The 57th Annual Graduate Student Colloquium

Photo: Arthur Lo

Hosted by the Department of Geosciences
April 10th – 11th, 2025

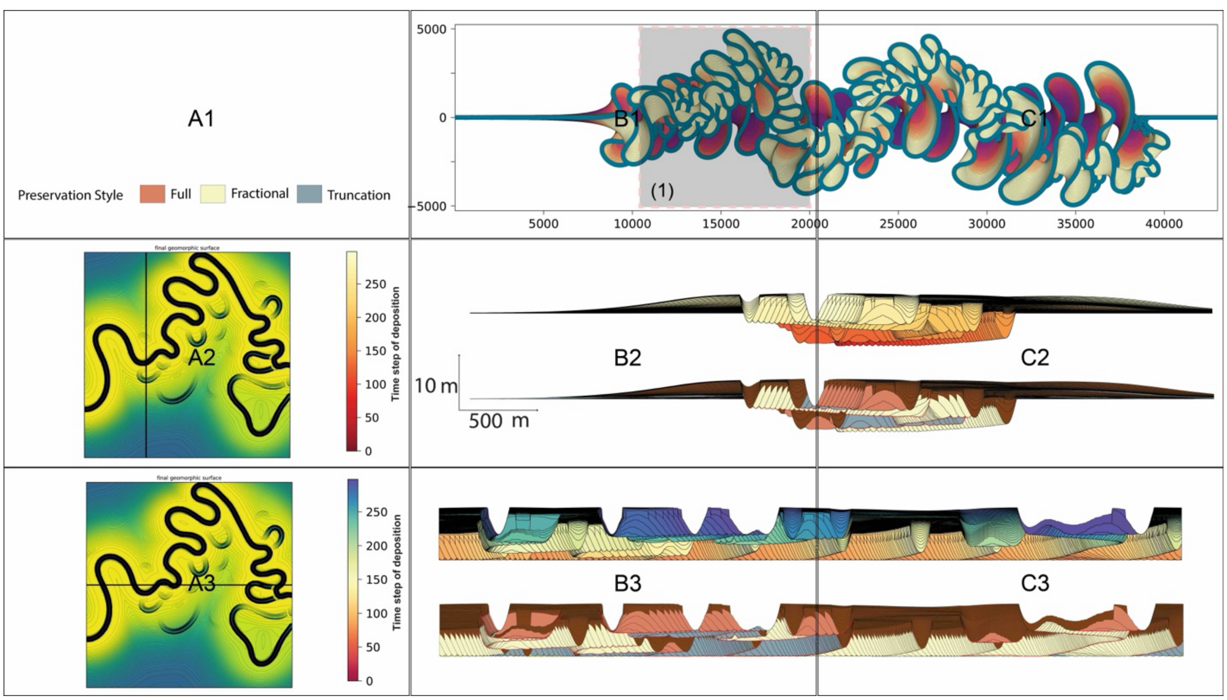
57th Annual Graduate Student Colloquium

Hosted by the Department of Geosciences.

The Graduate Student Colloquium is a forum where students present their research or research proposal to faculty, friends, and peers. It is hosted by the Department of Geosciences and is open to graduate students involved in geosciences research. The colloquium format stimulates research discussion, allows students to practice for national meetings, and helps students improve their presentation skills. It assists both the Department and Penn State in maintaining and strengthening their reputations for giving high quality talks and poster presentations at national and international meetings.

The Graduate Colloquium Committee wishes to thank the students for sharing their work and the post-docs and faculty for providing constructive feedback. The Committee thanks the Department of Geosciences for hosting this Colloquium.

Graduate Student Colloquium Committee
Emma Hartke, Ava Spangler, Rory Changleng, Miranda Sturtz, Aristle Monteiro



Data Visualization: Noshin Sharmili

Event Schedule

Thursday 10th April

Opening Remarks – 9:20 am
Oral Session 1 – 9:30 to 10:45 am
Break – 10:45 to 11:00 am
Oral Session 2 – 11:00 to 11:45 am
Lunch Break – 12:00 pm to 1:00 pm
Poster Session 1 – 1:00 to 2:45 pm
Break – 2:45 to 3:00 pm
Oral Session 3 – 3:00 to 4:45 pm

Friday 11th April

Poster Session 2 – 10:15 to 12:00 pm
Lunch Break – 12:30 pm to 1:30 pm (Graduate student pizza lunch)
Oral Session 4 – 1:45 to 2:45 pm
Break – 2:45 to 3:00 pm
Oral Session 5 – 3:00 to 3:45 pm

The Peter Deines Lectureship

The first-place award for an oral presentation by a post-comprehensive Ph.D. student is designated the Peter Deines Lectureship for the following academic year.

This award was started in 2004 to represent the tremendous amount of respect and admiration the graduate students in the Department of Geosciences had for Dr. Peter Deines, who that year was stepping down from the position of Graduate Program Chairman. Recipients of the honor are invited to give a departmental colloquium talk during the proceeding academic year.

The department and the world lost a great man and wonderful person when Peter passed away on February 2, 2009. It is with great pride that the Graduate Student Colloquium continues the tradition born in 2004.

Recipients:

2024-25: Safiya Alpheus
2023-24: Samuel Shaheen
2022-23: Shelby Bowden
2021-22: Julia Carr
2020-21: Graduate Student Colloquium Canceled due to COVID-19 pandemic
2019-20: Allison Fox
2018-19: Beth Hoagland
2017-18: Matthew Herman
2016-17: Rosie Oakes
2015-16: John Leeman
2014-15: Ashlee Dere
2013-14: Jonathon Schueth
2012-13: Elizabeth Herndon
2011-12: Bryan Kaproth
2010-11: Tim Fischer
2009-10: Aaron Diefendorf and Bryn Kimball
2008-09: Daniel Hummer
2007-08: Gavin Hayes
2006-07: Christina Lopano
2005-06: Shawn Goldman and Courtney Turich
2004-05: Margaret Benoit

The Peter Deines Lectureship

Peter Deines (4/02/36 - 2/02/09) earned a Geologen Vordiplom at the Rheinische Friedrich Wilhelms Universität, Bonn, Germany in 1959, an M.S. (1964) and a Ph.D. (1967) in Geochemistry and Mineralogy from Penn State University. Since 1967, and after 2004, as an Emeritus Professor, he was a member of the Geological Science Faculty of the Pennsylvania State University. He earned an international reputation for his geochemical research, teaching, and science administration. Recognition came in teaching awards, election to the University Senate, in which he served for 24 years, and election especially to Treasurer of the International Geochemical Society. In that office, he was so effective that he was awarded a unique Honorary Life Membership for his financial management of the society. He was a principal organizer of that Society's primary international meetings, the famous Goldschmidt Conferences.

With his gift for organization, he also served the Department of Geosciences on most of its committees. He served as its Graduate Program Chairman, while also administering committees for the College of Earth and Mineral Sciences, primarily for scholarships. Most important was his commitment to the University Academic Senate, in which he served in 28 committee posts, including its Chair for 1990-91; and to the University, on 34 committees and commissions, including University Ombudsman since 2006. He also was elected President of the Faculty-Staff Club. Dr. Deines' research centered on precise explanations of natural variations in stable isotope abundances as means of understanding geologic processes. Results were presented in lectures throughout the world and in over 60 published papers. His illustrated book, "Solved Problems in Geochemistry", was polished by his teaching of eight graduate courses and is available on the web especially for graduate students.

A 40-year member of the Nittany Valley Symphony, Peter will be missed for his finesse with violin and viola.

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A Metabolic Framework for using Lipid Biomarker Isotopologues as Environmental Proxies

9:45 am – 10:00 am
Caleb Norville
Ph.D. student, 3rd year, Pre-Comps
Assessing Post Wildfire Vegetation Recovery After a Recent Afroalpine Fire: Implications for Interpreting Fire Events from Fossil Charcoal

10:00 am – 10:15 am
Madison Hernandez
M.S. student, 2nd year
Coastal Agricultural Tipping Points of Aquifer Salinization due to Climate-Induced Compound Hazards

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Ph.D. student, 1st year, Pre-Comps
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Em White
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Insights into late Archean crustal growth from peraluminous granitoids

A Metabolic Framework for using Lipid Biomarker Isotopologues as Environmental Proxies

Juliana Drozd[1], Christopher House[1], Katherine Freeman[1]

[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

The lipid biomarker (molecular fossil) record is often used to interrogate Earth's biogeochemical past, with the chemical structures and stable isotope compositions of lipids preserved in the rock record serving as proxies for properties that tell us about the past ecology and climate of our planet. Many of these proxies rely on our knowledge of how biosynthetic lipid production changes in response to environmental stressors, like increased temperature or changes in nutrient availability. A key problem with this, however, is that metabolic regulation, which controls biological responses to environmental stressors, is difficult to directly assess with the information that we can access in the biomarker record. The commitment of metabolites through different pathways can control the abundance and carbon isotope composition of biomolecules, but this commitment can be regulated to respond to the specific organism's needs and the environmental conditions. The three main types of lipids, fatty acids, MEP-derived isoprenoids, and MVA-derived isoprenoids, have different intramolecular and molecular-average carbon isotope compositions because of their different biosynthesis pathways and the commitment of precursor metabolites down those specific pathways. The carbon isotope differences between fatty acids and isoprenoid lipids and the intramolecular isotope patterns within the lipids vary based on the commitment through three key enzymes involved in lipid biosynthesis. Changes in the commitment through these enzymes are associated with different physiological conditions, like nitrogen starvation and oxidative stress, which can be linked to changes in environmental conditions. The changes in the isotopic composition of lipids in response to changes in commitment through the key enzymes are investigated with metabolic isotopologue modeling and compared to published data to create the theoretical framework for lipid biomarker-based metabolic proxies.

Assessing Post Wildfire Vegetation Recovery After a Recent Afroalpine Fire: Implications for Interpreting Fire Events from Fossil Charcoal

Caleb Norville[1], Sarah Ivory[1,2], Jacob Miller[1], James Russell[3], Andrea Mason[3], Bob Nakileza[4]

[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

[2]*Earth and Environmental Systems Institute, The Pennsylvania State University*

[3] *Brown University Department of Earth, Environmental, and Planetary Science*

[4] *Makerere University Department of Environmental Management*

The Afroalpine zone of the Rwenzori Mountains of southwestern Uganda contains a unique mountain ecosystem receiving very high annual precipitation. These conditions result in a moisture limited wildfire regime where intense modern rainfall should preclude large fires except during periods of prolonged drought. Because it is very wet, conservation efforts had not previously focused on Afroalpine wildfire management until a large wildfire in 2012 burned the area around Afroalpine Lake Africa and its catchment. This event raised concerns about the potential role of climate change in exacerbating fire risks in places where fires were previously thought to be unlikely and highlighted the need for accurate and locally specific records of Afroalpine wildfire history and its impacts on vegetation. Previous analysis of sediment cores from Lake Africa identified intervals of heightened charcoal values during the late Pleistocene and Holocene which can be statistically interpreted as wildfire events. However, other mechanisms can artificially increase charcoal such as fluvial input of charcoal released from Afroalpine glaciers, or extralocal inputs deriving from the nearby and more fire prone Ericaceous vegetation. Here we use high resolution charcoal and pollen sampling of the 2012 fire interval from a short gravity core to calibrate local records of fires and post-fire recovery of vegetation. Preliminary results indicate extremely high charcoal values near the top of the short core allowing us to pinpoint the 2012 event and determine that this was an unprecedentedly severe event for the area over the last 10kyrs. As the region appears to have no history of fire before 2012, managing future fires and fire risk is even more critical as ecosystem recovery is likely very long.

Coastal Agricultural Tipping Points of Aquifer Salinization due to Climate-Induced Compound Hazards

Madison Hernandez[1], Antonia Hadjimichael[1] , Rachel Housego[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Saltwater intrusion into freshwater aquifers is a growing issue for coastlines around the world. Compound effects of climate change and human use of natural resources leave these crucial freshwater same resources at risk. Once freshwater resources surpass a salinity threshold, they are rendered no longer available for irrigative use, and it is unclear how future climate and hydrologic conditions will affect this system. This study aims to identify how changes in mean temperature, mean precipitation, standard deviation in temperature, standard deviation in precipitation, and sea level rise influence aquifer salinization at the 16 irrigation wells closest to the Delaware Bay in Dover, Delaware, USA. These uncertain factors translate into SEAWAT model inputs of sea level, groundwater recharge, and groundwater pumping at each irrigation well. The 500 simulations generated each run for a 75-year time period in which saltwater moves through the system and wells vulnerable to salinization are identified. Three of the 16 vulnerable wells are most at risk of damaging salinization, while four are at a lesser risk of salinization. The final nine of the vulnerable wells are safe from salinization by the end of the century. Using the delta moment-independent method of sensitivity analysis, it is found that temperature then precipitation has the largest influence on salinization, while that sea level rise has the smallest impact on salinization. This indicates that the groundwater extraction will be the largest contributor to aquifer and well salinization in Dover, DE.

PAH Humbug: Orbitrap-IRMS Investigation of Polycyclic Aromatic Hydrocarbons

Mila Matney[1], Kate Freeman[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of organic molecules composed of multiple aromatic rings. PAHs are found abundantly on Earth and are derived from both natural and anthropogenic processes. They are also a ubiquitous component of extraterrestrial organic matter, with aromatic compounds making up approximately 30% of all carbon in the galaxy. Given the pervasive presence of these compounds, both on Earth and in space, it is of great scientific interest to develop techniques to chemically understand the origin and formation pathways of these compounds.

Orbitrap-IRMS is an emerging technique for high-mass-resolution analysis of intramolecular stable isotope data, able to provide accurate, position-specific data for very small quantities of sample. These features make Orbitrap-IRMS a tool well-suited to the analysis of isotope ratios within low-concentration terrestrial and extraterrestrial PAH samples. However, due to the repetitive structures of PAHs and the possibility of rearrangement during ionization, measuring position-specific data for these types of structures is very difficult. Previous work has shown the utility of clumped-isotope measurements in PAHs, but further work is needed to develop this method and extend it to additional forms and alkylated PAHs. Through this work, we may acquire new stable carbon isotope data that can inform us as to the provenance, synthesis pathways, and chemical histories of PAHs. With this knowledge we can build a more solid understanding of the evolution of extraterrestrial organic matter and better extrapolate ancient events in Earth history.

Insights into late Archean crustal growth from peraluminous granitoids

Emily L. White[1], D. Graham Pearson[2], Yan Lao[2], Richard A. Stern[2], William J. Davis[3], Jesse R. Reimink[1]

[1] *Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2] *Department of Earth & Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada*
[3] *Geological Survey of Canada, Natural Resources Canada, Ottawa, ON, Canada*

The differentiation of Earth's lithosphere is unique compared to other observed terrestrial planets, as it features a thick felsic continental crust dominated by granitoids. However, the growth and evolution of Earth's earliest continents is still widely debated. Understanding if continental crust was either formed rapidly or gradually is reliant on the geochemical record of the earliest preserved crust. This record can provide insight into the timing and composition of Earth's earliest magmatic systems. As large-scale stabilization of continental crust occurred in the late Archean (~3.0-2.5 Ga), the isotopic signatures of this crust can infer on the extent of early crustal recycling. The Slave Province within the Canadian Shield features a near-constant record of episodic crustal growth, making it an ideal testing ground for models of this continent growth through time.

This study focuses on isotopic analyses of zircon-bearing peraluminous granitoids from the Neoarchean to investigate the evolution of Earth's earliest crust. Zircon is a durable and insoluble mineral which records the magmatic evolution of its host rock, used in determining age (from U-Pb) and source (from Hf-O). These granitoids exhibit a range of εHf of +6.2 to +0.7 and suggest a sedimentary source at time of formation indicated by their >1 Alumina-Silica Index (ASI) and elevated $\delta^{18}O$ values. We present whole-rock major elements (via X-ray Fluorescence (XRF)) and zircon U-Pb-Hf-O (via Laser Ablation Split-Stream (LASS) and Secondary Ion Mass Spectrometry (SIMS)) from eleven late Archean peraluminous granitoids from across the Slave Province. Our results offer key insight into the geochemical history of the early Earth and its distinct lithospheric development, and can further assess the nature of continent growth during the Archean.

Thursday 10th April

<u>Oral Session 2</u>
11:00 am – 12:00 pm

11:00 am – 11:15 am
Oliver Nielson
Ph.D. student, 2nd year, Pre-Comps
A novel machine-learning method to isolate volcanic signatures from sedimentary Hg records

11:15 am – 11:30 am
L. Alejandro Giraldo
Ph.D. student, 2nd year, Pre-Comps
Mummified fossils from the Eocene of Australia: quantifying humidity in a drying continent

11:30 am – 11:45 am
Chandan Sahu
Ph.D. student, 1st year, Pre-Comps
Do rocky exoplanets have different mantle properties and thermal evolution from Earth?

11:45 am – 12:00 pm
Ava Spangler
Ph.D. student, 2nd year, Pre-Comps
Community-Informed Adaptation Pathways for Urban Flood Resilience in Baltimore

A novel machine-learning method to isolate volcanic signatures from sedimentary Hg records

Oliver Nielson[1], Isabel Fendley[1]
[1]Department of Geosciences and Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, USA

A key driver of Earth system perturbations is the emplacement of large igneous provinces (LIPs) and their associated volatile emissions. To diagnose how the Earth system reacts to volatile degassing, it is necessary to quantify degassing at the same (or higher) temporal resolution as environmental indicators. A common approach is to use mercury (Hg) concentration in sediments to indicate volcanic degassing because degassing is a dominant source of Hg to the environment. However, recent work has shown that various other environmental and post-depositional factors influence Hg concentration, blurring the volcanic signature.

We present a new machine learning-based approach for isolating volcanic signatures in stratigraphic Hg records. Our model uses a random-forest classification with 20 trees and no depth constraint. The model aims to predict Hg concentration, given information about the depositional environment, via geochemical data, including total organic carbon, redox-sensitive trace metals and detrital elements. The training is tailored to predict Hg variation throughout a subset of a record with no expected degassing to accurately characterise Hg behaviour in an unperturbed system. The model is then applied to the total record to quantify any unpredictable (volcanic) Hg variation.

We used our model on data from a core of Early Jurassic age from the Cheshire Basin, UK, which has a high temporal resolution (ca. 5 ka) and spans the Hettangian to Pliensbachian (ca. 13 Ma). The dataset contains 1418 unique samples. We trained the model on 98% of the dataset, excluding 2% as outliers. We evaluated our model's effectiveness at isolating regional/global increases in available Hg via three independent means: 1. Compared high-resolution coeval records from multiple localities 2. Assessed similarity with previous methods of isolating volcanic signals in Hg. 3. Utilised Hg thermal desorption profiles to assess how Hg host variation affects the model's prediction. Our results indicate a large cluster of volcanic degassing events during the Sinemurian-Pleinsbachian Boundary Event. This is a globally recognised, but less understood, carbon isotope excursion.

Mummified fossils from the Eocene of Australia: quantifying humidity in a drying continent

L. Alejandro Giraldo[1], Peter Wilf[1], Raymond J. Carpenter[2], Robert M. Kooyman[3,4,5], Vera Korasidis[6]

[1]*Department of Geosciences and Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, USA*
[2]*School of Biological Sciences, University of Adelaide, Adelaide, SA, Australia*
[3]*Department of Biological Sciences, Macquarie University, Sydney, NSW, Australia*
[4]*Research Centre for Ecosystem Resilience, Royal Botanic Gardens, Sydney, NSW, Australia*
[5]*Missouri Botanical Garden, St. Louis, MO, USA*
[6]*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, VIC, Australia*

The middle Eocene (ca. 43–40 Ma) Anglesea fossil site in southeastern Australia represents one of the best examples of the continent's once widespread rainforests. The rainforest affinity of the flora is supported by the presence of exquisitely preserved leaf fossil material, including five species of yellowwoods (Podocarpaceae), one of sheoaks (Casuarinaceae), and one of *Megahertzia* (Proteaceae), along with several undescribed taxa pertaining to typical rainforest families such as Lauraceae, Monimiaceae, and Atherospermataceae. Although these taxa indicate a humid environment, this interpretation relies on the physiological constraints of their extant relatives, and a more precise, quantitative assessment of past humidity levels at Anglesea remains elusive. Here, we employ morphological measurements of stomatal complexes (maximum stomatal pore area, pore depth) and quantify stomatal density from multiple Anglesea plant species to estimate maximum leaf water conductance (Gw_{Max}). This approach enables us to quantitatively constrain the humidity of the Eocene ecosystem, offering a more refined assessment of the paleoenvironmental conditions at Anglesea that is not dependent on the identification of the plant material.

Do rocky exoplanets have different mantle properties and thermal evolution from Earth?

Chandan Sahu[1], Bradford Foley[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Understanding exoplanet interiors remains a challenge in the planetary science community due to the inherent difficulty of direct observation. While atmospheres of these planets are being observed using advanced telescopes like HST and JWST, interior modeling provides information about their interior structure, composition, and evolution relevant for interpreting atmospheric observations. Specifically, processes within a planet's deep interior, such as heat transport and magnetic field generation, as well as surface processes like outgassing, volcanism and tectonics can all shape atmosphere evolution and can be informed by interior models. Current models often assume an Earth-like interior mineral composition, however rocky exoplanets could come in a range of different compositions. Studies from the Hypatia catalog and other similar compilations of stellar compositions show that stars can have a wide range of elemental abundances, leading to diverse mineral compositions in terrestrial planets, as they reflect the refractory materials present in the host star.

Our research investigates how variations in interior composition affect the mantle solidus and, consequently, the planet's thermal history. The solidus, marking the onset of melting, is crucial for determining cooling rates and melt production. On Earth, olivine and pyroxene are the primary minerals in the upper mantle. Variability in elemental abundances in stars suggests planets may have diverse olivine-pyroxene ratios. We use two geochemical models: MELTS and Perple_X, to calculate the phase diagrams and mantle solidus determine how different mineralogies affect the mantle's solidus profile. We then integrate the calculated solidi with the mantle adiabat and heat sources/sinks to simulate interactions between mantle composition, temperature, viscosity, and lid growth over geological timescales. This helps us understand heat transport, melt production, volatile outgassing, volcanism, and other dynamic processes during a rocky planet's evolution, aiding to understand geological history of exoplanets and identifying planets that may support life over long periods.

Community-Informed Robust Adaptation Pathways for Urban Pluvial Flood Resilience in Baltimore

Ava Spangler[1,2], Antonia Hadjimichael[1,2]

[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2]*Institute of Earth and Environmental Sciences, The Pennsylvania State University, University Park, PA, USA*

Urban pluvial flood risk poses a growing threat to the city of Baltimore, driven by changes in climate and rainfall, increased impervious area, aging infrastructure, and severe social inequity. Adaptations to urban flooding should strengthen community-scale resilience while navigating the uncertainties associated with future actions. However, the highly uncertain future climate and conflicting stakeholder objectives complicate the selection of effective and socially acceptable strategies. This study addresses these challenges through a community-informed Multi Objective Robust Decision Making (MORDM) process, coupled with Dynamic Adaptation Policy Pathways (DAPP). Community stakeholders are engaged on a large scale through community partnerships, including priority identification sessions, focus groups, and metric identification workshops. The combination of community partnership, MORDM, and DAPP will create an original set of adaptation pathways which are aligned with community goals and values and furthermore are adjustable under changing future constraints and conditions. This framework will enhance the city's capacity to respond to evolving pluvial flood conditions while accounting for diverse stakeholder interests and will provide guidance for addressing both the immediate and long-term challenges of urban flooding in Baltimore.

Thursday 10th April

Poster session 1
1 pm – 2:45 pm

Fran Meyer
Ph.D. student, 3rd year, Pre-Comps
Primary host phases of uranium in marine phosphorites: understanding marine uranium cycle sinks

Eric Hasegawa
Ph.D. student, 4th year, Pre-Comps
Constraints on meteoritic organic alteration from organic oxygen isotope geochemistry

Guilherme Zakarewicz
M.Sc. student, 1st year, Pre-Comps
Application of Distributed Acoustic Sensing for Surface Wave Analysis in Arctic Permafrost

Gabriel Rocha dos Santos
Ph.D. student, 4th year, Pre-Comps
Monitoring Landfast Sea Ice Dynamics Using DAS and Conventional Sensors in Utqiaġvik, AK

Joseph Miller
M.S. student, 2nd year
Magnitude Estimation of Low-yield Mining Blasts using Distributed Acoustic Sensing

Wan Ki (Arthur) Lo
Ph.D. student, 1st year, Pre-Comps
Long-term Ground Deformation Analysis on Big Island, Hawaii, with Sentinel-1 InSAR Time-series

Cole Stern
Ph.D. student, 2nd year, Pre-Comps
Initial Experimental Results of the Effect of pH on Carbonate Associated Phosphate

Primary host phases of uranium in marine phosphorites: understanding marine uranium cycle sinks

Fran Meyer[1], Dr. Anthony Chappaz[2], Dr. Madeline Marshall[3], Dr. Leanne Hancock[4], Dr. Kimberly Lau[1]

[1]*Pennsylvania State University, Department of Geosciences*
[2]*Central Michigan University, Department of Earth and Atmospheric Sciences*
[3]*Albion College, Department of Earth and Environment*
[4] *Michigan Department of Environment, Great Lakes, and Energy*

Uranium (U) speciation controls its reactivity and mobility in natural systems and is strongly modulated by redox conditions. Uranium enrichment and isotopic composition have emerged as a promising proxy to reconstruct Earth's oxygenation. However, interpretation of U concentrations and isotope ratios is based on poorly constrained assumptions of U burial pathways. To investigate the primary host phases of U in marine sediment, we characterized U host phase association in phosphorites from two geologic time intervals using X-ray Fluorescence (XRF). The Phosphoria Rock Complex (PRC) was deposited in a shallow, epicontinental sea during the Permian Period. The Monterey Formation (MF) formed in the borderland basins of California during the Miocene Epoch. By using the relative elemental counts from XRF analyses, we identified spatial relationships between U and other detectable elements. Further, we estimated semi-quantitative proportions of U associated with key potential U-bearing phases - sulfides, Fe-oxides, apatite/carbonate, organic matter (OM) - by determining elemental proxies for each phase. We determined that most U is associated with phosphate and OM in PRC samples, while samples from the MF show U associated with sulfides, phosphate, and OM. None of the XRF maps from PRC or MF have crystalline uraninite present. These results demonstrate the importance of OM for U sequestration and the variability of U sinks in reducing marine basins. Future use of U as a proxy for redox conditions should consider the variability of host-phases within samples, as well as if the primary phases of U formed syn- or post-deposition.

Constraints on meteoritic organic alteration from organic oxygen isotope geochemistry

Eric Hasegawa[1], Benjamin Tutolo[2], Katherine Freeman[1], Max Lloyd[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2]*Department of Geoscience, University of Calgary, Calgary, Alberta, Canada*

Oxygen isotope geochemistry of meteoritic insoluble organic matter (IOM) can provide answers to questions surrounding the alteration history of IOM. Just like macromolecular organics on Earth, IOM has different oxygen functional groups with different isotopic exchangeabilities. Labile functional groups in IOM, such as carboxyl groups, exchange their oxygen with water under neutral pH and temperature conditions as low as 15 ºC. Thus, they are susceptible to exchange in both terrestrial and extraterrestrial settings. On the other hand, ether bonds in IOM cannot exchange their oxygen without breaking bonds and provide no information on alteration fluid oxygen chemistry. Therefore, to determine a record of alteration fluids' isotopic compositions, it is necessary to identify a functional group that is neither extremely reactive nor nonreactive.

In this study, we used phenol and labeled water (~6300 ‰ VSMOW) to better understand oxygen exchange kinetics of phenolic groups in IOM. We observed oxygen exchange over the course of hours to days at high temperatures (200 ºC) and low pH (-0.61), and no measurable exchange at high pH (~14) even at high temperatures (180 ºC). These results suggest negligible exchange in terrestrial conditions and limited exchange in extraterrestrial conditions. We also showed that phenolic oxygen exchange is directly dependent on activity of H^+, with no catalysis in alkaline solutions. On meteoritic parent bodies, melting of HCl-enriched ices would have first created low pH conditions that would alter the isotopic composition of phenolic groups. Subsequent evolution of parent body water-rock ratios would have increased pH and stabilized the isotopic composition of the phenolic groups, thus preventing further change. Therefore, phenolic groups may hold an oxygen isotopic signal of meteoritic parent body ices, which can help us determine the origins of these ices.

Application of Distributed Acoustic Sensing for Surface Wave Analysis in Arctic Permafrost

Guilherme Zakarewicz[1], Gabriel dos Santos[1], Nolan Roth[1], Tieyuan Zhu[1]
[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

Permafrost, a subsurface condition that covers large areas of the planet, is highly sensitive to temperature variations. As global temperatures rise, Arctic regions experience severe consequences, including soil subsidence and carbon release, threatening both populations and ecosystems. Permafrost is often located in remote regions with extreme weather conditions, making direct observations challenging. Geophysical methods, particularly surface-wave techniques, provide valuable subsurface characterizations of permafrost by estimating the seismic waves velocity. Distributed acoustic sensing (DAS) has emerged as a cost-effective alternative with high spatial and temporal resolution, showing potential for detecting freeze-thaw cycles and monitoring permafrost degradation. However, its application in permafrost studies remains unexplored in the literature.

This study presents preliminary results from an active-source survey conducted in August 2024 at Utqiaġvik, Alaska. Using the multichannel analysis of surface waves (MASW), we derived 1D shear-wave velocity (Vs) profiles along a DAS cable. We compare our results with a previous MASW study using geophones at similar locations to address key questions: How does DAS-based MASW compare in terms of frequency content, accuracy, and spatial resolution? Does DAS introduce additional noise or require additional processing steps? Can DAS serve as a viable alternative to geophones for seismic monitoring in remote Arctic environments?

Preliminary findings suggest that DAS has a lower frequency content, allowing Vs estimations down to 50 meters, whereas geophones provide results only to 14 meters. Therefore, our next steps aim to assess the sensitivity of the method for detecting freeze-thaw cycles and identify long-term permafrost degradation. This framework represents a non-invasive alternative for monitoring remote regions and it provides more information about the mechanical behavior of cryotic environments. Hence, it has broader implications to infrastructure resilience, environmental management, and policymaking. Understanding the feasibility of DAS in Arctic environments could expand its use in cryoseismology and climate change studies.

Monitoring Landfast Sea Ice Dynamics Using DAS and Conventional Sensors in Utqiaġvik, AK

Gabriel Rocha dos Santos[1], Tieyuan Zhu[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

The stability of landfast sea ice is crucial for Arctic coastal ecosystems, supporting subsistence activities, transportation, and infrastructure. However, as climate change accelerates sea ice thinning and retreat, monitoring ice interactions becomes increasingly important for assessing its stability. While previous studies have used remote sensing to track sea ice motion, seismic approaches remain underexplored. In this study, we investigate the relationship between sea ice motion and seismic energy, providing new insights into ice collision dynamics. We analyzed two major ice interaction events in Utqiaġvik, Alaska, using marine radar, a broadband seismometer, and Distributed Acoustic Sensing (DAS). Ice velocity was derived from radar imagery and compared with seismic noise to assess the response of each instrument. Our results reveal a strong correlation between decreasing ice velocity and increasing seismic power, supporting the hypothesis that ice compression and ridging generate seismic signals. Harmonic tremors, associated with repeated stick-slip motion, emerge within stable ice conditions, while broadband tremors coincide with ice collision and locking phases. These findings highlight the potential for integrating seismic and remote sensing techniques to improve Arctic ice monitoring. Our study demonstrates that seismic monitoring can enhance our ability to assess landfast ice stability, offering valuable insights for both scientific research and Arctic communities that rely on predictable ice conditions.

Magnitude Estimation of Low-yield Mining Blasts using Distributed Acoustic Sensing (DAS)

Joseph Miller[1], Tieyuan Zhu[1]
Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

Distributed Acoustic Sensing (DAS) offers an innovative approach to seismic monitoring by utilizing pre-existing fiber optic cables for detecting and characterizing seismic events. This study utilize DAS for two main objectives: estimating magnitudes of mine blasts and the potential contribution of DAS directivity to calculating magnitudes. We manually pick 407 out of 683 reported mine blasts recorded over the 2.5-year monitoring period during the Fiber Optic foR Environmental SEnsEing (FORESEE) project. Blast yields range from 2,540 lbs to 57,790 lbs and emplacement depths from < 10 ft (3 m) to 2,255 ft (687 m). We first investigate how DAS recordings are influenced by factors such as fiber orientation, wave propagation direction, geologic regime, and blast parameters including emplacement depth and yield. We then calculate the magnitudes of mining blasts using a data-driven transferable scaling relationship. Previous work has validated the relation between peak strain-rate and M_L for events $2 < M_L < 6$; however, its performance calculating magnitudes $< M_L$ 2 remains unexplored. Here, we show that the scaling relation is effective at low-magnitudes and correlates with the Pennsylvania Seismic Network (PASEIS) catalog within $\pm M_L$ 0.5. Furthermore, we demonstrate a correlation between DAS-derived magnitudes and magnitudes determined from blast yield, also within $\pm\mathbf{M}0.5$. Finally, highlight how directivity, possibly represented through site-specific model parameters, provide deeper insight into DAS response from cable construction. This work contributes to the advancement of seismic monitoring by demonstrating the unique potential of DAS in urban settings, particularly for small-scale events and provides insights into optimizing its use for future geophysical applications.

Long-term Ground Deformation Analysis on Big Island, Hawaii, with Sentinel-1 InSAR Time-series

Wan Ki (Arthur) Lo[1], Christelle Wauthier[1,2]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2]*Institute for Computational and Data Sciences, The Pennsylvania State University, University Park, PA, USA*

Volcanoes may experience flank slip both in response to magmatism, and during periods of quiescence. Flank instabilities can lead to debris flows, catastrophic collapse, and tsunami generation. Understanding flank instabilities on Big Island, Hawaii is further complicated by the presence of neighbouring volcanoes, as studies suggest elastic interactions and stress-transfer occur between Mauna Loa and Kilauea. To examine long-term flank slip rates and patterns for Kilauea and Mauna Loa volcanoes on Big Island, Hawaii, we processed Sentinel-1 InSAR scenes from 2014-2023 to generate InSAR time series for the island. The time series was separated into two periods: November 2014 – April 2018, and September 2018 – December 2023, to avoid decorrelation due to the 2018 eruption and summit collapse at Kilauea. While additional processing is necessary to correct for atmospheric noise over Mauna Loa, deformation measurements for Kilauea were benchmarked with GPS data; we found that our InSAR time series broadly aligned with deformation trends seen in the GPS time series. Deformation data from the InSAR time series are being incorporated into numerical models for further examination of flank slip mechanisms.

Initial Experimental Results of the Effect of pH on Carbonate Associated Phosphate

Cole J Stern[1], Ellen Olsen[1], Miquela Ingalls[1]
[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

Phosphorus is a life-critical element and the limiting nutrient on global primary production on geologic timescales. Tracking aqueous phosphate levels through geologic time is crucial for understanding the evolution and development of life. Proxies such as Fe/P ratios in banded iron formations and authigenic phosphorites provide snapshots into the ancient phosphorus cycle during periods in which these enigmatic facies formed. Carbonate-associated phosphate (CAP) has emerged as a promising proxy for aqueous phosphate concentrations and can be applied to any carbonate-bearing geologic formation in Earth history and modern environments. CAP is based on the observation that the phosphate concentration of a precipitating solution ([P]) is the primary control on the amount of phosphate incorporated in carbonate minerals that form from that fluid. However, CAP also varies with mineralogy (calcite, aragonite, vaterite, etc.) and precipitating solution composition. Dodd et al. (2020) identified pH to have a strong influence on CAP but was limited in its analysis of that impact, including the effect of variable [P]. Experimentally quantifying the correlation between solution pH and CAP is critical for future application of this proxy in environments and periods of Earth history with non-neutral pH (e.g. alkaline lakes on Earth and Mars, Precambrian seawater, etc.).

We precipitated calcite from synthetic seawater solutions with consistent salinity, only varying pH (7.6 to 9.6) in an airtight, temperature-controlled apparatus with an automated pH-stat titration maintaining pH throughout precipitation. CAP values of the calcite precipitates were measured by a colorimetric assay and spectrophotometry (Ingalls et al., 2020, 2022).

Thursday 10th April

Oral session 3
3 pm – 4:00 pm

3:00 pm – 3:15 am
Jasmine Walker
Ph.D. student, 3rd year, Pre-Comps
The Role of Fine Sediment in Channel Mobility, Stratigraphic Architecture, and Subsurface Fluid Flow

3:15 pm – 3:30 pm
Young Kim
Ph.D. student, 4th year, Pre-Comps
InSAR Time-Series Reveal Over Ten Meters of Slip on a Detachment Fault Prior to the Catastrophic 2018 Collapse at Anak Krakatau, Indonesia

3:30 – 3:45 pm
Rory Changleng
Ph.D. student, 3rd year, Pre-Comps
Beyond Acasta: Newly Identified Palaeo-Eoarchaean Terranes in the Slave Craton

3:45 am – 4:00 pm
Edward Spagnuolo
Ph.D. student, 3rd year, Pre-Comps
Giant Seeds of a Living Australian Legume Lineage Discovered in Eocene Borneo (South Kalimantan, Indonesia)

The Role of Fine Sediment in Channel Mobility, Stratigraphic Architecture, and Subsurface Fluid Flow

Jasmine Walker[1], Liz Hajek[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Understanding how fluvial systems respond to change and record the history of those changes into the landscapes around us is essential for a variety of goals ranging from sustainably managing ecosystems, remediating environmental contaminants, efficiently exploring for natural resources, and successfully mitigating global changes in climate from atmospheric carbon. In my research, I combine remotely sensed data, numerical models, and subsurface data to characterize, quantify, and infer the process-based impact of the supply of fine sediment on river mobility, delta dynamics, and subsurface character. By exploring the implications of fundamental sedimentological drivers through multiple spatial and temporal scales of observation, I will provide insight into how fine sediment ultimately builds stratigraphy and what implications this has for meeting the resource-needs of modern society.

The transport of fine sediment is a key control on fluvial processes in the modern and the stratigraphic architecture created by these processes over time because fine sediment has the potential to be transported, deposited, and potentially remobilized from source to sink. The supply, transport, and deposition of fine sediment are key process-based controls on the deposits left by ancient fluvial systems. Understanding the transport of fine sediment is, therefore, key for predicting the distribution and connectivity of subsurface reservoirs, aquifers, and potential carbon storage sites. This work seeks to understand how the supply of fine sediment impacts fluvio-deltaic processes and the implications for subsurface connectivity. To fill this knowledge gap, I will investigate the following key questions:

1. Does channel mobility change in response to variable supply of fine sediment?
2. How does variation in the supply of fine sediment impact deltaic processes?
3. What impact does increasing the supply of fine sediment have on stratigraphy, and what implications are there in subsurface fluid flow?

InSAR Time-Series Reveal Over Ten Meters of Slip on a Detachment Fault Prior to the Catastrophic 2018 Collapse at Anak Krakatau, Indonesia

Young Cheol Kim[1], Christelle Wauthier[1,2], Thomas R. Walter[3]
[1]*Department of Geosciences, Pennsylvania State University, University Park, PA 16802 USA*
[2]*Institute for Computational and Data Sciences, Pennsylvania State University, University Park, PA 16802 USA*
[3]*GFZ German Research Centre for Geosciences, Helmholtz Centre Potsdam, Telegrafenberg, 14473, Potsdam, Germany*

Flank instability on volcanic islands can culminate in catastrophic collapses and trigger disastrous tsunamis. For example, Anak Krakatau in Indonesia experienced a flank collapse on December 22, 2018, which triggered a tsunami resulting in hundreds of casualties in the surrounding coastal areas. To investigate the pre-collapse surface displacements at Anak Krakatau, we analyzed over a decade of Interferometric Synthetic Aperture Radar (InSAR) time series spanning from 2006 to 2018. We used SAR data from ALOS-1 PALSAR (2006-2011), COSMO-SkyMED (2012-2018), and Sentinel-1 (2014-2018), which revealed line-of-sight (LOS) displacements of the southwestern flank preceding the 2018 collapse throughout the entire period. The LOS velocities ranged from about -80 to -250 mm/yr.
We inverted the COSMO-SkyMED dataset, which has the highest spatial and temporal resolutions, from April 2012 to December 2018, and assuming the detachment fault plane was affected by normal slip on a rectangular plane within an elastic homogeneous half-space. This analysis indicates a rectangular dislocation with dimensions of 1.69 km in width, 0.64 km in length, and 12 m of cumulative slip at a depth of 0.61 km (the reference surface is 67 m above sea level, which is the mean elevation of our data points), corresponding to an average slip rate of 1.8 m/yr. Second. we fixed the fault geometry and found the optimal slip for shorter time periods where the displacement rate changes in a least-squares sense. This approach revealed slip rates ranging from approximately 1.2 to 3.1 m/yr. Applying a similar method to ALOS-1 and Sentinel-1 data, we obtained slip estimates of 3.7 m (with a rate of about 0.88 m/yr) and 4.5 m (with a rate of about 1.1 m/yr), respectively. In total, we discovered approximately 15 m of slip before the collapse from our long-term (2006 – 2018) InSAR time series and geodetic modeling.

Beyond Acasta: Newly Identified Palaeo-Eoarchaean Terranes in the Slave Craton

Rory Changleng[1], Joshua Garber[1,2], Erik Schoonover[1], Andrew Smye[1], Graham Pearson[3], Jesse Reimink[1]

[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2]*School of Earth and Environmental Sciences, University of St Andrews, St Andrews, UK*
[3]*Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada*

Rocks preserved from the very early Earth provide the only archives that record the processes governing planetary formation and evolution. Palaeo–Eoarchaean (3.2–4.0 Ga) terranes offer unique windows into the geological mechanisms that built the first continents, mediated geosphere–hydrosphere interactions, and paved the way for life's emergence. However, the rarity of preserved terranes limits our understanding of these processes.

The Slave Craton (Northern Canada) represents a key repository of Palaeo–Eoarchaean crust. Whilst the Acasta Gneiss Complex (up to 4.02 Ga) has been investigated extensively, neighbouring basement gneiss terranes remain relatively understudied. The Eokuk Uplift and Kangguyak Gneiss Complex represent two such examples. Geological Survey of Canada expeditions mapped these terranes in the 1990s and provided maximum U–Pb zircon age constraints of 3.25 Ga at Eokuk and 3.37 Ga in the southern Kangguyak Gneiss Complex. Renewed interest in Eokuk followed the recent discovery of a gneiss sample with a zircon crystallization age of ~3.8 Ga—the sixth oldest such age globally—firmly establishing Eokuk as containing evolved ancient crust. However, the relationship between these ancient rocks and the Acasta Gneiss Complex, exposed >300 km south-southwest of Eokuk, remains ambiguous.

This study presents new U–Pb zircon geochronology for both terranes, providing age constraints on 16 components from Eokuk and 23 components from Kangguyak. The analysed samples represent diverse compositions from granitic, gabbroic and tonalitic orthogneisses to immature quartzites and metaconglomerate paragneisses. Preliminary results confirm the presence of ~3.7–3.8 Ga Eoarchaean crust in Eokuk and extend the age range of the northern Kangguyak Gneiss Complex to at least 3.4 Ga. These findings indicate that Palaeo–Eoarchaean crustal components are more widespread in the Slave Craton than previously recognised. The Eokuk and Kangguyak terranes thus provide rare and valuable new samples for evaluating early Earth continental formation processes.

Giant Seeds of a Living Australian Legume Lineage Discovered in Eocene Borneo (South Kalimantan, Indonesia)

Edward J. Spagnuolo[1], Peter Wilf[1], John-Paul Zonneveld[2], David Shaw[3], Aswan[4], Yan Rizal[4], Yahdi Zaim[4,5], Jonathan I. Bloch[6], and Russell L. Ciochon[7]

[1]*Department of Geosciences and Earth and Environmental Systems Institute, Pennsylvania State University, University Park, PA, 16802, USA.*

·*Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, T2L 2A7, Canada.*

[3]*Biostratigraphic Associates (UK) Ltd., Stoke-on-Trent, ST6 8NE, UK.*

[4]*Paleontology & Quaternary Geology Research Group, Department of Geology, Institut Teknologi Bandung, Bandung 40132, Indonesia.*

[5]*Department of Geology, Institut Teknologi Sumatera (ITERA), Lampung 35365, Indonesia.*

[6]*Florida Museum of Natural History, University of Florida, Gainesville, FL, 32611, USA.*

[7]*Department of Anthropology and Museum of Natural History, University of Iowa, Iowa City, IA 52242, USA.*

The Neogene collision of the Australian tectonic plate (Sahul) with Southeast Asia (Sunda) restructured the vegetation of both regions. The rarity of plant macrofossils from Sunda has limited the understanding of pre-collision vegetation and plants that migrated from Sunda to Sahul. Despite the importance of legumes in the living flora, no reproductive or pre-Neogene fossils of the Fabaceae are known from the Malay Archipelago. We collected 47 plant macrofossils from the Tambak Member of the Tanjung Formation (middle-late Eocene) while surveying the Wahana Baratama coal mine near Satui, South Kalimantan, Indonesian Borneo. These fossils represent Southeast Asian forests before the Sahul-Sunda collision. We studied three isolated large (up to 72 mm in length) seeds from the upper Tambak Member, along with 43 fossil leaves and two palynological samples from the lower Tambak Member. We describe the extinct legume *Jantungspermum gunnellii*. The *J. gunnellii* seeds are flattened on one side, bilobed, and heart shaped with a long hilum (~60 mm) overlain on the suture, closely resembling *Castanospermum*, the Australian black bean tree. The leaves represent seven morphotypes, which include Fabaceae but are otherwise unidentifiable. The palynoflora includes diverse ferns and palms, Typhaceae, Onagraceae, and forest taxa, including Podocarpaceae, Sapindaceae, and Fabaceae, indicating a largely freshwater coastal swamp environment in the lower Tambak Member. The *Jantungspermum* seeds are double the length of *Castanospermum* seeds, representing a closely related but extinct papilionoid taxon. The discovery suggests a Sundan pre-collision history, a much later Sunda-Sahul migration, and an eventual Asian extinction for the *Castanospermum* lineage, which today inhabits coastal rainforests of northern Australasia. The seeds represent the only known fossil relative of *Castanospermum*, the oldest legume fossils from Malesia, and one of the largest fossil angiosperm seeds. The new seeds, leaves, and palynomorphs provide a window into Eocene Malesian vegetation and rare macrofossil evidence of Sundan history for a living Australasian lineage.

Friday 11th April

<u>Poster session 2</u>
10:15 am – 12 pm

Jackson Stafner
Ph.D. student, 3rd year, Post-Comps
Time-Lapse P-wave Velocity and Attenuation Models of a Shallow Hydrofracturing and Injection Experiment at the FE Warren AF Base

Bailey Hoplight
Ph.D. student, 1st year, Pre-Comps
Oxygen Isotopes in Ginkgo biloba in elevated CO_2

Christian Lundy
Ph.D. student, 1st year, Pre-Comps
Stabilization of Wastewater-Derived Phosphorus in a Florida Keys, USA Karstic Aquifer

Renan Beckman
Ph.D. student, 1st year, Pre-Comps
Investigating Copper Porphyry Formation Using Continuous and Discrete Depth Profiling of Zircon

Lillian Miller
Ph.D. student, 1st year, Pre-Comps
Investigating Flank Instability Using InSAR Time Series and Geophysical Analyses at Pacaya Volcano in Guatemala

Poster session 2 *(continued)*
10:15 am – 12 pm

Amina Abdulsalam
Ph.D. student, 1st year, Pre-Comps
Impact of agricultural activities and the role of groundwater discharge on the nutrient flux to Lake Erie

Ethan Heidtman
Ph.D. student, 1st year, Pre-Comps
Using multi objective reinforcement learning to inform reservoir operations for saltwater intrusion management

Liz Tofte
M.S. student, 1st year
Observing and Quantifying Seasonal Sea Ice Melt and Sediment Plume Development at Arctic River Mouths

Noshin Sharmili
Ph.D. student, 3rd year, Pre-Comps
Interpreting Meandering Channel Migration From Ancient Deposits

Time-Lapse P-wave Velocity and Attenuation Models of a Shallow Hydrofracturing and Injection Experiment at the FE Warren AF Base

Jackson Saftner[1], Jonathan Ajo-Franklin[2], Tieyuan Zhu[1]
[1]*Pennsylvania State University,*
[2]*Rice University*

Remote characterization of subsurface fractures is a long-standing challenge in geophysics, and our ability to monitor the evolution of such fractures plays a critical role in ensuring the efficacy of many geotechnical endeavors. For these purposes, it is essential to accurately determine both the spatial extent of the fracture network and its hydraulic properties. Fortunately, recent laboratory studies have demonstrated that active source seismic monitoring can link fracture aperture and fluid content to the seismic velocity and attenuation response of fractures.

However, active source studies have historically been limited at the field-scale due to poor quality of monitoring datasets, with surveys typically conducted months or years apart. The development of the Multi-Level Continuous Active Source Seismic Monitoring System (ML-CASSM) overcomes these limitations by enabling high spatio-temporal resolution imaging of evolving fracture properties through permanently installed sensors that collect highly repeatable seismic data with temporal resolutions on the order of minutes.

In this study, we examine the time-lapse velocity and attenuation response captured by an ML-CASSM dataset collected during a shallow fracturing and injection experiment conducted at FE Warren Air Force Base (FEW), Wyoming. Here, an induced fracture was initiated at 11.6 m depth, and afterwards a remediation amendment was injected into the induced fracture network. We employ a time-lapse visco-acoustic Full Waveform Inversion (FWI) workflow to resolve P-wave velocity (Vp) and attenuation (1/Qp) structure with greater accuracy and resolution than traditional tomographic approaches. Throughout the experiment, we observe reductions in Vp and Qp, consistent with mechanical opening of the fracture and changes in fluid content.

Our results show that the active source monitoring approach can provide spatially continuous observations with fine temporal resolution of fracture propagation and fluid migration in complex media, overcoming the limitations of small-scale laboratory studies and delivering field-scale insights into real-world fracture behavior.

Oxygen Isotopes in *Ginkgo biloba* in elevated CO_2

Bailey Hoplight[1], Max Lloyd[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Plants transpire water at different rates depending on environmental conditions that cause the opening and closing of stomatal pores. In climates with elevated [CO_2] stomatal pores close to reduce transpiration, leading to a depletion of leaf water $\delta_{18}O$. Both leaf water and xylem water taken in from the roots contribute to the isotopic composition of plant materials. To better understand the effect of stomatal conductance on $\delta_{18}O$ in plant materials, I will examine oxygen and hydrogen isotopes in bulk wood from trees grown in elevated [CO_2]. *Ginkgo biloba* saplings and seedlings were grown under elevated [CO_2] levels (from 425 to 1000 ppm) in open-top chambers for 4 growing seasons as part of the Fossil Atmospheres project run by the Smithsonian Natural History Museum. Prior to the experiment, the ginkgo saplings had grown under regular atmospheric conditions. Since the water used in this experiment is from the same source, it allows for the comparison of oxygen isotopes between different trees. Specifically, I will analyze $\delta_{18}O$ of bulk wood in tree rings from the years before and after being placed in the chamber. I hypothesize that as [CO_2] increases the difference in $\delta_{18}O$ depletion will increase, because of stomatal pore closing. This study will expand the understanding of how plants adapt to higher levels of [CO_2] and have implications for plant suitability for surviving future climates.

Stabilization of Wastewater-Derived Phosphorus in a Florida Keys, USA Karstic Aquifer

Christian Lundy[1], Rachel Housego[1]
[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

Injection into saline aquifers is a popular method of disposal for treated wastewater in coastal areas. The injected freshwater buoys to near-surface due to density differences and often rises only several kilometers from the injection site. Phosphorus contained within the wastewater poses a threat to water quality and ecological health, as phosphorus is a limiting nutrient in marine ecosystems and can lead to eutrophication. Aqueous phosphorus can become stabilized after reaction with calcium to precipitate as the mineral hydroxyapatite (Ca5(PO4)3). Residence time controls whether the precipitation occurs before reaching the surface. Wastewater flow through primary (rock pore space) or secondary (karst conduits) permeable zones strongly controls the residence time and therefore the stabilization of a phosphorus plume.

This study investigates the flow of wastewater injections through a karstic saline aquifer (the Key Largo Limestone) in Marathon in the Florida Keys, USA. Rock cores from both primary and secondary flowpath locations up to 27 meters in depth will be analyzed for hydroxyapatite using X-ray absorption spectroscopy at the Stanford Synchrotron Radiation Lightsource (SSRL). Secondary karst conduits will be identified using aerial drone thermal imagery. A correlation between depth and hydroxyapatite concentration will be established to compare to geochemical modeling data showing decreased mineralization at higher salinity. Comparison between locations of primary and secondary flowpaths shows that phosphorus stabilization is higher at locations of primary flow, as a longer residence time allows for higher levels of hydroxyapatite precipitation. This study shows the importance of close monitoring of wastewater injection into karstic aquifers.

Investigating Copper Porphyry Formation Using Continuous and Discrete Depth Profiling of Zircon

Renan Beckman[1], Jesse Reimink[1]
[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

Copper is critical for the future of green renewable energy. The continued development of renewables globally will likely increase demand on the copper metal supply. Thus, major investment has been put towards exploration and understanding of copper deposits around the world. Many large mining companies take advantage of porphyry copper deposits (PCD). These are magmatic systems that produce high grade copper ore during the hydrothermal processes associated with the magma body. Within these magma bodies zircon will form. Zircon is an igneous mineral which exhibits characteristic oscillatory zoning which are similar to tree rings. As zircon forms it will trap trace elements in its crystal structure which records the thermochemical evolution of the zircon's surrounding magmatic environment in these zones.
The trace elements within the zircon crystal lattice can be measured using depth profiling, from rim to core, using a laser ablation system coupled with ICP-MS. Zircon depth profiling as a technique is not new but there is still much to be learned and optimized. Traditional techniques use continuous depth profiling, which ablates continuously through the entire depth profile. Continuous depth profiling has been proven to be extremely informative regarding the evolution of magma chemistry, with particularly important information gleaned from the outer zircon growth zones, which contain the low-temperature growth histories. However, there is still room for improved strategies to obtain more precise, and therefore more useful, thermochemical information from zircon growth zones. I will present a novel depth profiling technique, discrete laser ablation, and compare it to continuous depth profiling results.. Discrete depth profiling ablates in sections, allowing us to split the depth profile into discrete packets of ions. By doing this we will be able to gain better spatial resolution of zircon geochemistry which will be applied to refine petrogenetic model for copper porphyry formation.

Investigating Flank Instability Using InSAR Time Series and Geophysical Analyses at Pacaya Volcano in Guatemala

Lillian Miller[1], Dr. Christelle Wauthier[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Pacaya, an active basaltic stratovolcano on the Central American Volcanic Arc, experienced flank creep from 2014 – 2021. To assess ongoing instability, ascending and descending InSAR time series of Pacaya were produced from January 2022 through November 2024 using Sentinel-1 C-band SAR imagery. Using the Stanford Method for Persistent Scatterers (StaMPS) Multitemporal InSAR (MTI), interferogram pairs were created using daisy chain pairs with a temporal difference of 3 days and were processed using GAMMA software. Ascending and descending mean velocity plots at Pacaya were generated and three areas of significant subsidence on the northern slope, northern summit, and southwestern summit were identified. Time series plots were created by averaging the pixel values within a 100 m radius of three reference points within each area of deformation at Pacaya. From these calculations, clear and significant Line-Of-Sight range increases (LOS subsidence) are visible of about 170 and 250 mm at the north slope, 100 and 300 mm at the north summit, and 300 and 370 mm at the southwest summit for ascending and descending, respectively. This deformation is likely due to lava compaction from lava flows at the north slope, north summit, and southwest summit throughout 2021. The deformation pattern follows an exponential decrease in the LOS subsidence, an indicative feature of lava flow compaction, for the ascending time series for the north and southwest slopes and the descending time series for the southwest slope. Due to the strength of the lava compaction signals, further research is required to determine if a flank motion signal is present at Pacaya. If flank motion is identified, future work also includes conducting flank instability geophysical analyses by calculating the volume, coefficient of friction, runout distance, and post-failure velocities for each kinematic element discovered at Pacaya.

Impact of agricultural activities and the role of groundwater discharge on the nutrient flux to Lake Erie

Amina Abdulsalam[1], Rachel Housego[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Nutrient pollution in freshwater systems is a major contributor to environmental degradation, leading to harmful algal blooms and hypoxia, endangering water quality and ecosystem health. While previous studies on Lake Erie have focused on surface runoff as a nutrient source, the role of groundwater discharge, particularly through bluff faces along the Pennsylvania coastline, has been underexplored. This research aims to assess the transport of agricultural nutrients, particularly nitrogen and phosphorus, from these bluffs into Lake Erie via groundwater discharges. At the study site, six wells reaching depths of 35 feet with screens at 5 feet were installed to monitor nutrient flux aligned with hypothesized groundwater flow toward the lake. Conductivity-depth-temperature sensors installed in the wells capture real-time conditions at 15-minute intervals, calculating discharge rates by converting pressure and conductivity into hydraulic heads and estimating flux based on head gradients and regional geology. Additionally, piezometers are positioned adjacent to the wells at 15-ft depths and horizontally into the bluff face to collect groundwater samples for nutrient analysis across all seasons and during various stages of fertilizer application. This field approach will be complemented by data from the on-site meteorological station, land use records, and geological information to contextualize findings regionally. HydroGeoSphere modeling will be used to simulate groundwater-surface water interactions, enhancing understanding of nutrient transport pathways and seasonal variability in nutrient loading. Anticipated findings include new insights into groundwater's contribution to nutrient pathways and bluff erosion, influenced by the area's permeable soils and rapid groundwater flows. Additionally, this research will explore the influence of local and non-local factors on groundwater nutrient concentrations and seasonal variations driven by hydrologic processes. This study initiates the first focused groundwater monitoring effort in the Pennsylvania watershed of Lake Erie, providing critical data to support existing theories on groundwater's role in coastal hazards and nutrient loading.

Using multi-objective reinforcement learning to inform reservoir operations for saltwater intrusion management.

Ethan Heidtman[1], Antonia Hadjimichael[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA,*

Reservoirs are vital infrastructure for the management of water resources, and reservoir operators must often balance multiple competing needs, including hydropower generation, water supplies, and environmental flows. The Conowingo Reservoir, the focus of this study, is contained by a large hydroelectric dam on the Lower Susquehanna River, and faces water demands from Baltimore, Maryland, local recreation, and environmental flows, among others. In recent years, saltwater intrusion from the brackish Chesapeake Bay during low freshwater-flow events has become an emerging public water supply concern for communities dependent on the Conowingo Reservoir's releases. In this study, we first develop an updated environmental flow requirement with sub-daily temporal resolution that captures tidal salinity cycles and maintains downstream flows capable of diluting salinity at safe levels. Second, this updated flow requirement will be implemented as an objective in an evolutionary multi-objective direct policy search (EMODPS) framework that combines simulation-based optimization with reinforcement learning to identify optimal reservoir operating policies. We utilize this framework to discover adaptive operation policies that mitigate saltwater intrusion events, while still meeting existing objectives, under increasingly variable hydroclimatic conditions and rising sea levels. With this approach, we demonstrate how applying these adaptive and multi-objective policies on reservoir operations can mitigate emerging water quality concerns in coastal systems and improve their resilience to increasing climate stressors.

Observing and Quantifying Seasonal Sea Ice Melt and Sediment Plume Development at Arctic River Mouths

Liz Tofte[1], Anastasia Piliouras[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

The Arctic's seasonal coastal processes, such as sea ice melt and sediment plume formation, play a critical role in regulating coastal productivity. Despite their importance, these processes are under-observed, even as the Arctic experiences rapid environmental change in response to a warming climate. Arctic rivers transport freshwater, heat, sediment, and nutrients to the coastal ocean, directly interacting with sea ice during the melt season and forming dynamic sediment plumes during the open-water season. By observing these coastal processes at Arctic river mouths, we aim to better understand the seasonality of river fluxes and how they respond to climatic changes over time. This study examines seasonal sea ice melt and sediment plume development at six major Arctic river mouths—the Yukon (AK), Colville (AK), Mackenzie (CA), Yenisei (RUS), Kolyma (RUS), and Lena (RUS)—from 2003 to 2023. Using Moderate Resolution Imaging Spectroradiometer (MODIS) data and GIS analysis, we aim to (1) characterize seasonal coastal ice melt and sediment plume patterns, (2) assess temporal changes over two decades, and (3) compare behaviors across different river systems. We analyze sea ice using NSIDC sea ice data products, and analyze river sediment plumes using the Normalized Difference Turbidity Index (NDTI). Preliminary analyses find that annual variability is high within systems and that spatial patterns of ice melt may be influenced by deltaic sub-ice platforms. Subsequent analyses will further improve our understanding of how river discharge influences sea ice melt as well as sediment transport in response to climate change at the pan-Arctic scale.

Interpreting Meandering Channel Migration From Ancient Deposits

Noshin Sharmili[1], Liz Hajek[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Sedimentary deposits serve as nature's historical record, highlighting how rivers responded to past climatic and environmental shifts. Natural events like flooding and riverbank erosion present challenges, exacerbated by ever-changing climate and land-use patterns. To improve the subsurface prediction, which is crucial for aquifer management, hydrocarbon reservoir connectivity. The present research endeavor is to employ remote sensing data gathered from current rivers and a simple kinematic modelling technique to examine the synergistic effects of channel movements in forming channel-belt deposits that exhibit distinct migration characteristics. We extracted the channel network from Landsat imagery and documented channel lateral mobility rates in a range for single-threaded river systems. Multiple centerline-based variables have been computed according to the method of Schwenk et al. (2017), which were tested against migration rate to see the existence of any quasilinear or other statistical relationship. We also performed simple kinematic numerical models of meandering, followed by Sylvester et al. (2019) and tested synthetic cross-sections for different migrations rates with multiple iterations. The initial results suggest that higher migrating systems have higher aspect ratio compared to the lower migrating systems. Besides, higher migrating systems have more truncated, less persistent, and less preserved bars whereas lower migrating systems have more preserved and persistent bars. We also inferred that a higher migrating system creates more complex sedimentary architecture than a lower migrating system. In the future, we will compare patterns of synthetic channel-body architecture to channel-belt architecture from Cretaceous and Paleogene fluvial deposits exposed in the Western United States. The present study will contribute to reconstructing paleo-morphodynamics and anticipate subsurface heterogeneity in ancient fluvial deposits.

Friday 11th April

<u>Oral session 4</u>
1:45 pm – 2:30 pm

1:45 pm – 2:00 pm
Alexander Thames
Ph.D. student, 5th year, Post-Comps
Assessing Compound Climate Impacts on Agricultural Water Requirements in the Upper Colorado River Basin

2:00 pm to 2:15 pm
Youki Sato
Ph.D. student, 5th year, Post-Comps
Unraveling the Synthesis Mechanisms Behind the Isotopically Enriched Acetic Acid Present in Kidd Creek Mine, Ontario Canada

2:15 pm – 2:30 pm
Nolan Roth
Ph.D. student, 5th year, Post-Comps
Thunderquakes image subsurface structure

2:30 pm – 2:45 pm
Karen Pham
Ph.D. student, 5th year, Post-Comps
Forest decline and recovery reveals legacy of human-baobab interactions

Assessing Compound Climate Impacts on Agricultural Water Requirements in the Upper Colorado River Basin

Alexander Thames[1], Antonia Hadjimichael[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

Changes to the relationship between precipitation and temperature due to climate change can exacerbate water scarcity in the US by increasing evapotranspiration and reducing runoff and soil moisture. These changes are especially significant for the agricultural sector, potentially compounding irrigation demands while decreasing supply. In the western US, the Upper Colorado River Basin within the state of Colorado is one of these affected watersheds where rising temperatures, earlier snowmelt, and decreased streamflow have exacerbated water management challenges. To combat an increasingly uncertain future, watershed managers have traditionally relied on "top-down" planning scenarios that employ general circulation model ensembles to project how these changes might evolve with time and affect agricultural water requirements. However, top-down scenarios typically do not provide insights into the system's internal variability, nor do they capture the range of plausible, yet deeply uncertain, changes in the regional hydroclimate. We therefore propose a "bottom-up" approach to evaluate how these changes in precipitation and temperature might affect the basin. We present a stochastic weather generator for use in exploratory modeling by combining a multivariate normal distribution for precipitation with a hydroclimatic copula linking precipitation and temperature. Informed by downscaled CMIP6 projections for the region, this stochastic weather generator allows us to explore a wide range of precipitation and temperature changes. We then quantify the hydroclimatic impacts, both in magnitude and variability, of these changes on irrigation water requirements across different users, crops, irrigation methods, and elevations. The results of this analysis allow us to quantify how the compound effects of climate change impact hydroclimatic agricultural stressors, which can inform future water conservation planning in the region.

Unraveling the Synthesis Mechanisms Behind the Isotopically Enriched Acetic Acid Present in Kidd Creek Mine, Ontario Canada

Youki J. Sato[1], Min Song[2], Barbara Sherwood-Lollar[2], Christopher H. House[1], Katherine H. Freeman[1]

[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA

[2]Department of Earth Sciences, University of Toronto, Toronto, ON, Canada

Fracture water samples collected from Kidd Creek Mine (KCM) in Timmins, Ontario, Canada in a recent study by Sherwood-Lollar et al. (2021) draw from Canadian Shield rocks that have been estimated to be up to 2.7 billion years old (Thurston et al., 2008). Abnormally high concentrations of both acetate (1.2 – 1.9 mM) and formate (0.48 – 1 mM) were measured in KCM fracture waters, both of which were unusually enriched in ^{13}C. Sulfur isotope studies in the same system have demonstrated that the high dissolved H_2 and sulfate concentrations in the fracture waters were generated from radiolytic activity (Li et al., 2016). Additionally, acetate produced by acetogenic microorganisms or consumed by methanogens or sulfate reducing bacteria cannot fully explain the highly enriched $\delta^{13}C$ values (~ -7‰) of acetate detected in these fracture waters. These results taken together suggest that radiolytic synthesis processes may be important for cycling carbon in this deep subsurface environment.

Given this evidence, we will measure the intramolecular carbon isotope pattern of acetic acid collected from KCM fracture waters using the gas chromatography Orbitrap mass spectrometer (GC Orbitrap MS) available at Penn State to test a hypothesis regarding the reactions and different pools of carbon responsible for the enriched $\delta^{13}C$ values observed in this system. **If the carboxyl group on acetate is more ^{13}C - enriched relative to the methyl carbon $\delta^{13}C$, then the methyl carbon is likely derived from formate synthesized via radiolysis reactions (measured to be -15‰) that has undergone further reduction with aqueous H_2. The source of carboxyl carbon is then likely to be from dissolved inorganic carbon (~0‰) in solution.** The method I developed for measuring the intramolecular $\delta^{13}C$ values of acetate on the GC Orbitrap MS will be able to differentiate between such isotopic differences. Studying the abiotic chemistry present in early Earth analogues such as Kidd Creek Mine will be potentially useful for interpreting geochemical signatures that may be observed on Mars and other extraterrestrial environments (i.e., differentiating between biotic vs. abiotically synthesized acetate based on the available carbon pools).

Thunderquakes Image Subsurface Structure

Nolan Roth[1], Rafal Czarny[2], Young Cheol Kim[1], Tieyuan Zhu[1]
[1]Department of Geosciences, The Pennsylvania State University, University Park, PA, USA
[2] Institute of Mine Seismology, Kingston, Tasmania, & 7050, Australia.

Passive-source seismic tomography is often limited in low-seismicity regions, such as the karst terrains of the Central and Eastern U.S. where subsurface hazards threaten infrastructure, water management, and public safety. While geosphere-atmosphere interactions are typically considered over long timescales, we demonstrate that thunder-induced seismic events, “thunderquakes”', can be leveraged for dynamic subsurface imaging. Using hundreds of thunderquakes passively observed with Distributed Acoustic Sensing (DAS), we image the shallow structure of an urban karst terrain in Central Pennsylvania and verify the results with engineering logs and Interferometric Synthetic Aperture Radar (InSAR). This study establishes thunderquakes as a novel seismic source for meteorologically-driven passive imaging in source-limited regions.

Forest decline and recovery reveals legacy of human-baobab interactions

Karen V. Pham[1], M. Christelle Andriambelomanana[2], Elodie Chevallier[3], Bruno Bernard Jean Chrys[3], Felicia Fenomanana[3], Michaël Ramananjanahary[4], Roi Razafy Magnefa[3], George Manahira[3], Dylan S. Davis[5,6], Kristina G. Douglass[3,5,6], Sarah J. Ivory[1,7]

[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*

[2]*Mention Bassins sédimentaires Evolution Conservation, Université d'Antananarivo, Antananarivo, Madagascar*

[3]*The Morombe Archaeological Project, Morombe, Madagascar*

[4]*Mention Biologie et Ecologie Végétales, Université d'Antananarivo, Antananarivo, Madagascar*

[5]*Columbia Climate School, Columbia University, New York, NY, USA*

[6]*Division of Biology and Paleoenvironment, Lamont-Doherty Earth Observatory, Palisades, NY, USA*

[7]*Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, USA*

In Madagascar, the *renala* baobab (*Adansonia grandidieri*) is classified by the IUCN as "Endangered", and populations are declining. This species is ecologically and societally important, and its loss will negatively affect other species, such as fruit bats, which extract nectar from baobab flowers, and humans, who have both cultural and economic (e.g., food, medicine, and building materials) ties to baobabs. Despite their significance, the mechanisms that limit baobab survivorship are unclear. In this study, where the research questions and priorities have been crucially shaped in collaboration with local community members in Velondriake, Southwest Madagascar, we investigate past baobab survivorship and causes of decline to inform on issues that may hinder baobab forest health in the present-day.

Here, we used Accelerator Mass Spectrometry (AMS) radiocarbon dates on baobab tree cores to model the ages of individual trees across three sites in Velondriake to understand when and where baobab populations declined in the past 1000 years. We examined whether these periods of decline coincided with potential causes for ecosystem shifts, including increases in aridity and decreased human landscape mobility as a result of colonial pressures and dynastic warfare. Preliminary results suggest coinciding periods of poor baobab survivorship at three sites across Velondriake; however, some baobab populations were able to recover. These populations are located near a current forest margin and may have benefited from the activities of nearby Mikea communities, whose lifestyles have been historically centered on foraging and forest management. Our work demonstrates the potential use of radiocarbon dating to model tree growth rates in a biologically complex species and also suggests that Indigenous communities may play a key role in forest conservation.

Friday 11th April

Oral session 5

3:00 pm – 3:45 pm

3:00 pm – 3:15 pm
Sierra Melton
Ph.D. student, 5th year, Post-Comps
Growth and collapse of ice-shelf-like floating extensions at Helheim Glacier

3:15 pm – 3:30 pm
Watsawan (Fai) Chanchai
Ph.D. student, 5th year, Post-Comps
Spatial Redox Variability in Upper Ediacaran Carbonate Strata from the Zavkhan Terrane, Southwest Mongolia

3:30 pm – 3:45 pm
Kayla Irizarry
Ph.D. student, 5th year, Post-Comps
Faunal patterns are controlled by facies change through the Drumian Isotope Carbon Excursion (DICE) in SW Montana

Growth and collapse of ice-shelf-like floating extensions at Helheim Glacier

Sierra Melton[1], Richard Alley[1], Byron Parizek[1,2], Sridhar Anandakrishnan[1]
[1]*Department of Geosciences, and Earth and Environmental Systems Institute, Pennsylvania State University, University Park, PA, USA*
[2]*Mathematics and Geoscience, Pennsylvania State University, DuBois, PA, USA*

When a glacier has a floating extension (often called an ice shelf or ice tongue), this floating part provides buttressing that slows the flow of glacial ice into the ocean. However, ice shelves are susceptible to melting and weakening from both warming air temperatures and ocean water. Ice shelf collapse has been observed to speed flow of non-floating ice and to expose grounded ice cliffs that can retreat rapidly by iceberg calving, raising sea level.
Many Greenland outlet glaciers currently lack persistent floating ice shelves and instead terminate in grounded or nearly grounded ice cliffs. Southeast Greenland's Helheim Glacier sometimes forms ice-shelf-like floating extensions through the winter, which break off in the summer to reveal a tall marine ice cliff. Using both PlanetScope and Sentinel-1 satellite imagery to generate a year-round, near-daily record of Helheim's terminus change at high spatial resolution, we explore the growth and collapse of Helheim's floating extensions and examine how this transition between floating front to ice cliff corresponds with Helheim's general calving behavior. In 2023 and 2024, Helheim's floating extensions were more extensive than previously observed, breaking off later in the year and forming huge tabular icebergs. Tabular icebergs, which indicate a floating glacial front, continued to calve throughout both years. This calving behavior was distinctly different from that observed previously at Helheim before 2023. We are examining how this transition may be related to changes in the ice mélange, air temperature, tides, and glacier velocity. The growth and collapse of ice-shelf-like floating extensions offers a unique opportunity to study these processes and Helheim Glacier's response in high resolution, which will help us understand how ice shelves break apart and attempt to regrow.

Spatial Redox Variability in Upper Ediacaran Carbonate Strata from the Zavkhan Terrane, Southwest Mongolia

Watsawan Chanchai[1], Mary Lonsdale[2], Emmy Smith[2], Kimberly Lau[1]
[1]*Department of Geosciences, The Pennsylvania State University, University Park, PA, USA*
[2]*Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD, USA*

The role of marine oxygenation in driving biotic changes during the terminal Ediacaran is widely debated. Constraining the redox conditions of shallow marine settings can improve our understanding of the circumstances under which early animals evolved. Redox conditions from a single basin are used to infer broader redox states, though local processes may strongly control geochemical records. Despite uncertainties about local influences, few studies have examined basin-scale redox variability during this critical interval. The Zavkhan terrane, southwest Mongolia, is an ideal site to study lateral redox variations because of its thick, well-exposed carbonate strata with continuous lateral facies changes. Carbonates from the upper Ediacaran Zuun-Arts Formation, collected at three studied sites, were deposited from proximal to distal locality relative to the shoreline. In this study, we used the cerium anomaly (Ce/Ce*) to investigate local redox conditions in the Zuun-Arts Formation. Our goal is to better understand the spatial heterogeneity of marine oxygenation in this basin and provide insights into interpreting the Ce anomaly proxy. We compared differences in Ce/Ce* values and other geochemical indicators between studied sections to determine if these records track regional or site-specific influences. We observed generally increasing Ce/Ce* values over time, indicating a transition to locally anoxic seawater in the Zavkhan basin. However, the carbonate succession from the nearshore site, compared to the other more distal sites, shows disparate geochemical characteristics (e.g., low Y/Ho, elevated Eu anomaly) and stratigraphically stable Ce/Ce* values. We hypothesize that this proximal site may be disconnected from the open ocean and record non-seawater signals. Our study explores how local redox conditions relate to depositional environments and evaluates the use of Ce anomaly proxy across a carbonate platform. This study provides new insights into ocean redox patterns, relevant to understanding paleoenvironments prior to the early animal radiation.

Faunal patterns are controlled by facies change through the Drumian Isotope Carbon Excursion (DICE) in SW Montana

Kayla Irizarry[1], Mark Patzkowsky[1], Kimberly Lau [1]
[1] *Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA*

The Cambrian is marked by anomalously high background extinctions rates with punctuated extinction events in the middle to upper Cambrian. It has been hypothesized that persistently low oxygen conditions in marine settings was a main driver of extinctions during this time. Here we use the Drumian Isotope Carbon Excursion (DICE), which has been related to expanding anoxic conditions in other regions, to define the relationship between fluctuating oxygen levels and faunal change. To achieve this goal, we have created a carbon isotope curve, redox proxy record, and quantitative paleontological collections from Cambrian age strata in SW Montana, USA. The Meagher Limestone (Wuliuan) and Park Shale (Drumian) are the focus of this analysis. The Drumian Isotope Carbon Excursion (DICE), a negative carbon isotope excursion of -2 to -4‰, was identified in the uppermost Meagher and Park Shale. The uppermost Meagher Limestone represents the shallowest environment in this section and does not contain any macrofossil or skeletal elements, but burrows are common. Overlying the Meagher Limestone is the Park Shale, represented by an interval of deepening and an increase in faunal abundance and diversity. Two distinct faunal communities exist within the Park Shale, a low diversity inarticulate brachiopod dominated fauna in the deep subtidal shales and a higher diversity trilobite dominated fauna in the shallow subtidal carbonates. Redox conditions through this interval are defined using the cerium anomaly proxy. Redox conditions do not change through the DICE interval, with almost all samples indicating oxic conditions. Samples generally fall close to the oxic-anoxic threshold, indicating that the environment was not oxygen rich. Our main findings are that the DICE is not a time of dramatically expanded anoxia in this region, but that low oxygen conditions typical of the Cambrian are prevalent, and that water depth changes are the main driver of faunal change.