MGU

Michigan Geophysical Union

2023

ANNUAL SYMPOSIUM PROGRAM BOOKLET

APRIL 13TH, 2023

UNIVERSITY OF MICHIGAN

DEPT. OF EARTH AND ENVIRONMENTAL SCIENCES

DEPT. OF CLIMATE AND SPACE SCIENCES

Welcome to the 19th annual Michigan Geophysical Union!

The end of the winter semester is always chaotic and many of us have to balance a number of commitments. Even so, MGU is once again incredibly proud to showcase the diverse research in Earth, environmental, and space sciences that our students have been pouring their hearts into. It is the honor of the organizing committee, this year composed of 14 student members and two faculty advisors, to create this space for celebrating the scholarly achievements of our more than 60 graduate and undergraduate presenters. It is the privilege of the co-chairs to have collaborated with this dedicated team, who kept track of dozens of emails, weekly Zoom meetings, a Discord server, and just made it work every single week this semester.

Before 2022, MGU used to be chaired by a single graduate student. Frankly, we don't know how they ever pulled it off! What we do know is that teamwork makes the dream work, and we personally enjoy how having one co-chair representing each of the CLaSP and EES departments this year reflects the cross-disciplinary spirit of this symposium. The home bases of EES and CLaSP are split across Central Campus and North Campus, physically divided by the Huron River (and miserably crowded Blue Buses). The Huron carries water down to Lake Erie, the smallest of the Great Lakes, an interconnected system that constitutes one-third of the entire world's fresh water, born of the retreating ice sheets ~14,000 years ago. Separation is a matter of perception; Earth and planetary scientists know that if you zoom out far enough, you'll appreciate that this planet is one big, beautiful, intricately woven system. Our departments are no different. MGU is always a special place where you can learn about earthquakes, dinosaurs, and coronal mass ejections all across two rooms in the span of a single day, in a welcoming and positive environment to boot. And if you ask the right questions to presenters from these far-fling research areas, you might think of clever ways all these things intersect.

We owe the success of MGU to the diligence of our organizing committee, the important scientific contributions of our presenters, the expertise of our judges, and the continued support of both the CLaSP and EES departments. And of course, this wouldn't be possible without you, our attendees, so thank you!

We look forward to many more MGUs to come, and possibly some exciting changes coming soon! Keep your seismometers scribbling to monitor the potential for some tectonic shifts in future MGUs.

-Austin Brenner (CLaSP) and Allison Curley (EES)

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EVENT SCHEDULE

MORNING

OPENING REMARKS (9:00 AM - 9:10 AM)

POSTERS – BALLROOM (9:10 AM - 11:00 AM)

A01 - *Assessing the Change in Insurance Coverage and the Social Justice Implications of Risk Rating 2.0 in Miami-Dade Count*, **Caroline Collins** p.9

A02 - *Examining Sub-Seasonal Forecasting of North American Heatwaves*, **Sloane Poppei** p.45

A03 - *Assessing the Accumulated Winter Season Severity Index and Possible Teleconnection Patterns for Ann Arbor*, **Victoria Scheidt** p.54

A04 - *Improving coastal ice cover forecasting: a case study from the Laurentian Great Lakes*, **Manish Venumuddula** p.59

A05 - *Development of Self-Calibrating Magneto-Inductive Sensor for Spaceflight Constellations*, **Cole Dorman** p.15

A06 - *Enabling Boomless Cubesat Magnetic Field Measurements with The Quad-Mag Magneotmer and Underdetermined Blind Source Separation*, **Alex Hoffmann** p.23

A07 - *Stormtime Geomagnetic Disturbance Events – Impact of High-Resolution Grid and Adaptive Kinetic Physics*, **Timothy Keebler** p.29

A08 - *Muddy Signals: Records of Climate in C And N Chemistry of An Anoxic System*, **Cecilia Howard** p.25

A09 - *Examining the effects of silica-amended seawater on microbial iron oxidation precipitates*, **Benjamin Klein** p.30

A10 - *Hydrothermal braunite synthesized under simulated diagenesis of manganese oxides with reduced manganese: Implications for the ancient manganese cycle*, **Kaitlin Koshurba** p.31

A11 - *Controls on the photochemical production of hydrogen peroxide in arctic surface waters*, **Nathan LaFramboise** p.32

A12 - *Investigating the Interannual Trends and Controls on Hydrogen Peroxide*, **Teige O'Brien** p.42

A13 - *Sunlight stimulates respiration of ancient permafrost carbon in arctic surface waters*, **Emma Rieb** p.49

A14 - *Cyanophage Lysis of Bloom-Forming Cyanobacteria Microcystis Spp. From Western Lake Erie*, **Ava Tackabury** p.57

A15 - *Carbon and Nitrogen Source to Sink Dynamics in a Modern Hypoxic Lake System*, **Diana Velazquez** p.58

A16 - *Multicomponent diffusion in basaltic melt: a universal eigenvector matrix*, **Bobo Bai** p.3

A17 - *Sulfide Inner-Core in Mars Inferred from Melting Experiments of Fe-S System at High Pressures*, **Francesca Riley** p.50

A18 - *Pyroxene Phenocrysts as Tracers of Melt Water Content in Lunar Basalts*, **Xue Su** p.56

A19 - *Diffusive Ti isotope fractionation in haplobasalts*, **Siyang Zhou** p.65

A20 - *Paleotemperature reconstruction using dual clumped-isotope thermometry of speleothems from New Mexico, and future contextualization*, **Jungpyo Hong** p.24
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A22 - *Can we reconstruct past ocean temperatures from the shells of sea snails? Insights into disequilibrium effects in marine gastropods through dual clumped isotope thermometry (Δ47/Δ48)*, **Alex Quizon** p.48
A23 - *Faunal Assemblage Changes in Shell Beds from the Pleistocene Florida Platform*, **Benjamin Woodmansee** p.61
A45 - *Ocean Temperatures and Seasonality Along the United States East Coast During the Last Interglacial as Determined by $\delta^{18}O$ of the Bivalve Mercenaria*, **Cecilie Philips** p.43
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Break Time (12:30 PM – 1:30 PM)

AFTERNOON

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A33 - *Experimentally elucidated fluid-apatite sulfur partitioning: Metasomatism of fluorapatite and chlorapatite at 800 °C and 1 GPa*, **Justin Casaus** p.7

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A49 - *First skull of the enigmatic archaic ungulate mammal 'Carcinodon' in the Denver Basin, Colorado, prompts reevaluation of that genus*, **Megan Riley** p.51
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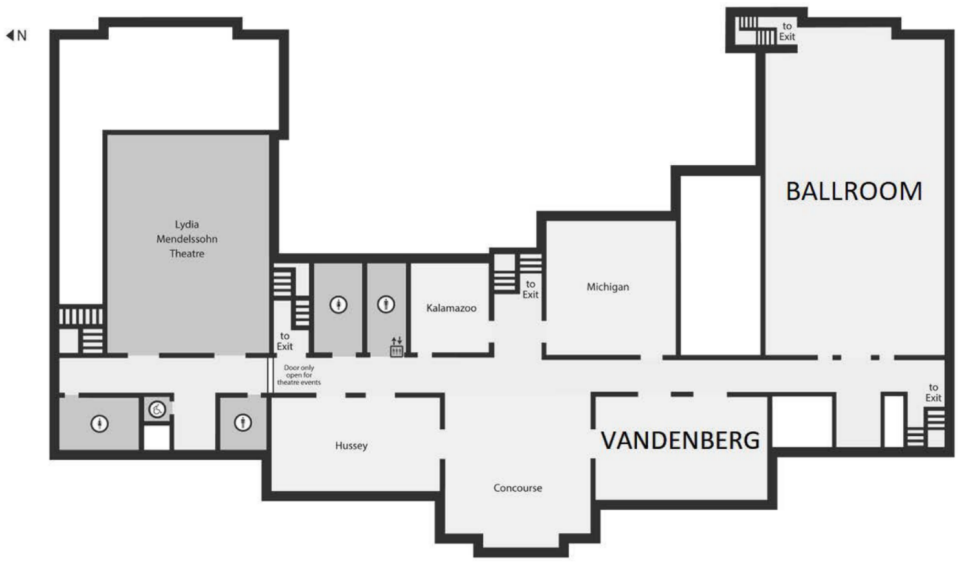
CLOSING REMARKS AND AWARDS (4:30 PM - 5:00 PM)

EVENT MAP



Michigan League Second Floor

19th ANNUAL MGU Michigan Geophysical Union APRIL 13, 2023

Landslide size as a function of topography and rheology

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Landslides are hazardous events that occur globally. They can cause considerable fatalities and severe damage to infrastructure, which is related to the size of a landslide. Researchers have studied landslide size distribution for a landscape and its characteristics with the objective of mitigating and managing the risks associated with them. One approach is to use theoretical modeling tools to assess the stability of materials on hillslopes by investigating the influence of the controlling factors on the size of a landslide and its distribution over a landscape. Such factors include hillslope topography (slope gradient), near-subsurface properties (strength), environmental properties (rainfall), and tectonic settings (earthquakes). Current studies assess the stability of soils or rocks on hillslopes assuming uniform strength with depth without considering the impact of weathering. Researchers have found that weathering alters the strength of the soils and rocks in depth as well as with slope gradient. In particular, steep slopes tend to have thinner and slightly weathered layers, in contrast to gentle slopes that have thicker and highly weathered layers. For that purpose, we use theoretical models to provide an assessment of the stability of the hillslope materials with a range of topographic parameters and strength parameters that varies with depth as well as slope gradient. The result of this modeling provides an insight about the differences in landslide sizes and predicted landslide size distribution for various strength models. We find that the when the strength varies with depth and slope, the slope stability models predict smaller minimum volumes for gentler slopes and larger minimum volumes for steep slopes compared to the only depth-dependent strength model. In addition, to investigate the impact of the strength models on the landslide size distribution for a landscape, a synthetic landslide size distribution is obtained. To produce that, first, a probability for the failure of each landslide size is calculated from the slope-stability modeling. After that, statistical analysis for topography data from study area in eastern Topatopa Mountains in Southern California provides a probability of existence for hillslope gradient and hillslope length. Lastly, the joint probability of both topography data and slope-stability analysis produces a synthetic landslide size distribution. It has been observed that the synthetic landslide size distribution follows the same distribution of real landslide inventories. Altogether, in this work we develop a novel workflow that combines theoretical models with statistical analysis for topography data from real landscapes to produce a synthetic landslide size distribution.

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GROWTH INCREMENT MEASURES IN A FEMALE WOOLLY MAMMOTH TUSK: NEW INSIGHTS FOR INTERPRETING LIFE HISTORY

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Female woolly mammoths (*Mammuthus primigenius*) have tusks that grow throughout life and provide a record of life history, including calving events. Critical for interpreting life history from tusks is understanding how and why they grow differently in certain intervals than in others. Past work has begun to look at the difference between volume, longitudinal cross-sectional area, and simpler unidimensional length measurements of yearly growth increments. "Length" in tusk growth increments can be measured as extension along the tusk axis, width perpendicular to the tusk axis, or thickness perpendicular to growth increment boundaries. Here, we describe ZCHM-49, a new female woolly mammoth tusk from Chukotka, Russian Federation, and use measurements of its annual growth increments to open a discussion on tusk growth. We CT-scanned ZCHM-49 and then virtually reassembled scan data before segmenting and measuring the tusk in Amira 2019. Then, we compared measurements of this tusk taken by two researchers to assess measurement error. Human error can reach at most 13 % of differences in measurements, while growth increments vary from year to year typically 25 % and up to 200 %. Measured volumes do not follow the same pattern of growth as measured extensional lengths. This is partly due to desiccation fractures that propagate within the tusk and create air space, changing volumes of given yearly growth increments. Additionally, however, volumes differ from extensional lengths through time due to the fact that the volume added in any given year is not only determined by available resources, but also by the anatomical geometry of the pulp cavity. Extension, on the other hand, is not affected by pulp cavity shape; this suggests that extensional length is a better measure to understand yearly differences in growth rate than volume. Average growth rate of axial extension in ZCHM-49 was 25.24 mm per year, while growth of volume was on average 61,918 mm^3 annually. Based on extensional length measures, and correcting for possible human error in measurements, we interpret ZCHM-49 as having a tusk record that shows two likely full calving cycles, along with two likely lost calves or pregnancies, and an overall calving interval of approximately 5 years. This average calving interval is longer than some previously reported, but within normal limits of living elephants. This study adds an additional data point to work looking into how life history in mammoths may have changed over time as the animals went extinct.

Multicomponent diffusion in basaltic melt: a universal eigenvector matrix

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Diffusion is due to the thermally activated random motion of particles on the atomic scale and it is one of the two ways of mass transport (the other one is convection). In a multicomponent system, the different components interact with each other. Therefore, the concentration gradient of one component can affect not only its own motion, but also the motion of other components, leading to cross effects. Because of the cross effects, diffusion in an N-component system is described by an N-1 square matrix called diffusion matrix ([D]). Natural silicate melt usually contains 6-10 major components (defined to be more than 1 wt% oxide), thus diffusion in natural silicate melt is always multicomponent diffusion. Previous study shows that the matrix of eigenvectors of [D] is roughly independent of temperature, whereas the matrix of eigenvalues of [D] follows an Arrhenius relation with temperature. In this study, we evaluate whether the diffusion eigenvectors depend on melt composition. A MATLAB code was written to obtain a universal eigenvector matrix by simultaneously fitting concentration profiles from 27 diffusion couple experiments in basaltic melts (Guo and Zhang, 2018, 2020). The obtained "universal" eigenvector matrix is significantly different from that of Guo and Zhang (2020). Using this new eigenvector matrix, we transformed the oxide concentrations into eigen-component "concentrations" and plotted the profiles of eigen-components as a function of distance using data from earlier diffusion experiments (Zhang 1989; Chen and Zhang, 2008, 2009; Yu et al., 2016; Yu et al., 2019; Guo and Zhang, 2018, 2020). Most (992 out of 1022) profiles of eigen-components are monotonic and show no obvious uphill diffusion, supporting that the matrix of eigenvectors is invariable with composition.

FIRST OCCURRENCE OF THE EARLY PALEOCENE MAMMAL *HEMITHLAEUS* OUTSIDE OF THE SAN JUAN BASIN WITH IMPLICATIONS FOR TOOTH REPLACEMENT IN ARCHAIC UNGULATES

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Archaic ungulates (i.e., condylarths) were among the most speciose and ecologically diverse mammals in the early aftermath of the Cretaceous-Paleogene (K-Pg) mass extinction. The Puercan North American Land Mammal 'age' (NALMA) captures the first ca. 1 million years (Ma) of the Paleocene and is characterized mostly by archaic ungulates present in the San Juan Basin of New Mexico. Elsewhere in the Western Interior of North America, however, Puercan mammals are primarily known from isolated teeth and jaw fragments. Recently, abundant skulls and associated upper-lower dentitions of archaic ungulates have been discovered at Corral Bluffs, an exposure of earliest Paleocene portions of the Denver Formation just east of Colorado Springs, Colorado, providing a new window into the earliest evolution of archaic ungulates. In this study, we describe the upper and lower dentition of an archaic ungulate (DB22-21) from ca. 600 thousand years after the K-Pg boundary (Puercan 2 NALMA) at Corral Bluffs. Notably, it exhibits an erupting left P2, deciduous (d)P/p3–4, M/m1–2, and erupting right M/m3. The dP/p3 closely resemble those of the adult dentition; dP/p4 are molariform, resembling the morphology of M/m1. We assign DB22-21 to the periptychine periptychid species *Hemithlaeus kowalevskianus* based primarily on: (1) protocone apex shifted buccally with prominent lingual slope, (2) reduced hypocone equal in size to an enlarged protostyle; both at the same mesiodistal line lingual to the protocone apex, (3) paraconid small and level with the height of talonid cusps, situated near base of protoconid, (4) metaconid shifted distobuccally and twinned with prominent protoconid, and (5) within size range of other *H. kowalevskianus* specimens (e.g., m2 L = 4.93 mm). DB22-21 thus represents the first occurrence of *H. kowalevskianus* outside of the San Juan Basin. Further, the preservation of both the dP/p3–4 and the unerupted adult premolars in the crypt of the maxillae and dentaries (confirmed via digital preparation of μCT data) represents the earliest example of tooth replacement patterns in archaic ungulates, and the first example of dental eruption patterns in the Periptychidae, one of the most successful groups of early Paleocene mammals. Future study will compare tooth replacement patterns in *H. kowalevskianus* to other eutherians, potentially illuminating the origin of dental replacement patterns characteristic of extant placental mammals.

Persistence of Methane Emissions from Offshore Oil and Gas

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Methane is a key greenhouse gas. Regulation of methane could produce noticeable short-term change since it has a much shorter atmospheric lifetime than carbon dioxide. Although methane emissions from onshore oil and gas production have received more attention, offshore emissions are less studied. This investigation will explore methane emissions measured from repeat observations of the same set of central hub platforms to evaluate temporal emissions characteristics. We are looking only at shallow water hubs in the Gulf of Mexico, which are thought to be large methane sources. Episodic emissions are a feature of oil and gas production, which complicates snapshot measurement techniques. Using data from a series of airborne campaigns spanning from 2019-2022, we have calculated changes in the emissions behavior of each site at different measurement intervals, from 1 week to 4 years. Preliminary analysis suggests no relationship between production and emissions, using inventory production data. There also seems to be no relationship between the chance of finding consecutive emissions and the time interval, which means that the time between observations does not impact the chances of recording emissions at a given site. This suggests that the snapshot method of data collection, with aircraft campaigns flying over the hubs, should capture a representative sample of the actual emissions, regardless of the time of sampling, so long as there is an adequate number of samples. This provides a solid argument against measurement biasing towards high emission events and solidifies the claim that this is a valid sampling method since the emissions behavior is independent of time. Further data analysis is needed to investigate the average likelihood of a site to be recorded emitting methane, and the likelihood of capturing a high-emission event across the basin.

DISSECTING EARTH'S MAGNETOSPHERE: EXTERNAL VS INTERNAL ENERGY TRANSFER PATHWAYS

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Our planet has an internally generated magnetic field which dominates the motion of plasma in the near-Earth space known as the magnetosphere. This inflated cavity presses against the surrounding solar wind environment and shields us from the shocked supersonic flow. During storm events, also known as space weather, solar wind is able to couple to the magnetosphere and large amounts of energy enters near earth space and causes the intrinsic planetary magnetic field to rapidly fluctuate. This fluctuation can induce currents in large conducting objects on the Earth's surface such as power lines. In this work we study the global transport of energy within the magnetosphere by using the Space Weather Modeling Framework simulation tool.

We dissect the magnetosphere by first defining the topological boundaries and bounded volumes which comprise the system. Then we integrate the energy within the volumes as well as the energy flux between the volume interfaces. With these results we see two distinct energy pathways, one between the magnetosphere and the surrounding environment, and the other inside the system between the two major subregions. It is found that the internal energy circulation is much stronger than the external circulation during the most active time of the storm. Time shifted correlation coefficient plots are used to determine the sequencing of each of the energy loops and their connection to particular solar wind signals.

Experimentally elucidated fluid-apatite sulfur partitioning: Metasomatism of fluorapatite and chlorapatite at 800 °C and 1 GPa

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Melts and fluids are important agents for mass transfer in igneous, metamorphic, and sedimentary environments. They play a key role in the mobility of elements in the crust and lithospheric mantle. The mineral apatite [$Ca_{10}(PO_4)_6(F,Cl,OH)_2$] is generally present in all of these environments and is susceptible to post-crystallization alteration by a wide variety of fluids and P-T conditions.

Observations of natural systems and experimental studies demonstrate the formation and alteration of igneous apatite with respect to rare earth elements (REEs), radiogenic isotopes for geochronology, and more recently on the incorporation of distinct polyvalent sulfur (S) ratios that can be used to quantify the oxygen fugacity (fO_2) of a melt.

Currently, attempts are being made to use metasomatized apatite chemical compositions to infer the composition of an altering fluid and the fO_2 of the system. However, most natural observations and experimental work on metasomatic alteration of apatite to date has only addressed the enrichment or depletion of REE and other trace elements, such as radiogenic isotopes, for the purposes of melt provenance and geochron resetting.

To further our understanding of how apatite responds to various metasomatic systems, we conducted a series of apatite-fluid experiments at 800 °C and 1 GPa to test various S coupled substitutions into apatite (e.g. $Ca^{2+}+P^{5+}=Na^{+}+S^{6+}$; $2P^{5+}=Si^{4+}+S^{6+}$) and to assess the feasibility of whether polyvalent S in metasomatized apatite could be used as an oxybarometer. Here, we report the results of the metasomatism experiments wherein S and metal free synthetic fluorapatite and chlorapatite grains were reacted with an H-O-S +/- Na-, Si-, S-, Sr-, Fe-, and Ce-bearing fluid that determine the efficacy of metasomatized apatite as an oxybarometer and recorder of fluid compositions.

ECOMORPHOLOGY OF THE TERMINAL PHALANGES IN ARTIODACTYLA

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When investigating the ecology of artiodactyls, special attention is often given to the teeth as well as the calcaneus and astragalus in the hind foot, as these bones serve as good indicators of diet and locomotion. However, when it comes to assessing the substrate use of an organism, bones directly in contact with the substrate may be more informative than other postcranial elements. Understanding the link between organismal form and function in extant species is an important step in making inferences about related fossil organisms. Using 2D geometric morphometric analysis, I will measure the allometric shape of the distal phalanges (toe bones) and evaluate the relationship between morphology, locomotor habit, and environment to develop a scheme for relating phalanx shape to the environment that an animal lives in. I aim to collect a sample representative of all living artiodactyl families, as together they exhibit a wide range of locomotor modes and habitats ranging from high speed cursorial grassland specialists like gazelles to slower, forest-dwelling species like okapi.

Assessing the Change in Insurance Coverage and the Social Justice Implications of Risk Rating 2.0 in Miami-Dade County

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The National Flood Insurance Program (NFIP) is the primary source of flood insurance coverage for the residential United States, allowing for some transfer of financial risk of property ownership onto the federal government. Since the development of the NFIP in 1968, they have historically mapped properties into Flood Insurance Risk Maps (FIRMs) which designate the risk of flooding and determine whether flood insurance is required for a federally backed mortgage. These maps are split into "flood zones" which group neighboring properties together and set the premium rate. Many have argued that the FIRM mapping system has two main flaws: the underrepresentation of flood risk and the lack of equity of grouping various properties into one flood zone. In October 2021 the NFIP released a new risk mapping system called Risk Rating 2.0 with new risk criteria and the abandonment of the flood zone. Risk Rating 2.0 takes into account the individual construction and value of each property as well as its location to set a premium price.

This project uses insurance coverage data from before and after the development of Risk Rating 2.0 in Miami-Dade county, one of the most vulnerable flood counties in the United States. The goal is to analyze the change in the rate of uninsured people and properties before and after the implementation of Risk Rating 2.0 and to comment on potential social injustices that come with the new mapping system.

Finally, I plan to develop an addition to the Climate Science and Impacts Concentration within Climate and Space Sciences to incorporate a case study on the social impacts of climate change. I hope to use the insurance coverage analysis as well as commentaries on the social inequity in the flood insurance system to allow students in the department to take a more multidisciplinary look at the effects of climate change. The final goal is to create a slide deck with both technical and social science components that future professors in the ClaSp department could incorporate into the core curriculum.

Ion Composition Study at Earth's Outer Magnetosphere

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While Earth's frontside magnetic field is compressed due to the kinetic pressure of the incoming solar wind plasma, the nightside field lines are stretched out into a long lobe known as the magnetotail. In these regions, magnetic reconnection enables particle exchange from the solar wind into the magnetosphere. This solar wind influx, as well as a comparable number of ions from ionospheric origin, contribute to the composition of the magnetospheric hot plasma. Because of this, protons of solar wind origin are confused with those of ionospheric outflow depending on the location in which they are observed. In order to distinguish the plasma contribution from both sources, a multi-satellite data observation is necessary. During its trajectory, *Wind* spacecraft spent a significant amount of time in the magnetotail, where its Solar Wind and Suprathermal Ion Composition Experiment (*SMS*) measured mass, charge, and energy for ions with an energy/charge ratio up to 230 keV/e. Although *SMS* originally aimed to determine the abundance of several ion species in the solar wind, its measurements within the magnetosphere can reveal the ion composition at the magnetotail. Combining magnetospheric observations made by *Wind* with upstream measurements made by the Advanced Composition Explorer (*ACE*) spacecraft will allow us to identify the ratio between the solar wind and ionospheric plasma and what mechanisms efficiently enhance their entry. Therefore, studying this ion composition in Earth's outer magnetosphere will help us frame the importance of mass and energy flow during the dynamics of space weather and geomagnetic events.

VISUALIZING CLIMATE CHANGE AND THE CORRELATION WITH POLITICAL VIEWPOINTS

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Climate change, in a cultural setting, has an inherent association with the Arctic regions of the planet. However, climate change is a global phenomenon, with impacts much beyond the polar regions. The problem then becomes determining the impact of climate change on the lives of individuals and communities throughout the world. For this project only the Midwestern United States was considered, but it could easily be expanded to other areas given more time.

For this project, daily data was used from seven different sites in the Midwest area: Ann Arbor, MI; Muskegon, MI; Green Bay, WI; La Harpe, IL; Greenville, OH; South Bend, IN; and State College, PN. Using the daily data, yearly averages are conducted of Average Daily Temperature, Average Daily High Temperature, Average Daily Low Temperature, Days Above Temperature Threshold, Yearly Rain Totals, Yearly Snow Totals, Days Above a Rain Threshold, and Yearly Longest Drought.

Using all of these variables, a linear regression was performed on the data to determine the underlying trend of the climate in that area with respect to that variable. A statistical significance test has also been conducted for each variable at each site.

The statistically significant data points will be matched up with the site's county political views according to the Yale Climate Survey, and another linear regression will be conducted to determine the strength of the relationship between political views on climate change and the degree to which climate change actually impacts the site. Comparisons can also be made about the impact of climate change on urban vs. rural areas and coastal vs. inland cities, and will help bring a better understanding and degree of realism to how climate change truly affects the area in which we live.

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Climate and hydrology in the Campanian (~75 Ma) Western Interior Basin: Insights from clumped and strontium isotope measurements of freshwater unionid bivalves

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A NEON - PALEONTOLOGICAL PERSPECTIVE ON THE MORPHOLOGICAL DIVERSIFICATION OF CARANGARIAN FISHES (JACKS, FLATFISHES, BILLFISHES, AND ALLIES)

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With lineages as anatomically and ecologically disparate as flatfishes, remoras, billfishes, and jacks, the Cenozoic spiny-rayed fish clade Carangaria represents an intriguing system for studying patterns of morphological change. Past studies of patterns of body shape evolution in carangarians have employed two different approaches. The first quantifies fluctuating levels of disparity over time using fossil species, without a consideration of phylogenetic relationships. The second fits explicit models of trait evolution using data for living species and time-calibrated molecular phylogeny. Both offer incomplete perspectives on patterns of diversification. Here we combine neontological and paleontological approaches to test past hypotheses about shape evolution in carangarian fishes. We selected 16 well-preserved fossil specimens and integrated them into a molecular phylogenetic backbone containing 69 living species. Within the limits of the available fossil record, we attempted to sample fossil species across major clades and throughout the evolutionary history of Carangaria. Placing fossils within trees for which there are limited morphological datasets is challenging, so we adopted an approach based on a combination of taxonomy and verbally argued placements to assign fossils to specific internodes. The length of the branch subtending fossils (and their branching point along an internode) was inferred analytically. Our strategy uses a maximum likelihood approach to place these fossils under a Brownian motion model of shape evolution, conservatively biasing our results toward supporting a time-homogenous, diffusive model of change. Our integrated results, combining shape data from both extinct and extant species, support elevated rates of diversification early in the history of Carangaria and then slow down thereafter but the clade has continued to accumulated diversity to the present day. These results deviate from the findings using only extant taxa which showed that the Carangarian diversity became constrained soon after rates slowed down. Our findings support the well-established significance of fossil data in understanding patterns of evolutionary diversification and provides one approach toward including fossils in a comparative framework when detailed character matrices are not available.

Cyanobacteria Capable of Neurotoxin Biosynthesis Intermittently Associated with Western Lake Erie Harmful Algal Blooms

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The production of toxins in cyanobacterial harmful algal blooms (cyanoHABs) is a significant concern for human and ecosystem health. Saxitoxin, one of the world's most potent neurotoxins, was recently detected during autonomous monitoring of cyanoHABs in western Lake Erie (WLE). Additional neurotoxins are also a concern, particularly anatoxin-a and guanitoxin. Biological sources of saxitoxin, anatoxin-a, and guanitoxin in WLE have not previously been established. Here, we identified the organisms possessing the biosynthetic pathways known to produce saxitoxin and anatoxin-a by analyzing nearly 500 metagenomic sequencing samples available from the GLAMR database that were collected between 2014 – 2022 spanning February to October. Genes involved in saxitoxin and anatoxin-a biosynthesis were only observed in samples collected during the summer months and the complete guanitoxin biosynthesis cluster was not identified. Identification of the organisms producing neurotoxins and their spatiotemporal distribution provides a framework for better understanding risks associated with neurotoxin production in western Lake Erie and delivers a means to further investigate and monitor their presence.

DEVELOPMENT OF SELF-CALIBRATING MAGNETO-INDUCTIVE SENSOR FOR SPACEFLIGHT CONSTELLATIONS

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Magnetic fields are a fundamental parameter of space plasmas. Despite this, common spaceflight magnetometers create constraints due to their mass, size, cost, and calibration requirements to compensate for off-set and gain drifts in their measurements. Relatively inexpensive and lightweight magnetometers, including fluxgate magnetometers, are power-efficient but measure the variability in magnetic fields as opposed to the absolute magnetic field without careful pre- and in-flight calibration. The solution to these issues is self-calibrating magnetometers, which would greatly improve efficiency and lessen spacecraft constraints. Self-calibrating magnetometers using lightweight chip-based systems in combination with a calibration Helmholtz coil enable assessment of their own measurement drift and correct it to find the absolute field reducing the complexity for single instrument and inter-spacecraft calibration for constellation missions.

A Helmholtz coil can self-calibrate a PNI RM3100 by generating magnetic field “pulses” which when post-processed, enable calibration of each sensor axis. The RM3100 is already a popular magnetometer model for CubeSats due to their low cost, small volume, radiation tolerance and flexible system design. Together, RM3100 magnetometers self-calibrated by Helmholtz coils can mature the tool for the robust accuracy needed for low-Earth orbit spacecraft, outer magnetosphere, or interplanetary magnetic field missions.

Impact of Single Fluid and Multifluid MHD on GMD Forecasting: An Inner Boundary Condition Sensitivity Study

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Altering global MHD model inner boundary conditions, such as temperature, parallel velocity, and ion composition can impact ground magnetic disturbances (GMD) by changing the geospace response to solar drivers. As solar and magnetospheric activity increases, we see an increase in light and heavy ion densities in Earth's magnetosphere. These additional ions impact physical processes, including reconnection rates, ring current development, and wave environments. Many of the physical mechanisms responsible for additional ion outflow are not included in the idealized magnetohydrodynamic (MHD) equations. The Space Weather Modeling Framework (SWMF) using a passive static inner boundary condition [e.g., Welling & Liemohn, 2014] approximates outflow magnitude with ideal MHD equations, but does not accurately show the outflow pattern. To better reflect the ion composition this requires us to switch from ideal MHD equations to a multifluid MHD equation set, allowing for multiple ion species to be present, solving for separate momentum and energy equations. Changing between these two equation types results in higher computational costs and diverges from real-time analysis, but may improve simulated ground-based magnetometer results by reflecting an accurate ion outflow pattern. We compare the ground magnetic response as a function of ion outflow type, exploring the importance of mass outflow on GMD. Both single and multifluid MHD equation sets are exercised. The overall effect of inner boundary conditions on GMD forecasting is summarized.

ACTINOPTERYGIAN FISH ASSEMBLAGE FROM THE UPPER CRETACEOUS (CAMPANIAN-MAASTRICHTIAN) DUWI FORMATION, WESTERN DESERT, EGYPT AND THE FIRST RECORD OF SAURODONTIDAE FROM AFRICA

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Formation of High-Grade Ore at the Thacker Pass Sediment-Hosted Lithium Deposit, Nevada

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Reconstructing marine climates on the Plio-Pleistocene Florida Platform: Assessment of a regional extinction event

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In southern Florida, a sequence of densely fossiliferous shell beds illustrates a regional extinction event over the course of the Late Pliocene through the Middle Pleistocene. Cooling water temperatures have long been invoked as a potential mechanism for this Plio-Pleistocene extinction event, but prior paleotemperature and seasonality estimates through this interval have yielded ambiguous results and may be biased due to poorly constrained $\delta^{18}O_{water}$ values on the ancient Florida Platform. In this ongoing project, we are applying high-resolution Δ_{47}-sclerochronology to fossil bivalves to produce the first strictly quantitative estimates of (i) mean water temperatures, (ii) seasonal extreme temperatures, and (iii) mean $\delta^{18}O_{water}$ values in each of the major Plio-Pleistocene formational units of southern Florida. Here, we present preliminary Δ_{47}-derived temperature and $\delta^{18}O_{water}$ reconstructions from the Caloosahatchee Fm. (Early Pleistocene), Bermont Fm. (Middle Pleistocene), and Fort Thompson Fm. (Late Pleistocene). Our formation-level temperature and seasonality estimates are used to evaluate hypotheses of climate change as an extinction driver through the section. Additionally, reconstructed $\delta^{18}O_{water}$ profiles indicate considerable subannual-scale variability in past $\delta^{18}O_{water}$ compositions, which may reflect the seasonal mixing of isotopically-distinct freshwater masses with marine water masses in the nearshore marine and estuarine environments of the ancient Florida Platform. Observations of substantial $\delta^{18}O_{water}$ variability demonstrate the utility of Δ_{47}-paleothermometry in this unique geologic setting.

Subtle effects of tectonics on the faunal history and paleoecology of mammals from the Miocene Dove Spring Formation, southern California

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Modern taxonomic diversity is largely concentrated in topographically complex regions and it stands to reason that the fossil record contains evidence of the origins of this phenomenon. Evolutionary, ecological, and geological processes are potential causes that are often investigated at the regional scale. Studies of fossil assemblages from individual basins are essential to assess the primary influence on past communities. We combine investigations of faunal composition, mammal diversity, paleoecology, and depositional environments to present an integrated analysis of the diversification history of a terrestrial, Miocene basin from southern California. Three major tectonic episodes altered the geometry and habitat viability of the Dove Spring Formation (12.5-8.5 Ma): early extension (12.5-10.0 Ma) is associated with stable environments and high per-capita origination rates; rotation and translation at 10.0 Ma disrupted existing drainages and extinction became the dominant form of faunal change; incipient extension at 9.0 Ma formed new drainage networks with lower preservation potential as species richness continued to decline.

To investigate links between tectonics, vegetation, and moisture availability we sampled tooth enamel from common ungulate families. Using high-resolution stratigraphy and geochronology, we compared the isotopic record to the timing of tectonic episodes. Dove Spring ungulate $\delta^{13}C$ values range from -27.0‰ to -5.7‰ and $\delta^{18}O$ values range from -10.61‰ to -0.62‰. Using locally estimated scatterplot smoothing we determined that subtle but statistically significant changes in mean $\delta^{13}C$ and $\delta^{18}O$ values occur across all taxa at 10.5 Ma, just preceding sedimentological evidence for basin rotation and translation. This suggests that faunal change during this episode was driven by changes in vegetation and moisture availability related to tectonic history.

To test the hypothesis that faunal change was driven by the preservation potential of sediments, we measured decimeter-scale stratigraphic sections and conducted facies analyses for 49 highly productive fossil localities. The majority of localities were floodplain and pond deposits, with floodplains becoming more common midway through the sequence. This suggests that preservation potential is not responsible for the decline in species richness. Our results collectively indicate that the basin's tectonic setting had a subtle but measurable effect on environmental conditions and its faunal history.

An Extended Metric Study of SWMF Conductance Model Influences on Estimating FACs: Effectiveness of semi-physical MAGNetosphere-Ionosphere-Thermosphere (MAGNIT) Model

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MAGNIT, a semi-physical auroral precipitation model that uses global MHD plasma parameters, characterizes four discrete (monoenergetic, broadband) and diffuse (electron, ion) auroral precipitation sources. MAGNIT is coupled within the SWMF, where BATSRUS MHD values are used to calculate ionospheric conductance in differing patterns; the affected electric field returns to the GM model, allowing for changing magnetospheric response to solar wind driving. A metric study on the CME storm 'Galaxy 15' (April 2010), validates MAGNIT (coupled with SWMF-BATSRUS) against measured AMPERE data, via field aligned current (FAC) characteristics. The performance of SWMF with MAGNIT is further supported by comparisons against SWMF couplings with RLM and CMEE empirical models.

Additional analysis of the data-model comparison is conducted by studying FAC location and latitude/magnetic local time spread throughout various phases of storms, illustrating the temporal and spatial influence of each precipitation source. The critical precipitation source in different storm phases is identified, and the role of each source in deviating from observed FAC values is investigated. This information on auroral precipitation sources and its weight on MHD FACs, and metrics from model-data comparisons, will be used to modify MAGNIT settings to optimize model performance.

The History of the Northern Lights: Observations from 30,000 BCE to Present

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The northern lights, also known as the aurora, are a spectacular phenomenon that humans have observed and recorded throughout history using drawings, oral mythology, written word, and most recently, photographs and videos. We outline the history of auroral observations from 30,000 BCE to the present, and discuss some historical impacts of the aurora throughout this period. We present ancient record keeping practices as well as the oral history preserved by multiple indigenous groups, and outline the path from auroral observations to contemporary auroral science.

The aurora is a visual representation of the physical properties that govern the interaction between Earth's and Sun's invisible magnetic fields. We highlight the improvements of today's auroral observations from those of the past, and the new types of discoveries that the novel detection mechanisms enable. We demonstrate the connection between auroral observations to the protection of astronauts in high radiation space environments and to the safeguarding operations of the power grids on Earth.

ENABLING BOOMLESS CUBESAT MAGNETIC FIELD MEASUREMENTS WITH THE QUAD-MAG MAGNEOTMER AND UNDERDETERMINED BLIND SOURCE SEPARATION

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In situ magnetic field measurements are often difficult to obtain due to the presence of stray magnetic fields generated by spacecraft electrical subsystems. The conventional way to mitigate this problem is to place magnetometers on a deployable boom and enforce strict magnetic cleanliness requirements. However, this approach is not suitable for low-cost platforms such as CubeSats, which have very limited volume and budget. In this paper, we present a novel solution that combines the Quad-Mag CubeSat magnetometer with the Underdetermined Blind Source Separation (UBSS) noise removal algorithm. The Quad-Mag consists of four magnetometer sensors in a single CubeSat form-factor card that allows distributed measurements of stray magnetic fields from different subsystems. The UBSS algorithm can separate the ambient magnetic field from the noise signals without prior knowledge of their magnitude, orientation, or number. UBSS is a two-stage algorithm that first identifies noise signals using cluster analysis and then separates them using compressed sensing. We enhance UBSS with single source point (SSP) detection to improve noise identification and iteratively weighted compressed sensing to improve noise separation. We validate our method using a mock CubeSat and show that UBSS reduces four noise signals of more than 100 nT at each sensor to 6 nT. We also demonstrate the performance of our system for 1U, 2U, 3U, and 6U CubeSats in simulation. Our results indicate that the Quad-Mag and UBSS package enables accurate magnetic field measurements from a CubeSat without requiring a long boom.

Paleotemperature reconstruction using dual clumped-isotope thermometry of speleothems from New Mexico, and future contextualization

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Accurate paleotemperature reconstruction has been a major focus of paleoclimate studies and is important in providing a basis for evaluating the accuracy of climate models, which are used for future climate change prediction. Among various proxies, speleothem records are acknowledged as well-dated archives of past terrestrial climates, and recent developments in dual clumped-isotope (Δ_{47} - Δ_{48}) thermometry offer hope for precise temperature reconstructions, despite kinetic isotope fractionation that might happen during carbonate precipitation in the caves. Here, we present initial dual clumped-isotope data of pool carbonates from caves in New Mexico. The samples range in age from the Last Glacial Maximum (LGM) to the mid-Holocene. Dual clumped-isotope (Δ_{47} - Δ_{48}) indicate that the carbonated formed close to isotopic equilibrium, and the mass-47 clumped isotope measurements (Δ_{47}) indicate a temperature difference between the LGM and the Holocene of approximately 9º C. These results will be viewed in the context of year-long soil temperature measurements near the caves in New Mexico. Cave bedrock temperatures are known to reflect annual mean surface temperatures as other terrestrial proxies, and therefore, analyses of modern soil temperature variation will help understand the relationship between the reconstructed cave temperature and terrestrial surface temperature. Together, these will contribute to understanding how speleothem proxies work and will lead to a more precise reconstruction of paleo-surface temperature in the southwestern part of the United States.

MUDDY SIGNALS: RECORDS OF CLIMATE IN C AND N CHEMISTRY OF AN ANOXIC SYSTEM

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Variations in local and global climatic conditions impact lake ecosystems in many ways, including degree of oxygenation and timing and rates of primary productivity. However, the interplay between these climatic variations and the sediment record is poorly understood. Organic carbon and nitrogen chemistry are useful tools for tracing carbon from source to sink and investigating changes in these pathways. This study considers covariation of sediment carbon and nitrogen chemistry (% total organic carbon (%C_{org}), %N, C_{org}/N, and $\delta^{13}C_{org}$) with climatic factors in Middle Island Sinkhole, a submerged karst feature in Lake Huron impacted by low-oxygen groundwater. The influx of anoxic groundwater creates a redoxcline and promotes the growth of extensive microbial mats on the sediment surface as well as the burial and sequestration of large amounts of carbon sourced from water column phytoplankton, with sedimentation rates of 0.24–0.7 cm yr^{-1}. We studied cores collected each year from 2011–2017 and in 2021, and identified significant fluctuations in C and N down to at least 12 cm based on the core collection year. We found that while the carbon and nitrogen chemistry in the surface sediments (≤1.5 cm depth) seems to be driven primarily by the mats, deeper sediments (1.5–12 cm) track year-to-year changes in local ice cover and resulting shifts in chlorophyll. Years with low duration of ice cover (notably 2016) were associated with high chlorophyll and increased C and N burial, while the reverse was true for years with a high duration of ice cover (notably 2014). The interannual shifts in deeper sediments demonstrate that this anoxic system is recording local climate variability at least ephemerally. These variations were most pronounced in sediments below the surface rather than in surface sediments actively deposited that year, suggesting communication between the surface and deeper sediments. This raises the concern that annual C and N signals are being translated downcore of their deposition layer, an issue that would require sampling at higher depth resolution and deeper coring to resolve.

Serpentine Mineralogy from Fe-Ti Oxide-Bearing Ultramafic Intrusions in the Duluth Complex, MN

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The Duluth Complex consists of a series of mafic intrusions that formed 1.1 Ga as part of the Midcontinent Rift System. The western margin of the complex hosts ~12 different Fe-Ti oxide-bearing ultramafic intrusions (OUIs). Little is known about the genesis of the OUIs, which contain significant domestic Ti resources. In this study, we use mineralogy of serpentinized olivine to understand lower temperature alteration that impacted the system. Two OUIs, Titac and Longnose, were studied using a variety of tools to understand serpentine textures and mineralogy, including petrographic microscopy, scanning electron microscopy (SEM), Raman spectroscopy (Raman), X-ray diffraction (XRD), and electron probe microanalysis (EPMA). From petrographic microscopy and SEM, serpentine textures were determined. In Longnose, serpentine forms parallel veins that cluster in some parts, along with mesh and interpenetrative textues. The olivine experienced heavy alteration, seen by thicker veins. Titac olivine is not as heavily altered, as seen by thinner and presence of original olivine. Serpentine veins here have mesh and interpenetrative textures. Despite less intense alteration, Titac has a few larger serpentine veins. Both OUIs also contain magnetite veinlets that form within some serpentine veins. Serpentine mineralogy was determined through Raman and XRD. Serpentinization of olivine formed lizardite, antigorite, and magnetite. We found, with Raman, that Titac contained more lizardite than antigorite. Magnetite veinlets were only found with lizardite. Longnose contained more antigorite than Titac, though lizardite dominated. There is also evidence of mixing of the two phases. Lizardite indicates alteration at a lower temperature (~400 °C) while antigorite indicates alteration at a higher temperature (~600 °C), so the results indicate the occurrence of multiple alteration events. EPMA was used to measure serpentine compositions. The serpentine was found to be Fe-rich, containing up to ~24 wt% FeO. The mineralogy (from T/(T+M) cation ratios of measured elements) matched with what was found with Raman and XRD. These analyses are part of a larger study of the OUIs and will help us to understand the final step in formation of the OUIs, a magmatic process. This can then be used to study similar intrusions.

ANDEAN INTERGLACIAL CLIMATE DURING MIS-15 (621–563 ka)

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Systematic oscillations between glacial-interglacial conditions follow the rhythm of orbital eccentricity and define Earth's climate over the last 1 million years. Marine sediments and polar ice archives clearly record these 100 ka glacial-interglacial cycles, however, few terrestrial paleoclimate records have been developed over the same timeframe. As a result, we have an incomplete understanding of how terrestrial environmental conditions, e.g., surface temperatures, rainfall patterns, and water availability, respond to global climate. In this study, we analyze lake sediment records from Lake Junín in the Peruvian Andes (11°S) which span the last 700 ka. Previous studies document clear changes in sediment characteristics and chemistry at Lake Junín over glacial-interglacial cycles, highlighting the environmental and hydrologic sensitivity of this region to global climate perturbations. The most volatile interval at Lake Junín occurred from 621–563 ka during an interglacial known as MIS-15. Identifying why MIS-15 was extremely variable and the resulting impact on surface conditions will improve our overall understanding of South American climate sensitivity to global forcings. Here, we develop records of regional temperature and water stress at Lake Junín during MIS-15 to build a more complete picture of environmental conditions in the tropics during this interglacial. We use a combination of lake carbonate clumped and triple oxygen isotopes to reconstruct temperature and water stress histories, respectively. We find that average lake water temperatures over MIS-15 were stable (8 ± 5 °C, n = 13) and similar to modern day lake temperatures derived from carbonate clumped isotopes (13 ± 3 °C). These estimates represent a small, but growing, body of quantitative temperature reconstructions from South America during interglacial periods over the last 1 million years and suggest local temperature was insensitive to global climate variability during MIS-15. In contrast to the stable temperatures, water availability during MIS-15 was highly variable, following a precession-paced cycle (24 ka). These perturbations may be linked to changes in meridional insolation gradients that disrupt moisture conveyance on a continental-scale. In sum, our results support interpretations from other recent interglacials (e.g., the Holocene) that suggest, despite stable surface temperatures, transient intervals of regional water stress are characteristic of how South America experiences global interglacial periods.

CAPTURING ROCK MASS WEATHERING VARIABILITY ACROSS EXHUMATION, CLIMATE AND ELEVATION GRADIENTS

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In collisional mountain belts such as the Himalaya, landslides act as the dominant hillslope erosion process. This poses significant natural hazard to surrounding populations, but current slope stability models are incapable of predicting landslides at a regional scale. An important element to accurately predicting slope failure is the strength of the rock mass, however this can change significantly during the exhumation process and is subject to feedbacks between physical (i.e. fracturing) and chemical (i.e. reactions with meteoric fluid) alteration. This work examines how rocks break down across gradients in elevation, exhumation rate, and climate to better understand how they impact slope stability in active orogens. Weathering extent of the rock mass is evaluated using shallow geophysical surveys across the Melamchi Khola river catchment. The Melamchi Khola is a north-south river catchment located in the frontal Himalaya of Central Nepal that spans gradients in exhumation rate, climate, and elevation. Results from geophysical surveys will be combined with detailed observations from co-located boreholes and weathering profiles to quantify the extent of weathering in the shallow subsurface. Weathering extent will then be cross-examined with known gradients to generate a more accurate regional rock strength model that can be incorporated into slope stability models.

Stormtime Geomagnetic Disturbance Events – Impact of High-Resolution Grid and Adaptive Kinetic Physics

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Examining the effects of silica-amended seawater on microbial iron oxidation precipitates

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Banded Iron Formations (BIFs) are ancient iron-rich marine chemical sediments which can lend insight into (bio)geochemical activity in the ocean at the time of their formation. Bulk iron contained in BIFs precipitated from the deep Archean ocean [2.5-4.0 Ga] has been determined to have an average oxidation state of $Fe^{2.4+}$ (Beukes and Klein, 1992). This partial oxidation of iron indicates the presence of a major oceanic iron cycle in which both iron oxidation and iron reduction processes were occurring simultaneously. Photoferrotrophic bacteria are hypothesized to be responsible for the oxidation portion of the cycle by utilizing light energy to oxidize ferrous iron to ferric iron. This microbial iron oxidation is thought to have occurred in the ocean's mixing zone, resulting in the precipitates descending through Fe(II)- and silica-rich deep water before reaching the ocean floor. Prolonged exposure to Fe(II) and silica during settling could impact the chemistry of the precipitates. For example, secondary Fe(II)-induced mineralization pathways could transform initial products of photoferrotrophy to a different mineral assemblage altogether. In addition, silica oxyanions may also influence recrystallization and transformation dynamics. We constructed an experimental matrix to investigate the effect that extended exposure to a ferruginous and silica-rich seawater column has on products of microbial iron oxidation. First, we introduced the photoautotrophic iron-oxidizing bacterium *Rhodopseudomonas palustris* TIE-1 to either silica-amended or silica-deficient (10mM HCO^{3-}, pH = 7.0, ±1mM Si, 1mM Fe^{2+}) synthetic Archean seawater. Next, the biogenic precipitates produced under these two conditions were aged in either siliceous (1 mM Si) or silica-lacking (0 mM Si) seawater medium over a two-week period at room temperature. Precipitates formed and/or aged in a silica-deficient seawater media served as controls to observe how the presence of silica altered precipitate chemistry. Comparison of precipitates in silica-rich and silica-poor seawater analogs before and after simulated water column exposure will help determine the impact that settling through a siliceous water column has on their mineralogy, morphology, and elemental composition.

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Hydrothermal braunite synthesized under simulated diagenesis of manganese oxides with reduced manganese: Implications for the ancient manganese cycle

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Manganese containing minerals are effective paleo-redox proxies due to this transition metal's ability to exist in a wide range of valence states and its high redox potential. Reduced manganese (Mn^{2+}) is soluble and only undergoes low-level mineralization (<1 wt %) in carbonate rocks when substituting for Ca^{2+}. This metal is only deposited in considerable quantities in its oxidized forms (Mn^{3+} and Mn^{4+}) as insoluble (oxyhydr)oxides, and reduced manganese generally requires oxygen or O_2-related species to form these oxides. Therefore, manganese enrichments are usually inferred to indicate the interaction between Mn^{2+} and oxygen.

Braunite [$Mn^{2+}Mn^{3+}{}_6O_8(SiO_4)$], a partially oxidized manganese silicate, is a pervasive component of Paleoproterozoic and Neoproterozoic sedimentary manganese deposits, which are typically associated with fluxes in global oxygen. Braunite's sedimentary textures suggest that this mineral is a product of diagenesis; however, like many diagenetic minerals, the precursor precipitates and post-depositional processes that lead to braunite's mineralization are poorly constrained. Understanding braunite's mineralization process should illuminate the depositional and biogeochemical history of braunite-containing manganese enrichments and enhance our paleoenvironmental interpretations of these deposits. We hypothesized that the requisite conditions for braunite mineralization involve the deposition of a manganese oxide precursor mineral that subsequently undergoes diagenetic reactions with aqueous silica and Mn^{2+} present in sedimentary porewaters. We tested this idea by synthesizing a Mn^{3+}-oxide, feitknechtite (MnOOH), and conducted experiments aging this synthetic mineral at diagenetic temperatures a siliceous solution including and omitting aqueous Mn^{2+}. At the end of the aging period, we identified braunite had formed in solutions containing both aqueous silica and Mn^{2+}. In siliceous solutions that lacked reduced manganese, we identified the precipitate as manganite (MnOOH) a polymorph of our experimental precursor. The transformation of precursor manganese oxides to form braunite upholds this mineral's capability to be used as an indicator for manganese oxidation, and thus most likely implies oxygenation or dynamic oxygen levels during precursor mineral deposition. Our results further demonstrate the importance of reduced manganese, and thus reducing porewaters, for braunite mineralization to occur.

Controls on the photochemical production of hydrogen peroxide in arctic surface waters.

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Hydrogen peroxide (H_2O_2) is a reactive oxygen species (ROS) ubiquitous in fresh and marine waters where it influences aquatic biogeochemical processes. One limitation on understanding H_2O_2's roles in biogeochemical processes is a predictive understanding of how H_2O_2 concentrations vary in surface waters, which requires knowledge of the controls on H_2O_2 production. One way H_2O_2 is produced in fresh and marine waters is through photochemical reactions initiated by the sunlight-absorbing (chromophoric) fraction of dissolved organic matter (CDOM). Arctic freshwaters are high in CDOM concentrations compared to freshwaters at lower latitudes. Thus, it has been hypothesized that arctic freshwaters have high concentrations of H_2O_2. Rates of this photochemical production of H_2O_2 may increase in proportion to the apparent quantum yield of H_2O_2 ($\Phi H_2O_2,\lambda$) produced from CDOM. However, the $\Phi H_2O_2,\lambda$ for H_2O_2 production from CDOM remains too poorly understood to predict the magnitude and range of photochemically produced H_2O_2 in arctic surface waters. To address this knowledge gap, the $\Phi H_2O_2,\lambda$ was measured in arctic surface waters collected from the north slope and coastal plain of the Alaskan Arctic in summer 2022. The average $\Phi H_2O_2,\lambda$ in these waters ranged from 5-10 fold higher than seawater reported values at 300 nm, and 2-10 fold higher than seawater reported values at 400 nm. The average $\Phi H_2O_2,\lambda$ for these waters are within range of reported values from other freshwaters. The average $\Phi H_2O_2,\lambda$ of arctic lakes, was used to predict daily photochemical production rates of H_2O_2 in arctic lakes over the summer along with photon fluxes and CDOM concentrations. Photochemical production rates are more than twice as high as those reported in freshwaters at lower latitudes. These results confirm expectations of high H_2O_2 concentrations in Arctic freshwaters, and demonstrate that the expected controls on high H_2O_2 concentrations are the relatively high $\Phi H_2O_2,\lambda$ and CDOM concentrations in these waters. Future work will compare H_2O_2 concentrations in arctic lakes to those predicted from this study.

Emulating Simplified Physical Processes in Climate Models with Machine Learning Approaches

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Machine learning approaches have been used to effectively emulate various aspects of climate and weather models in recent years. The limitations to these approaches are not yet known, particularly with regards to varying complexity of the physical parameterization schemes being emulated within the model. Utilizing a hierarchy of simplified model configurations within NCAR's Community Atmosphere Model (CAM6), we explore the limitations of such emulators via their offline skill. These include a dry CAM6 configuration, a moist extension of the dry model, and an extension of the moist case that includes an additional convection scheme. Each model configuration is run with identical resolution and timespan. We explore the effectiveness of multiple machine learning methods, including random forests and neural networks. Each emulated field across the hierarchy uses a uniquely trained machine learning model in order probe the limits of the method's ability to replicate the expected result as the complexity of the physical processes increase. All emulators are then evaluated against the CAM6 output and do show significant skill, often in line with or exceeding similar approaches within the literature. In addition, as the CAM6 complexity is increased, the machine learning skill noticeably decreases, regardless of the extensive tuning and training process each emulator goes through. This indicates a fundamental limit on the feasibility of these commonly used machine learning approaches to act as replacements for physical parameterizations in climate models. We also consider the question of how such decreases in emulator skill correspond to 'online' performance, i.e., when the machine learning emulator is coupled directly to the climate model, replacing the original parameterization schemes.

Monitoring Spatiotemporal Seismic Velocity Changes Using Seismic Interferometry and Distributed Acoustic Sensing in Mexico City

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Mexico City is highly susceptible to seismic hazards due to the active seismicity on the western coast of Mexico. The city is particularly vulnerable to strong earthquake ground motion because it is located on top of a sedimentary basin that amplifies seismic waves over long durations. It is imperative that we improve seismic monitoring that can provide information about stress changes or material damage in the city. Coda wave interferometry is well-suited for time-lapse monitoring since coda waves are sensitive to changes in the subsurface. Moreover, Distributed Acoustic Sensing (DAS) can convert standard telecommunication fiber-optic cables into dense seismic sensing arrays with a high sampling rate, providing great potential for resolving spatiotemporal variations of near-surface velocity.

In this study, we collect DAS data using a 29-km long fiber optic cable that crosses Mexico City from South to North since May 2022, consisting of 2266 channels with a 12.8-m spacing and a 200-Hz sampling rate. We first calculate cross-correlation functions (CCFs) to obtain virtual waveforms between channel pairs and perform CCF stacking. We estimate the average velocity changes with CCFs and the trace stretching method of coda wave interferometry. In a preliminary investigation, we analyze three months of ambient seismic noise CCFs averaged over daily intervals. Further testing of various parameters is required to obtain stable results. The investigation continues as we search for time variations in the ambient seismic noise signal following the 2022 Mw7.7 Mexico City earthquake and attempt to identify what structure changes may represent.

Biologically driven isotopic fractionations in bivalve genera Dosinia and Mactra between 43°S and 53°N

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Isotopic compositions of mollusk shells, specifically $\delta^{18}O$, $^{\delta 13}C$, Δ_{47}, and Δ_{48}, have been widely used in paleoclimatology. Differences in isotopic composition between the outer shell layer (OSL) of fossil bivalves, which reflects water temperature and $\delta^{18}O$ of growth water, and the metabolically influenced ISL, relate to biologically-controlled precipitation mechanisms governing formation of each layer. These biologically driven isotopic fractionations (BioDIFs), or "vital effects," are typically avoided in paleoclimate studies, but new tools (paired $\delta^{18}O$-Δ_{47} and Δ_{47}-Δ_{48} measurements) and theory combining biology and geochemistry can provide new insight into the mechanisms driving these fractionations. Preliminary data suggest that different BioDIFs may be distinct between particular genera, however few large-scale studies of BioDIFs control for phylogeny and location/environment. We characterize BioDIFs in $\delta^{18}O$, $^{\delta 13}C$, Δ_{47}, and Δ_{48} in modern bivalve genera Dosinia spp. (13 species) and Mactra spp. (10 species) over a latitudinal range of 43°S to 53°N. This can test whether BioDIFs are the same among species of a certain genus. Examining latitude and growth environments may reveal how or whether external factors such as water temperature influence BioDIFs in bivalves, which could provide insight into how reliable the isotopic compositions of these bivalve shells are as paleoclimate proxies. Characterizing the relationship between BioDIFs and the environment in modern bivalves can inform how we interpret BioDIFs in fossil bivalves as a paleophysiological proxy, which can be used to investigate evolutionary relationships, responses to environmental stress, and survivorship during times of climate change.

Local $\delta^{18}O$-elevation lapse rates modeled from upstream basin characteristics across western USA: implications for paleoelevation estimates of Basin and Range, Rocky Mountains

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Stable isotopes of oxygen have often been employed for paleoaltimetry study, though the $\delta^{18}O$-elevation lapse rate is complicated within continental interiors due to competing fractionation processes. We approach these uncertainties for the interior continental western United States by considering average $\delta^{18}O$ of ~1,500 modern surface water collection sites across the Basin and Range (BR) and Rocky Mountains/Colorado Plateau (RMCP) in the context of upstream watershed climate and physiography. Using GIS to calculate watershed polygons and extract climate data from 30-year-normals, we compiled over 130 climate statistics across each watershed. From these variables, we then developed three multivariate models considering the $\delta^{18}O$-elevation relationship in the context of watershed climate variability. Finally, we applied these models to develop more than 600 "local" $\delta^{18}O$-elevation lapse rates for 350-km radii across the Western United States. Tukey range tests for the resulting lapse rates suggest that, though the models considering upstream climate characteristics predict $\delta^{18}O$ variability better than those only considering characteristics at the point of collection, there are only minimal differences in the distribution of lapse rates derived from each model for each given region. 99.9% confidence intervals around the mean $\delta^{18}O$-elevation lapse rate for BR (-0.926‰ per km to -0.790‰ per km) is considerably shallower than the rates defined by previous studies from precipitation (e.g. Lechler and Niemi, 2011), while the same confidence interval for RMCP (-0.0420‰ per km to 0.0802‰ per km) suggests a potential mean lapse rate of 0‰ per km. Thus, within the RMCP, surface waters both modern and those preserved within the geologic record may not record significant signatures of elevation from $\delta^{18}O$ alone. Moreover, the magnitude of paleoelevation for the BR may be greater than previously estimated. Our results also suggest that lapse rates will be variable on local, as well as regional, scales, even accounting for temperature, precipitation, humidity, and latitude, which should be considered for future paleoelevation estimates.

3-D imaging of Ordovician fossils from the Chambersburg limestone using µCT scanning

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Analysis of organisms and their structures preserved in the geological record can give deep insight into past life and environments. Nondestructive 3-D imaging can offer valuable insights into biological structures while preserving samples for future investigation. X-ray computed microtomography, commonly µCT scanning, produces a dataset of cross-sectional images showing the variations in sample density which can be reconstructed in 3D. I analyzed the fossils present in a sample from the Ordovician (485-443 Ma) Chambersburg Limestone of Virginia from the UMMP Collections. This sample is included in the UMMP as a specimen of *Nidulites pyriformis* (commonly referred to as *Mastopora pyriformis* in the literature), a dasycladacean calcareous algae, with two algal fossils visible on the sample surface. µCT scanning shows internal, high-density cortical cell cups of *Mastopora* with distinct hexagonal shapes. Other features visible in the scan include likely archaeocyathid sponges, a partial trilobite exoskeleton, and a shell fragment. The archaeocyathid (a marine sponge, often reef-building), the trilobite (consisting of a cephalon), and the unidentified shell fragment were all low density relative to the sample matrix, while the trilobite specimen also included a high-density cap covering one eye socket. The differences in density between the *Mastopora*, the eye cap, and the other fossils visible in the µCT scan reveal the presence of varying mineralization processes within the sample. Expanding the use of nondestructive imaging methods enables consistent interpretation of samples and identification of fossils and taphonomic processes not apparent from surface-level analysis.

Insights into Climate Reconstruction From Palm Leaf Traits

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In order to mitigate the effects of anthropogenic climate change on extant organisms and ecosystems, it is important to understand how life responded to past changes in climate. Plants are of specific interest to global change biologists, as their leaves interact directly with the atmosphere via photosynthesis and transpiration. Certain traits of plants are sensitive to environmental and climatic factors and vary between individuals depending on growth conditions and location, thus creating a record of the plant's local environment in its leaf morphology and chemistry. Presently, the majority of paleoclimate reconstruction using plant fossils has been applied at mid-latitudes, leaving a gap for the application of such methods in the tropics and sub-tropics. Plants in the family Arecaceae (palms) are particularly promising for low-latitude paleoclimate study due to their worldwide low-latitude distribution across a diverse set of biomes, their commercial and agricultural importance, and their extensive fossil record dating to the Late Cretaceous. This study investigates how palm leaf traits record climate changes both geographically (across ~7.5° latitude and ~12° longitude) and temporally (over the past century) with implications for tracing (sub)tropical paleoclimatic conditions. Models combining leaf traits such as stomatal density and size with leaf carbon isotope discrimination (Δ_{leaf}) yield reliable pCO_2 estimates, but could potentially be further constrained with vein density, measured as vein length per area (VLA). We measured each of these traits on leaves from the palm species *Sabal palmetto* (n=184), *Caryota urens* (n=32), and *Phoenix dactylifera* (n=25) collected both from living plants across the Southeastern United States (n=149) and from worldwide historical collections housed in herbaria dating back as far as 1864 (n=92). Climate data were compiled, including mean annual temperature, mean annual precipitation, and vapor pressure deficit, from each collection location and analyzed for their relationship to individual leaf traits. While the average Δ_{leaf} of each species fell within the expected range of C_3 plants (~18.00–22.00‰), *S. palmetto* and *C. urens* showed much greater ranges in Δ_{leaf} values with maxima above the expected range (17.49–25.98‰ and 18.02–28.07‰ respectively) and showed higher discrimination overall than *P. dactylifera* (17.44–21.95‰). This suggests that *P. dactylifera* is the best candidate for paleoclimatic reconstruction, as its isotopic behavior is most similar to that of plants currently applied to existing models.

Imaging Near-Coast Subsurface with Distributed Acoustic Sensing and Double Beamforming

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An Ocean-bottom Distributed Acoustic Sensing unit collected four-month data from a telecommunication fiber cable in the coastal Oregon region. The energy of the microseisms is concentrated below 2 Hz and is generated by ocean wave-solid earth interactions. We extract clear surface waves propagating both landward and seaward using a cross-correlation scheme. The geometry of the cable enables applications of conventional slant stack in subsections and 1D double beamforming to measure phase velocity. We generate dispersion curves from Cross Correlation Functions (CCFs) with a series of virtual receiver channels with slant stack. A continuous phase velocity profile is acquired by moving the virtual source along the array. With 1D double beamforming, we first define source beam and receiver beam pairs along the cable. Presuming phase velocities of both beams, we stack travel-time-adjusted CCFs of all the source-receiver pairs within the beams. Good velocity estimates stack CCFs constructively. We look for the best-fit velocity estimates in the source and receiver beams respectively which return the highest CCF amplitude with two-step grid search. Repeating the same procedure with different beam pairs along the array and averaging over all the available estimations, we retrieve a 2D velocity profile on the region. Finally, we separately invert both velocity profiles for subsurface shear wave velocity models. We integrate two models with respect to their uncertainties to present a final model of shear wave velocity.

Expanding the fossil record of Araceae: *Arthmiocarpus hesperus*, a fruit from the Cretaceous of South Dakota

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The study and re-evaluation of Cretaceous plant fossils is an opportunity to study and expand the known diversity of Cretaceous. Araceae are the most diverse family within Alismatales, the sister group of all extant monocots (other than *Acorus*), and have a fossil record that can be traced back to the Early Cretaceous. However, fertile material is scarce, hindering interpretation of the historical origin of the subfamilies within this family. In this study, we investigated the morphology and taxonomy of *Arthmiocarpus hesperus* (Wieland) Delevoryas, a permineralized fossil from the Upper Cretaceous of theFox Hills Sandstone Cottonwood Creek, South Dakota, which was formerly interpreted as a drupe from the fig family (Moraceae). By combining traditional paleobotanical techniques and X-ray micro-computed tomography (μCT) to re-examine this species' type material, 3D reconstructions of the seed and characterization of structures in multiple planes of section allowed us to resolve conflicting interpretations of fruit-seed morphology and anatomy, and identify additional characters useful in refining potential taxonomic affinities. Based on the features of the fruits and seeds, and occurrence of helically arranged sessile berries on a central spadix, we consider this specimen to be a member of Araceae. *Arthmiocarpus* presents an unique set of characters that differentiate it from extant and extinct members of Araceae, but might be most closely related to members within the subfamilies Monsteroideae. This is an example of how Cretaceous angiosperms present sets of characters that do not fit in the modern circumscription of the subfamilies, expanding the known diversity beyond the earliest divergent lineages into more derived groups.

Investigation of Ore Forming Fluids of the El Laco Iron Oxide Apatite Deposit, Chile

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Iron oxide apatite (IOA) deposits are important sources of Fe and REEs, which are elements critical to the sustainable energy transition. Despite their economic and societal importance, IOA deposits lack an accepted model for ore formation, which presents a challenge during the search for new deposits. The Pliocene El Laco deposit located in the Central Andes, is the youngest and best preserved IOA deposit found on Earth, providing a unique opportunity to study how IOA deposits form. The El Laco deposit is hosted in an andesitic volcanic complex, and is composed of six coeval ore bodies, described as massive magnetite flows (~98% magnetite), that resemble giant effusive basaltic lava flows. El Laco has been the subject of many studies over the past sixty years, yet the genetic model is still hotly debated. Three contrasting genetic models for ore formation have been proposed: 1) Complete replacement of andesite by magnetite that precipitated from a hydrothermal fluid; 2) Crystallization of magnetite from an iron oxide magma that formed as a result of liquid immiscibility; 3) Formation via ascent of a magnetite-bearing brine.

This project aims to constrain the ore fluid composition(s) from which the main stage magnetite and apatite crystallized, giving insight into genetic models for ore formation. This is accomplished via a comprehensive petrographic and microanalytical study of fluid inclusions trapped in coeval clinopyroxene phenocrysts during evolution of the deposit. Constraining the composition of fluid inclusions in the ore bodies is critical to understanding the evolution of the deposit, however, previous studies have only analyzed fluid inclusions in apatite and pyroxene in the host andesites and surficial ore samples. This study analyzes samples from dill cores laterally throughout the deposit, providing the first complete documentation of fluid inclusions throughout the entire volume of the El Laco ore bodies.

Here, we present preliminary petrographic and microthermometry observations from clinopyroxene hosted fluid inclusions in the host andesite and the ore bodies at El Laco. Petrographic observations reveal an abundance of primary and secondary multi-phase fluid inclusions, containing a solid phase, a vapor phase, and minor daughter crystals. Freezing experiments failed to see a change in phase compositions of the fluid inclusions, suggesting one phase is an amorphous sodium-rich solid. Heating experiments show first melting ~400°C, and homogenization of some fluid inclusions ~740°C, while other fluid inclusions fail to fully homogenize upon heating to 1100°C.

Investigating the Interannual Trends and Controls on Hydrogen Peroxide in the Western Lake Erie Basin

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In the Western Lake Erie Basin, toxin formation via *Microcystis* dominated harmful cyanobacterial blooms (CHABs) occurs following high concentrations of hydrogen peroxide (H_2O_2), but the relationship between H_2O_2 and toxin-forming blooms is not well understood. To investigate this knowledge gap, 8 years of summertime Western Lake Erie data was compiled and H_2O_2 concentrations were analyzed in context of known sinks and sources of H_2O_2 (e.g., photochemical and biological production of H_2O_2). Specifically, H_2O_2 concentrations were analyzed alongside indicators of photochemical production of H_2O_2 by light-absorbing chromophoric dissolved organic matter (CDOM), and sources of CDOM (e.g., river discharge). H_2O_2 concentrations were also analyzed alongside indicators of biological production, including primary productivity (chlorophyll-a and phycocyanin), and bloom toxicity (particulate microcystin concentrations). There were large inter-annual differences in summertime H_2O_2 concentrations in Lake Erie, with some summers characterized as high concentrations (216±20 nM) and some summers characterized by lower concentrations (75±6 nM). Max H_2O_2 concentrations during each summer were observed consistently during times of peak bloom and biological activity in Western Lake Erie (late-July to mid-August). Lastly, particulate microcystin concentrations were significantly, positively correlated with H_2O_2 concentrations, but phycocyanin and chlorophyll-a showed no significant relationship with H_2O_2. This study adds additional support for the relationship between H_2O_2 and bloom toxicity in Western Lake Erie. Specifically, this study supports the hypothesis that toxin-forming cyanobacteria are better able to tolerate water column H_2O_2 than non-toxic cyanobacteria.

Ocean Temperatures and Seasonality Along the United States East Coast During the Last Interglacial as Determined by $\delta^{18}O$ of the Bivalve *Mercenaria*

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The Last Interglacial (~125ka) was the most recent time in Earth's history that global average temperatures were warmer than today. Therefore, studying the Last Interglacial climate system might allow us to better understand our current and potentially future climate systems. The temperature during the Last Interglacial has primarily been studied in the northeast Atlantic, and there is a gap of data in the southeast Atlantic, along the east coast of the United States. To fill in this data gap, I analyzed Last Interglacial-dated *Mercenaria* sp. shells collected from field sites along the U.S. East Coast in Massachusetts, Virginia, North Carolina, South Carolina, Georgia, and Florida. I used a hand drill to drill holes down the center axis of each shell and performed traditional stable or clumped isotope analysis on each of the powder samples. Traditional stable isotope analysis gave me $\delta^{18}O_{carb}$ values over the lifetime of the shells while clumped isotope analysis gave me an average $\delta^{18}O_{water}$ value, both of which I used to reconstruct growth temperatures. Because these temperature values cover multiple years over the lifetime of the shell, we can construct the seasonality in these areas and analyze the seasonality trends of and between the different latitudes. However, the shells stop growing at a certain temperature in the winter, which inhibits the exact reconstruction of seasonality, but also allows for a different comparison to be made of the growth cessation temperature values between shells of differing latitudes.

TAPHONOMY OF MOUNTAIN-PROXIMAL VERTEBRATE MICROFOSSIL BONEBEDS FROM THE EARLY PALEOCENE DENVER FORMATION OF THE DENVER BASIN (EL PASO COUNTY, COLORADO)

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Exceptionally preserved vertebrate fossils from the early Paleocene portion of the Denver Formation exposed at Corral Bluffs, east of Colorado Springs, CO—including nearly complete mammal skulls—are shedding new light on the recovery of terrestrial ecosystems in the aftermath of the Cretaceous–Paleogene (K-Pg) mass extinction. Screen-washing of vertebrate microfossil bonebeds (VMBs) is underway to better understand the structure of vertebrate communities at Corral Bluffs, which likely lived closer to the Rocky Mountains than most of the contemporaneous local faunas currently known. Qualitative observations of lower taxonomic richness and abundance of vertebrate microfossils at Corral Bluffs relative to contemporary mountain-distal localities, however, suggest that taphonomic processes that yield VMBs might differ in respect to mountain-range proximity. Here, we present preliminary results comparing the vertebrate microfossils from Corral Bluffs to the Late Cretaceous Judith River Formation of northcentral MT to better understand the taphonomy of mountain-proximal vs. -distal VMBs, respectively. Corral Bluffs VMBs are characterized by high frequencies of small elongate and equidimensional fossils, large plate-like dermal bones including turtle shells, crocodile scutes, and fish scales, and conical crocodile and fish teeth. We quantified the raw size, shape and element distribution, and taxonomic richness of fossils from four Corral Bluffs localities and compared these data to previous studies on the taphonomy of Judith River VMBs. Vertebrate microfossils from Corral Bluffs were (1) statistically significantly larger, (2) more fragmentary and sparse, and (3) taxonomically depauperate relative to those from the Judith River Formation. Although the differences in taxonomic composition and abundance may be explained by the smaller sample sizes (< 500 total specimens) and ca. 10-million-year gap separating Corral Bluffs from Judith River VMBs, the differences in size and element preservation may be related to their proximity to paleo-uplands. Vertebrate-microfossil-accumulating sinks in mountain-proximal areas like Corral Bluffs were possibly less stable, easily disturbed, and therefore captured less of the vertebrate paleo-community than mountain-distal areas. Further sampling and analysis of VMBs at Corral Bluffs will determine whether these preliminary patterns are real or simply artifacts of incomplete sampling.

EXAMINING SUB-SEASONAL FORECASTING OF NORTH AMERICAN HEATWAVES

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Sub-seasonal weather forecasting is the prediction of weather patterns and conditions over two to six weeks. Lasting longer than a typical short-term weather forecasting period of up to ten days and shorter than climatological forecasting of more than a decade, this forecasting is a rapidly evolving field that requires analyzing many geophysical conditions. Particularly one that is most challenging to forecast is the prediction of heatwaves or prolonged periods of extremely high temperatures that can persist for several days or weeks. This exploratory work aims to observe the many methods used currently for predicting heat waves in North America and emphasize the implications and importance of this work for government and citizen use. Publications and data sources from NOAA, NWS, and other scholarly sources are used to determine the uncertainties attached to the ensemble forecasting models and initial observations for heat waves. Figures throughout the literature are analyzed in conjunction with the specifications attached to popular ensemble models used in the United States, such as GEFS and ECMWF to investigate future directions for this line of work. Amongst all findings, North American heat waves are determined to have difficulty forecasting in terms of differences between ensemble models and initial observations. Perturbations between the reconstruction of data and observations remain significant and determine that sub-seasonal forecasting needs to be improved to meet the standards of ensemble modeling. Future studies and movements in heat wave forecasting are needed to explain the differences between model and observation and find the potential sources of the divergence of outcomes.

Synthesizing phyllosilicates to better understand paleoenvironments on early Earth and Mars

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Unraveling the mechanism behind the precipitation of distinct clay types may be a key component in understanding the early environments on Earth and Mars. Silicate clays, or phyllosilicates, are structurally layered minerals that form in a variety of ways, both on the surface and subsurface. Phyllosilicate layers consist of silica tetrahedral sheets and octahedral sheets dominated by magnesium, iron, or aluminum cations. Phyllosilicates can be divided into subgroups based on their silica-to-cation ratios such as 2-layer and 3-layer structures. Previous studies have indicated a dominance of 3-layer magnesium-iron smectite clays preserved on the Martian subsurface while Earth's ancient oceans produced 2-layer iron silicates. To better understand the different clays constructed on these early planets, this project explores the controls of layered clay formation. We precipitated clays with varying concentrations and ratios of magnesium and silica while pH was altered at different stages of formation. We examined the magnesium silicate clays precipitated in this experiment using Raman spectroscopy, where the changes in photon energy of molecules create a spectra unique to each molecule. The spectra of our precipitates are compared to existing spectra to identify which silicates were produced. Our intention is to understand what formation conditions produce the differing layer structure of phyllosilicates on both early Earth and early Mars, and ultimately gain insights to the clay-forming paleoenvironments on these two planets.

Crustal Field Inclusion of the Dawn-Dusk Asymmetry of the Mars Magnetotail Current Sheet

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Mars generates a weak induced magnetosphere that allows solar wind to impinge on its upper atmosphere. Depending on the solar wind strength, solar activity of the Sun, and the Martian orbit, the magnetotail current sheet region of the planet will shift either towards the dawn or dusk direction. Magnetohydrodynamic (MHD) simulations between the solar wind and the Martian upper atmosphere revealed that the ionosphere possessed notable control over the magnetotail shift. However, the crustal field was not included in the MHD simulation results. The crustal field has been shown to substantially impact the current sheet and planetary ion escape, so it is crucial that it is included back into simulations. This study uses the Block Adaptive Tree Solar wind Roe-type Upwind Scheme (BATS-R-US) code to simulate the solar wind interaction at the Martian upper atmosphere with the inclusion of the crustal field. The influence of the crustal field will be determined by observing the shift in the magnetotail, the variation of the interplanetary magnetic field, and the escape rate of planetary ions.

Can we reconstruct past ocean temperatures from the shells of sea snails? Insights into disequilibrium effects in marine gastropods through dual clumped isotope thermometry (Δ_{47}/Δ_{48})

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Clumped isotopes are heavy atoms bonded to other heavy atoms (e.g., ^{13}C-^{18}O instead of ^{12}C-^{16}O). In geosciences, the most prominent application for clumped isotopes has been paleothermometry: the reconstruction of past temperatures to better understand past climate variability. This works because there is a direct relationship between clumped isotope composition (Δ_{47}) in the shells of biogenic carbonates (e.g., clams, scallops) and their formation temperatures (T), allowing us to reconstruct past ocean temperatures. However, this Δ_{47}-T relationship does not hold true for all carbonates. For example, calculated Δ_{47}-temperatures from corals and brachiopods are colder than instrumental temperatures, while those from speleothems are warmer. To investigate these mismatches, recent studies have paired Δ_{47} with another T-dependent clumped isotope measurement, Δ_{48}. These studies demonstrated that corals, brachiopods, and speleothems precipitate out of Δ_{47}/Δ_{48} equilibrium.

Dual clumped isotopes (Δ_{47}/Δ_{48}) have not yet been measured in *marine gastropods* (i.e., sea snails), even though they are abundant in the fossil record and thus have major potential to expand the paleoclimate archive. We measured Δ_{47}/Δ_{48} in marine gastropod shells to reconstruct formation temperatures and determine whether certain species precipitate out of Δ_{47}/Δ_{48} equilibrium. We found that whelks and conchs (*Busycon* spp. / *Austrofusus glans*, *Strombus alatus*) precipitate in Δ_{47}/Δ_{48} equilibrium and reflect Δ_{47}-temperatures roughly equal to instrumental. However, tower (*Turritella* spp.) and wavy turban snails (*Megastraea undosa*) appear to precipitate out of Δ_{47}/Δ_{48} equilibrium and reflect biased Δ_{47}-temperatures - colder and warmer than instrumental, respectively. For future work, we plan to link offsets from Δ_{47}/Δ_{48} equilibrium to specific precipitation mechanisms and to use these offsets to calculate revised formation temperatures in biased species.

Sunlight stimulates respiration of ancient permafrost carbon in arctic surface waters

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The thawing of ancient organic carbon stored in arctic permafrost soils, and its oxidation to carbon dioxide (a greenhouse gas), is predicted to amplify global warming. However, the extent to which CO_2 released by permafrost thaw may amplify global warming is uncertain due to lack of understanding of the coupled photochemical and microbial oxidation of dissolved organic carbon (DOC) in arctic surface waters. This process, called sunlight-stimulated respiration, is estimated to account for 8 – 22% of the CO_2 produced in the water column of arctic freshwaters. A critical unknown is the extent to which ancient DOC draining from permafrost soils to sunlit surface waters is oxidized to CO_2 by sunlight-stimulated respiration. To address this knowledge gap, we characterized the wavelength-dependent yield and radiocarbon age of CO_2 produced by sunlight-stimulated respiration of DOC leached from permafrost soils. Our results showed that sunlight exposure of permafrost DOC results in respiration of ancient CO_2 that is as old or older than the initial, bulk DOC (ages 4,000 – 11,000 a BP). The yield of this old CO_2 from sunlight-stimulated respiration depends on the wavelength of light, with UV light stimulating respiration of up to twice as much CO_2 as visible light. Together, these findings show that sunlight-stimulated respiration will continue to contribute a substantial fraction of the CO_2 emitted from arctic freshwaters as the DOC in these waters is increasingly comprised of permafrost carbon, and that the CO_2 produced will contribute to arctic amplification of climate change.

Sulfide Inner-Core in Mars Inferred from Melting Experiments of Fe-S System at High Pressures

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The recent InSight mission to Mars has revealed a liquid core that is larger and more sulfur-rich than previously thought. The estimated 18-26 wt.%[1,2,3] sulfur in the Martian core falls on the sulfur rich side of the Fe-S eutectic point at relevant pressures. In this study, high-pressure experiments were conducted using a multi-anvil press to investigate the sulfur-rich liquidus of the iron-sulfur system. Our data provide new constraints on the temperature at the Martian core-mantle boundary and allow us to model the crystallization regime of Martian core. By comparing our data to calculated areotherms, we predict that cooling of a core containing 18-26 wt.% sulfur will lead to solidification of troilite (FeS) at the center of the Mars, with interesting implications for restarting the magnetic field on the red planet.

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First skull of the enigmatic archaic ungulate mammal '*Carcinodon'* in the Denver Basin, Colorado, prompts reevaluation of that genus

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Archaic ungulates (i.e., 'condylarths') epitomize the ascendancy of mammals in the aftermath of the Cretaceous-Paleogene (K-Pg) mass extinction due to abundance and diversity in the early Paleocene. Nonetheless, their taxonomy is problematic due to their generally fragmentary fossil record, which comprises mostly isolated teeth and jaw fragments, and their broadly similar and plesiomorphic dental morphologies. Recently, in early Paleocene exposures in the Denver Basin just east of Colorado Springs, Colorado (Corral Bluffs), exceptionally preserved mammal skulls have been discovered, providing fresh insights into the taxonomy and paleobiology of early archaic ungulates. Here we report the discovery of a mammalian cranium that is almost complete, with a maxilla including almost all premolars and all molars on both sides (DMNH EPV.132501). We assign this skull to '*Carcinodon'* based on (1) P3 length exceeding its width, (2) P3 protocone being absent, and (3) P4 parastylar lobes being buccolingually narrow and roughly parallel, thus representing the first occurrence of that genus in the Denver Basin. The upper dentition closely resembles that of *'Carcinodon' olearyi* based on the: (1) prominent hypocones on M1–M2, (2) prominent lingual cingulum continuous with precingulum and hypocone shelf on M1–M3, (3) metacone shifted lingually relative to the paracone on M2–M3, (4) similar size (M2 length = 6.10 mm), (5) hypocone extends lingually past the protocone apex on M1, and (6) parastylar lobe on M3 extends much farther buccally relative to the metastylar lobe. Species of '*Carcinodon'* have been variably placed in the genera *Chriacus*, *Baioconodon*, and *Oxyclaenus*, all of which exhibit relatively plesiomorphic dentitions. Nevertheless, our study of the nearly complete dentition of *'C.' olearyi* supports the hypothesis that '*Carcinodon'* is polyphyletic. As such, we propose that *'C.' olearyi* and *'C.' antiquus* represent a new genus separate from genotypic species, *C. simplex*, that is phylogenetically basal to *Oxyclaenus*, *Eoconodon*, and *Triisodon*, and all of their descendants. Recognition of this new genus clarifies phylogenetic relationships among early Paleocene 'arctocyonids'. Further, DMNH EPV.132501 represents the first cranial remains of this taxon and for any other 'oxyclaenid-like' archaic ungulate. Study of its cranial anatomy is ongoing, but will hopefully illuminate cranial autapomorphies that help further differentiate early archaic ungulates.

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DIVERSIFICATION OF JAW GEOMETRY DURING THE INITIAL RADIATION OF LOBE-FINNED FISHES (OSTEICHTHYES: SARCOPTERYGII)

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The Cenozoic collapse of the West Tethyan biodiversity hotspot: a test using the fish otolith fossil record

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Marine biodiversity hotspots have disproportionately greater species richness than surrounding regions. The species richness and locations of these hotspots are thought to have changed throughout the Cenozoic—transitioning from the West Tethys in the Eocene to the Arabian Peninsula during the Oligocene and finally arriving in the modern-day Indo-West Pacific in the Miocene. Despite extensive research that has examined the geographic shifts in the marine invertebrate biodiversity through the Cenozoic, direct paleontological investigation of patterns for teleost fishes remains unexplored. Although the body fossil record for marine teleost fishes is sparse, the record of teleost otoliths—aragonitic structures found in the inner ear—represents a tool for testing a hypothesized collapse of the West Tethyan hotspot. Here I present data representing 125 localities dating from the Paleocene through the Miocene. These represent nearly 100,000 individual otolith fossils. Since the relative abundance of species in these faunas are known, the richness of individual assemblages can be meaningfully compared using coverage-based rarefaction (i.e., shareholder quorum subsampling), which standardizes richness estimates based on equal coverage of underlying abundance distributions. Using these statistical methods, I could not identify local richness shifts from the West Tethys to the Indo-West Pacific during the Paleogene to Miocene interval. Furthermore, the decline in biodiversity in the West Tethys is found to have occurred in the late Miocene. These results oppose the extensive literature on eastward shift of marine invertebrates into the Indo-West Pacific. It is unclear if teleost fishes made the same migration pattern as other marine organisms or if their shift occurred much later.

ASSESSING THE ACCUMULATED WINTER SEASON SEVERITY INDEX AND POSSIBLE TELECONNECTION PATTERNS FOR ANN ARBOR

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The Accumulated Winter Season Severity Index (AWSSI) is a product maintained by the Midwestern Regional Climate Center (MRCC) to provide context and information to the National Centers for Environmental Information (NCEI). The information collected gives a quantitative scale to the severity of winters similar to how the Enhanced Fujita scale compares tornadoes or the Saffir-Simpson for hurricanes. However, the meaning of a severe winter can greatly differ based on region, so the AWSSI score is most beneficial when compared to previous winter seasons from the same location. We aim to identify Ann Arbor's winter severity with the AWSSI scale to learn more about Ann Arbor's winter climate and the possible teleconnections involved in producing the extremes in the dataset.

This project uses previously written code to construct an AWSSI score for every day in the Ann Arbor dataset from July 1881 to the end of December 2022. The current graphs report the running daily sum of these scores for each winter season as well as the top three highest and lowest years' scores. The key message from these graphs is the particular winter season severity score in a context bounded by the highest and lowest scores in the same location.

The next steps in this project are to evaluate the atmospheric conditions that created the highest and lowest scores. Then using teleconnection patterns, like the El Nino Southern Oscillation (ENSO) index, in hopes of identifying similarities or trends with the scores. Possible correlations can lead to enhanced forecasting ability and a greater understanding of how winter seasons develop under specific climatological conditions. All to better inform the public on what to prepare for and expect each winter.

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HIGH-TEMPERATURE GRANULITE METAMORPHISM IN THE IVANPAH AND SOUTHERN MCCULLOUGH MOUNTAINS

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Pyroxene Phenocrysts as Tracers of Melt Water Content in Lunar Basalts

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CYANOPHAGE LYSIS OF BLOOM-FORMING CYANOBACTERIA *MICROCYSTIS* SPP. FROM WESTERN LAKE ERIE

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Microcystis spp., bloom-forming cyanobacteria, dominate cyanobacterial harmful algal blooms (cHABs) found within eutrophic freshwaters like western Lake Erie (Laurentian Great Lakes). Cyanophages (viruses) play a large role in cyanobacteria life cycles, driving nutrient mobilization and facilitating the transfer of genetic material. Cyanophage lysis of *Microcystis* host cells poses serious public health risks as *Microcystis* spp. can produce microcystin, a hazardous hepatotoxin, and lytic events can increase human exposure to toxins. In this study, strains of *Microcystis* from western Lake Erie were inoculated with the cyanophage MVGF_J_348, which also originated from western Lake Erie. In the lab, the virus was inoculated at two densities in four host strains. Host cell death was measured using optical density and viral replication was measured using qPCR. Two host strains (282-2 and 282-3) showed complete lysis within 2 days while the other two hosts (282-1 and 282-4) showed incomplete lysis and recovered within the 12-day sample period. Additionally, cyanophages Ma-LMM01 and MVGF_J_348 were quantified in environmental samples taken from western Lake Erie during the 2022 bloom season. MVGF_J_348 concentrations were elevated on certain dates and Ma-LMM01 concentrations were insignificant. The findings provide a further understanding of viral-host interactions between cyanophages and cyanobacteria in bloom environments, showing potential for future applications in bloom monitoring, control, and mitigation. Understanding lytic cyanophage activity in cHABs is crucial in protecting public health from bloom toxins.

Carbon and Nitrogen Source to Sink Dynamics in a Modern Hypoxic Lake System

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Rising water temperatures caused by climate change are predicted to strengthen stratification and increase the prevalence of anoxia in lakes. Lakes are major contributors to the global carbon (C) and nitrogen (N) cycle, so it is important to understand how anoxic conditions in freshwaters may alter biogeochemical transformations of organic matter (OM). This study investigates C and N source to sink dynamics in the hypoxic Middle Island Sinkhole (MIS), a submerged karst feature in Lake Huron, using sedimentary bulk and chlorophyll isotopes. The influx of anoxic groundwater into MIS distinguishes this region from overlying Lake Huron waters by promoting the formation of a strong redoxcline, thriving benthic microbial mats, and organic-rich sediments. Although cyanobacteria-rich mats overlie MIS sediments, preliminary comparisons of bulk and chlorophyll nitrogen isotopes support eukaryotic algae from the water column as the major contributor to photosynthetically-derived OM in MIS sediments, with an ~80% contribution. However, water column OM sources are microbially transformed upon their deposition into the sediments, which is reflected by the lower average $\delta^{15}N_{bulk}$ value of MIS sediments (-0.5 ± 0.8 ‰) compared to settling particulate OM (1.6 ± 0.2 ‰). One possible explanation for this pattern is the dissimilatory nitrate reduction to ammonium and diel vertical migration of diatoms causing the production of ^{15}N-depleted compounds in surface sediments (average $\delta^{15}N_{bulk}$: -0.7 ± 0.9 ‰) that may be preferentially consumed by microorganisms deeper in the sediments (average $\delta^{15}N_{bulk}$: -0.3 ± 0.6 ‰). In contrast, an enrichment of average $\delta^{13}C_{chl}$ is observed from surface (-26.6 ‰ ± 1.8) to deep sediments (-24.3 ± 0.5 ‰), an expected trend that likely results from the preferential removal of lighter carbon by microbial respiration. Freshwater low-oxygen conditions are expected to foster unique microbial processes and communities capable of impacting the balance of C and N pools as revealed by MIS sediment isotope signatures. Future work will focus on assessing the chemical reactivity of preserved sedimentary OM within this system to assess whether anoxic lake environments will become C and N sources or sinks. These findings also serve as a foundation for understanding C and N preservation and burial mechanisms, which are valuable for interpreting paleolake sedimentary records.

Improving coastal ice cover forecasting: a case study from the Laurentian Great Lakes

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To better support coastal ice forecasting and Great Lakes coastal management agencies, we revisit findings and improve the statistical ice cover model presented in Ji. et al [Climatic Change 154(1):125–141]. The model focused on the Apostle Islands National Lakeshore (APIS) and derived relationships between teleconnections and ice cover from 1972 to 2015. Upon analysis of APIS coastal ice cover, the study found a climatic regime shift after 1997. We consider these findings and improve the model by expanding the ice cover historical record and adding explanatory variables with increased climatic relevance. Our analysis of the expanded ice cover record indicates a continuation of the post-1997 regime shift with multiple years having no low-risk ice cover. The revisited model, therefore, continues to represent this regime shift and also shows improvements to the skill and real-life applicability of the model. This model provides a basis for coastal ice forecasting all around the Great Lakes as well as improving APIS management planning.

Morphological and ecological changes of *Chione elevata* through the Pliocene-Pleistocene boundary

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The Pliocene-Pleistocene fossil record of Florida records a major mollusk mass extinction over the past 3-5 Ma. Understanding the causes of this extinction event involves analyzing changes in taxa that lived during that time. Chione sp. is a bivalve taxon that commonly occurred in both the past and present (different species) in Florida and the Caribbean. It is found in great abundance in Plio-Pleistocene deposits in central Florida and surrounding regions. As with other bivalves, growth rates are dependent on environmental factors (i.e. nutrient concentration, temperature, predation). Due to the overall abundance of Chione within the Florida region, robust statistics are possible with this taxon that are not possible with rarer taxa. We gathered over 1000 valves of Chione from bulk sediment samples collected every half meter through 9m of section at Punta Gorda, a Florida shell quarry, taken from the 3/8" to 1" sieved size fraction. With each valve we examined the number of boreholes, ornaments, and notches (indicator of age). Surface area data was measured with a computer program, ImageJ, which we used to convert an 8-bit, high-contrast photo into numerical area measurements of each valve. We have found changes in predation through the section indicated by variability in the prevalence of boreholes; the number of boreholes per valve decreased dramatically through the 3 – 4 m and 6.5-7 m portions of the section. As low as 2% of Chione valves exhibited boreholes in these intervals (compared to 27% in the 5.9 – 6.1 m interval). Size distributions of Chione also vary through the section. Studying changes in a single populous taxon can lead to understanding of the environmental conditions at play. Results from this study will be paired with grain size indicators and isotopic paleothermometry to describe a holistic picture of the past environment, and to reveal a backdrop on which the mass extinction took place.

Faunal Assemblage Changes in Shell Beds from the Pleistocene Florida Platform

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The Earth is constantly evolving, with landscapes looking dramatically different then they did in the past. This is no different for the Southwest Florida ecosystem in which this project attempts to gain a more complete understanding of its diverse and colorful history over the last three million years. Using samples of fossilized seashells from the Pleistocene era taken from a quarry in southwest Florida, this study pieces together what the environment was like during that time period. It is already accepted that sea levels were higher in the Pleistocene compared to today. Additionally, the Panama Isthmus was rising out of the sea, drastically changing ocean currents around the globe. We attempt to uncover how these factors impacted this coastal community by analyzing the particular mollusk species present. This was done by first collecting 15 bulk samples at regular intervals within the studied section. Within each sample, we quantified the number of fossil shells, relative abundance of different species, paying particular attention to taxa that indicate changes in salinity. The results have shown that the ecosystem underwent significant changes over the studied time interval. For example, in some bulk samples freshwater-dwelling shells were prevalent, whereas in others the shells were limited to strictly salt water taxa. Some species rose and fell, while others remained a powerful and constant presence. Looking collectively at the over 2000 shells used in the study, it is clear that the Pleistocene Florida platform was an ever changing and dynamic marine to semi-marine environment.

Interrogating the record of Archean tectonics from metamorphic rocks in the Minnesota River Valley, USA (Superior Province)

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If and how plate tectonics operated in the Archean eon remains a controversial topic. The Minnesota River Valley (MRV) gneiss terrane in the southernmost part of the Superior Province contains a variety of tectonic "blocks" with diverse igneous and metamorphic rocks dating back to over 3.5 Ga. Therefore, its geologic history provides valuable insights into the tectonic processes that shaped the early continents. This study focuses on the granulite-facies Montevideo and amphibolite-facies Morton blocks of MRV, which are separated by the east-trending Yellow Medicine shear zone. We combined inverse thermobarometry calculations and phase-equilibrium modelling to constrain the pressure (*P*) and temperature (*T*) of peak metamorphism in the two blocks. The Morton amphibolite-facies metamorphic conditions are inferred to be 610–760 ℃ and 3.8–6.3 kbar, and the Montevideo granulite facies to be 800–860 ℃ and 4.4–7.0 kbar. The two blocks are likely metamorphosed together by advective heating due to plutonism at *c.* 2.6 Ga. We also performed zircon and monazite U–Pb geochronology and garnet diffusion chronometry to obtain ages and duration of metamorphism. The *P*–*T*–*t* data is used to determine the tectonic and thermal conditions of Archean metamorphism in the two blocks and whether significant lateral translation of the blocks—akin to modern plate tectonics—could have caused their juxtaposition.

Dissolved silica influences the bulk iron redox state and transformation products of photoferrotrophy

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Chemical sedimentary deposits known as Banded Iron Formations (BIFs) are one of the best surviving records of ancient marine geochemistry. The precursor sediments to BIFs precipitated from ferruginous, silica-rich waters prior to the Great Oxidation Event (GOE) at ~2.43 Ga [1]. Reconstructing the mineralogy of BIF precursor phases is key to understanding the coevolution of seawater chemistry and early life. Many models of BIF deposition invoke the activity of Fe(II)-oxidizing photoautotrophic bacteria as a mechanism for precipitating Fe(II,III) and/or Fe(III) minerals in the absence of molecular oxygen [2]. The identity of phases produced by ancient photoferrotrophs remains debated, but laboratory experiments provide a means to explore what their mineral byproducts might have been. Few studies to date have thoroughly characterized phases produced by photoferrotrophs in settings fully representative of Archean oceans. Furthermore, there is little data on the extent to which these oxidation products undergo Fe(II)-catalyzed mineral transformation, as might be expected during descent through ferruginous water masses. The concentration of dissolved Si is an important variable in this process, as interactions with silicate species may influence the morphology and reactivity of Fe(III)-bearing phases [3, 4]. To address these uncertainties, we cultured *Rhodopseudomonas palustris* TIE-1 as a photoferrotroph in synthetic Archean seawater with an initial $[Fe(II)_{aq}]$ of 1 mM and $[Si_{aq}]$ spanning 0 mM-1.5 mM. Ferrihydrite was the dominant precipitate across all Si concentrations, even with substantial Fe(II) remaining in solution. Substantial Si co-precipitated with ferrihydrite via surface adsorption, although amorphous silica may have formed an additional phase at $[Si_{aq}] \geq 1.2$ mM. Lepidocrocite, goethite, and magnetite were observed at low $[Si_{aq}]$ and are interpreted to be products of Fe(II)-catalyzed ferrihydrite transformation. Finally, the fraction of Fe(II) in precipitates increased as a function of $[Si_{aq}]$, suggesting that Fe(II) may associate with outer-sphere complexes on siliceous ferrihydrite. These experimental results deepen our understanding of the potential phases initially present in BIF sediments.

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Eutectic composition of Fe-C binary system at high pressures

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Diffusive Ti isotope fractionation in haplobasalts

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Isotope fractionation during diffusion is a fundamental process in magma systems. However, diffusive isotope fractionation has not been studied for many elements, and Ti is one of them. Being a high-field strength element, Ti diffusivity is not much different from that of Si in the melt. Therefore, the β factor (defined as $\ln(D_2/D_1)/\ln(m_1/m_2)$, where D is diffusivity, m is atomic mass, and subscripts 1 and 2 indicate light and heavy isotopes) for Ti isotope diffusion may be close to zero based on the empirical relation between β and ratio of diffusivity of the element to that of Si [1], and whether diffusive Ti isotope fractionation is observable in natural magmatic processes is unknown. Here, we report the first study of diffusive Ti isotope fractionation in haplobasaltic melts using diffusion couples from [2]. The $^{49}Ti/^{47}Ti$ isotope ratio profiles in diffusion couple experiments have been measured at WiscSIMS Lab using IMS-1280. We pushed the limits of current SIMS to measure these non-traditional stable isotope ratios. The resulting data show that SIMS measurements using IMS-1280 can reach 0.10‰ (2σ) with effort at TiO2 concentration of ~3 wt% using multi-collection Faraday cup with 10^{12} ohm feedback resistors. However, at low TiO_2 concentration of 0.015 wt%, the precision in measured $^{49}Ti/^{47}Ti$ is about 1.0‰ by single collection electron multiplier with magnetic field scan. For initial Ti concentration contrast of about 200 in a diffusion couple, the total variation in $^{49}Ti/^{47}Ti$ across a diffusion couple profile is about 3.2‰, which is much larger than equilibrium Ti fractionation on magma [3]. By fitting the isotope ratio profiles, the β value is 0.030±0.002 for the MgO- TiO_2 interdiffusion couples and ~0.036 for the TiO_2 interdiffusion couples both at 1500°C. Hence, the total Ti isotope ratio variation would be > 1‰ along a diffusion profile when the initial TiO_2 concentration contrast is larger than 15. Such high concentration contrast may be realized for basalt-rhyolite magma mixing. These results will allow us to quantify the transport of Ti isotopes and help us to gain a deeper understanding of the diffusion mechanism on molecular level.

1. Watkins et al. (2017) RiMG 82, 85; 2. Guo & Zhang (2016) GCA 195, 126; 3. Greber et al. (2021) Chem Geol 578, 120303.

Spectroscopic Observations and Global Magnetohydrodynamic Simulations of the Solar Corona During the 2017 Total Solar Eclipse

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Total solar eclipses are one of the best opportunities to study the elemental composition and plasma properties of the solar corona within 2–3 R_s above the solar surface. In this work, we present spectroscopic observations of the solar corona acquired during the 2017 August 21 total solar eclipse with a three-channel partially multiplexed imaging spectrometer operating at extremely high orders (> 40). The field of view covered a 4 R_s North-South slit span, starting at the central meridian which scanned a heliocentric distance of ~1.3 R_s off the west limb throughout totality. The line widths and Doppler shifts of the Fe X (637.4nm) and Fe XIV (530.3nm) emission when present, yielded ion temperatures and speeds along the line of sight in different coronal structures such as streamers and coronal holes. The plasma diagnostics inferred from the eclipse emission line profiles are then compared with emission line profiles of the extreme ultraviolet (EUV) lines (e.g., Fe X 18.45 nm and Fe XII 19.51 nm) observed with Hinode/EIS at the base of the southern polar coronal hole. EIS made a 60-arcsec scan in the East-West direction and recorded EUV line profiles from additional heavy ions up to 1.2 R_s, which provide additional diagnostics of the electron density and temperature in the coronal hole. Furthermore, the Alfvén Wave Solar Model (AWSoM) is also used to simulate the global corona during the eclipse, thus enabling an assessment of the impact of the distribution of plasmas from different coronal structures along the line of sight on the inferences of the plasma properties from the spectral data.

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