitid fossils and dolomitized strata.

Throughout the Horn River Group, horizontal wavy, thin, and obscure hair-like structures are observed. Their composition is organic in origin and rich in carbonaceous material. This study aims to characterize these structures and assess their likelihood as potential microbial mats using petrographic microscopy and Scanning Electron Microscope (SEM) analysis. By examining these potential microbial mat structures, we seek to gain insights into their origin and the paleoenvironmental conditions under which they formed. Endobenthic mats typically indicate low-energy, quiescent depositional environments with minimal erosion, suggesting specific sedimentary conditions during the deposition of the Horn River Group.

The main outcome of this research is a morphological characterization chart illustrating differences in morphological and textural features of likely microbial mat structures in organic-rich mudstones, which will serve as a foundation for future investigations.

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Lithium enrichment in the Granite Wash of the Western Canada Sedimentary Basin

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This study investigates lithium (Li) enrichment in the Granite Wash of the Western Canada Sedimentary Basin (WCSB), assessing its potential as an economic Li resource. Core samples from three wells were analyzed for sedimentological, stratigraphic, and geochemical characteristics to determine Li distribution and its relationship with depositional environments. Results show that Li concentrations range from 7.6 to 186.2 ppm, with the highest values occurring in massive to laminated mudstone and normally graded clayey silt, suggesting that paleosols and distal fluvial overbank environments play a significant role in Li accumulation. Sandstones also exhibit moderate Li enrichment, while dolomitic mudstone contains no significant Li, likely due to hydrodynamic sorting and low detrital input.

The distribution of Li correlates with the weathering and transport of basement-derived sediments, supporting the hypothesis that Li originates from the Precambrian crystalline basement of the Peace River Arch. Li-bearing feldspars and micas were chemically weathered, forming secondary clays that adsorbed and retained Li. This material was then transported through braided fluvial systems and concentrated in paleosols and overbank deposits. These findings support previous studies indicating that Li enrichment in the WCSB is not derived from hydrothermal processes or evaporitic sequences but is controlled by secondary mineral formation and detrital redistribution. Given the Granite Wash's large spatial extent, its potential as a Li resource warrants further consideration, particularly in facies most conducive to Li retention.

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Paleomagnetic Study of the Crowsnest Volcanics

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The Baja BC hypothesis proposes that a large portion of the North American Cordillera underwent northward displacement of 2,000 to 3,000 km between 90 and 50 million years ago. This hypothesis is based on paleomagnetic data from Cretaceous sequences, which record shallower inclinations than the expected mid-Cretaceous cratonic paleopole (Irving et al., 1985; Umhoefer, 1987) implying that they formed far south and were tectonically transported to the north relative to cratonic North America.

Irving et al. (1986) conducted a paleomagnetic study on the Crowsnest Volcanics, located on the eastern edge of the Cordillera. The goal was to establish a cratonic reference paleopole for the mid-Cretaceous. However, their study yielded shallower than expected paleomagnetic inclinations, similar to results obtained from sequences to the west.

Irving et al. (1986) concluded that the anomalously shallow inclinations were most likely due to the failure to adequately average paleosecular variation, caused by insufficient collected samples.

This study aims to collect new paleomagnetic data from the Crowsnest Volcanics using thermal and alternating field demagnetization techniques and rock magnetic analyses to determine the remanence carriers and isolate characteristic remanent magnetization. The new paleomagnetic directions will be compared to expected mid-Cretaceous reference poles to assess whether the previously reported anomalies were due to tectonic movement or an unaveraged geomagnetic field record.

The study will help define the boundary between far-traveled Cordilleran terranes and para-autochthonous cratonic North America. If a far-sided paleopole is recovered, it would suggest that the eastern boundary of Baja BC lies within the easternmost Rocky Mountain fold and thrust belt.

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Determining Eruption Frequencies of the Mono-Inyo Craters in Eastern California

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The Mono-Inyo Craters are a chain of largely rhyolitic domes running from the northwestern rim of the Long Valley Caldera to Mono Lake in eastern California. They have an eruption history that dates, at minimum, to the late Pleistocene ~42,000 years ago. They also have had numerous Holocene eruptions, documented by proximal studies of the volcanic chain and from tephra deposits recorded in lake sediment cores. Eruptions have even occurred in historic times, with Paoha Island forming ~250 years ago. Although this volcanic chain is arguably one of the most active in the USA (excluding Alaska), there are no estimates of eruption frequency, specifically for the Holocene. This has resulted in a major gap in knowledge of this volcanic chain's hazards, which could impact nearby communities (e.g., June Lake, Mammoth Lakes) and the city of Los Angeles' main water supply (Mono Lake). Here we examined tephra deposits in existing lake cores from June Lake, new cores from Parker Lake and selected proximal deposits to determine an estimate of eruption frequency for the last ~9,000 years. Tephra glass geochemistry was used to discriminate between Mono and Inyo Craters, but it cannot be used to distinguish between Mono Crater eruptions. As an alternative, we analysed Fe-Ti oxides from key samples in June Lake, Parker Lake, and several proximal deposits, as Fe-Ti oxide geochemistry has been successfully used to discriminate between Pleistocene eruptions. A combination of major, minor and trace element glass geochemistry, tephrostratigraphy and Fe-Ti oxide geochemical data were used to correlate the lake records to one another and link them to available proximal samples, resulting in the first Holocene eruption history of the Mono-Inyo Craters.

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Investigating the Lack of Cranial Material at the Danek Bonebed: A research study

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The Danek Bonebed is a monodominant Edmontosaurus bonebed located in Edmonton, Alberta. The locality also has material from Albertosaurus, ceratopsian, dromaeosaur, and Troodon material but the overwhelming majority of the material recovered from this locality is Edmontosaurus. Over 1000 specimens assigned to Edmontosaurus have been collected from the locality, but there is an interesting lack of cranial material, being represented by under 10% of the material. While the material is expected to be predominantly post cranial, the expected percentage of cranial material (based on the full skeletal inventory of Edmontosaurus) is almost double the actual amount. The purpose of this study is to determine whether this lack of cranial material is standard among North American hadrosaur bonebeds through comparison between other similar localities. The sites used for comparison are the Bleriot Ferry Bonebed (Edmontosaurus locality near Drumheller), Choteau Bonebed (Maiasaura locality in Montana), Fox Coulee Bonebed (Edmontosaurus locality near Drumheller), Liscomb Bonebed (Edmontosaurus locality in Northern Alaska), Prehistoric Park Bonebed (Edmontosaurus locality near Drumheller), Ruth Mason Bonebed (Edmontosaurus site in South Dakota), Spring Creek Bonebed (Edmontosaurus locality near Grande Prairie), Standing Rock Hadrosaur Bonebed (Edmontosaurus site in South Dakota), and Wendy's Bonebed (Gryposaurus locality in Southern Alberta). The Danek Bonebed's lack of cranial material does seem to be unusual among North American hadrosaur bonebeds, with the majority of other sites containing almost double the percentage of cranial material. This could mean that the Danek Bonebed could have some unusual preservational quality to it that is as of yet unknown.

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Advanced Machine Learning Tools for Multispectral Data

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Land classification using remote sensing (RS) is essential for environmental monitoring, urban planning, and resource management. Multispectral satellite imagery presents challenges due to its limited spectral resolution, requiring advanced machine learning (ML) techniques to extract meaningful patterns. This study investigates the application of the Kolmogorov-Arnold Network (KAN), a novel ML approach introduced in June of 2024, for multispectral land classification. Unlike traditional models, KAN employs a nonlinear learning framework that enhances its ability to recognize complex spatial and spectral patterns in RS data.

For this study, multispectral data of Edmonton, Alberta is collected by Landsat 8. The dataset consists of 2,000 data points and is split 80-20% for training and testing, ensuring model robustness. The KAN is then applied to classify each data point into one of five land types: agriculture, urban, water, vegetation, or bare land. The final output is a raster that visually represents the distribution of these classes across Edmonton.

Initial results show a training accuracy of 97.8% and a test accuracy of 96.7%, suggesting that KAN may outperform conventional classification methods in RS applications. By applying KAN to multispectral data, this study contributes to the growing intersection of ML and Earth Sciences, demonstrating its potential for improved land classification accuracy. Future work will explore optimizing KAN's architecture for RS applications using hyperspectral data, further assessing its suitability for large-scale land classification tasks.

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Observational Study on Physical Dynamics of Water Currents in Baffin Bay

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Global oceanic circulation is a major component of the hydrologic cycle, and Baffin Bay is a unique contributor to this system in many ways. Baffin Bay contains numerous currents and water masses (e.g., the West Greenland Current, Baffin Island Current), yet there remains little understanding of the physical mixing dynamics of these currents when they meet in Baffin Bay, how the water column is affected by their mixing, and the resultant currents and water masses. This study contains a quantitative analysis of oceanographic data collected in northern Baffin Bay to characterize these water masses by their physical properties and to compare the mechanics of boundary flow in Baffin Bay. This will be done by comparing Temperature – Pressure profiles and Temperature – Salinity – Density plots synthesized from CTD data collected during a cruise from September 6 to 25, 2008, that went from Lancaster Sound, up Nares Strait, then to Jones Sound and Baffin Island. These results are compared to existing oceanographic research on Baffin Bay currents' seasonality and variability, with the aim of deepening our understanding of Arctic water dynamics when it meets the West Greenland Current. Further research into Baffin Bay and Nares Strait is essential; with cruises planned further north of Baffin Bay, this analysis will set the framework for future research focused on the warming of the Arctic, and lowering of temperature gradients between the poles and tropics.

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Reevaluating the origin and extent of the Taltson magmatic zone: Evidence from the Gray Lake area of the western Rae craton

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The origin of the 2.0-1.9 Ga Taltson magmatic zone (TMZ) of the western Canadian Shield is debated. Some authors argue that the TMZ is a continental arc built on the western margin of the Rae craton, whereas others attribute TMZ magmatism to crustal thickening in an intracontinental setting. The full lateral extent of TMZ-aged magmatism in the western Rae craton is also unknown.

This poster presents petrographic, whole-rock geochemical and Sm-Nd isotope data, and zircon U-Pb data for two newly documented suites of granitic rocks from the Gray Lake area of the western Rae craton, ~130 km east of the previously recognized eastern boundary of the TMZ. The two granitoid suites, which are referred to herein as the 'Person' and 'Cliff' granitoids, differ in their petrographic and geochemical characteristics but have similar initial εNd values. The Person granitoids are weakly peraluminous, biotite monzogranites with initial εNd values of -10.2 to -11.0. Two samples of the Person granites yielded largely concordant U-Pb ages of 1935 and 1937 Ma. In contrast, the Cliff granites are dominantly metaluminous, amphibole-bearing monzogranites, granodiorites, quartz monzonites and quartz monzodiorites with initial εNd values of -8.3 to -13.1. These granites are also characterized by unusually high Mg#s and Ni and Cr contents for granitic rocks. The Cliff granites are zircon poor but separates were obtained from two samples. U-Pb analyses yielded a broad range of dates, which indicates that most zircon grains in the samples are inherited. However, some grains have apparently magmatic rims that yield dates of ~2004-1964 Ma. If these rims crystallized from the Cliff granite magma then they record the emplacement age of the pluton. Alternatively, if the rims are also inherited then their age represents a maximum estimate of the crystallization age of the pluton. These data indicate that older continental crust contributed significantly to both the Person and Cliff granitoids and also that the TMZ may be ~150 km wider than previously recognized. Implications for the tectonic setting of the TMZ are being explored.

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