Crossroads Conference 2013

GEOLOGY

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Welcome to Crossroads 2013!

We want to say a special thank you to all of you who are participating in this year's Crossroads Conference at Indiana University Department of Geological Sciences. Crossroads has a long and rich tradition at IU, and we anticipate this year will be even better with numerous student presentations, three special sessions, and a number of companies represented. We want to thank our sponsors, listed below, as well as all of the judges who have committed their time to this event, and the Department of Geological Sciences at IU for their support of this event. Thanks, and we hope you enjoy Crossroads 2013!

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Henry Scott	Indiana University South Bend
Todd Thompson	Indiana State Geological Survey

SCHEDULE OF EVENTS

FRIDAY

8:00 – 9:00	Breakfast served for presenters and judges – S201	
9:00 – 11:00	Poster Session I: Energy & Environment (MSBII Lobby)	Oral Session I: General (GY-143)
11:00 – 12:00	**Paleontology Keynote: Dr. Jim Farlow – GY-126**	
12:00-1:00	Lunch served for presenters and judges – S201	
1:00 – 2:30	Poster Session II: Mars & Beyond, Paleontology (MSBII Lobby)	Oral Session II: Energy & Environment, Mars & Beyond (GY-143)
2:30 – 3:30	**Mars & Beyond Keynote: Dr. Nathaniel Putzig – GY-126**	
3:30 – 5:00	Poster Session III: General (MSBII Lobby)	Oral Session III: Paleontology (GY-143)
5:00 – 6:00	**Energy & Environment Keynote: Dr. Bennett Brabson – GY-126**	
7:00	Social at Nicks – Downtown Bloomington (see last page map)	

SATURDAY

8:00 – 9:30	Breakfast served for presenters and judges – S201
9:30-10:00	**Awards Ceremony – GY-143**
10:00-12:00	**Company Presentations – GY-143**
12:00-1:00	Lunch served for presenters and judges – S201
1:00-1:30	**IU Imperial Barrel Award team presentation – GY-143**
1:30-4:00	Networking with company representatives – S201

Oral Sessions (Friday, April 5)

Oral Presentations are located in GY-143 15 minutes total

General – 9:00-11:00	Energy & Environment/ Mars & Beyond – 1:00-2:30	Paleontology – 3:30-5:00
Daniel Fetherston	Kristin Leftwich	Allison K. Bormet
Emily Stewart	Ryan Wells	Blaire Hensley-Marschand
Hind Ghanem	Ankur Roy	David M. Grossnickle
Liz Cola	Ryan Sullivan	Richard J. D. Bykowski
Matthew Dunlop	Tim Wright	
Theresa Dits		
Xiaotao Yang		

Poster Sessions (Friday, April 5)

Poster sessions are in the main lobby of MSBII, located just northeast of the Geology Building

Energy & Environment – 9:00-11:00	Paleontology /Mars & Beyond – 1:00-2:30	General – 3:30-5:00
Aaron Baer	Amy Goldman	Allison Bryan
Agnieszka Furmann	Devon Colcord	Anna Nowicki
Allen Quaderer	Kevin Webster	Elizabeth Sherrill
Andrei Butterfield	Sarah Beth Cadieux	Erica Cotter
Daniel Mizsei	Steven Battaglia	Haleigh Howe
David Mills	Brendan Paddack	Ian Wang
Dominique Haneberg-Diggs	Isabella Cross-Najafi	James Wallace
Hui (John) Wang	James Hardy	Jared Swihart
Karly Schmidt	Mackenzie Kirchner-Smith	Jeremy Maurer
Katherine Gigandet	Miao Zhao	Joshua D. Field
Mark J. Belding	Wesley Vermillion	Ray Chuang
Paola Crippa	Zhan Qingbin	Rebecca Caldwell
Steven Emenhiser		Ryan T. Deasy
		Scott David
		Yanyan Chen
		Ying-Feng Chen

Keynote speakers

Dr. James Farlow – Friday 11:00 am

"Dinosaur Tracksites of the Paluxy River Valley (Glen Rose Formation, Lower Cretaceous), Somervell County, Texas"

Dr. Farlow is a vertebrate paleontologist, specializing in dinosaur trace fossils, biomechanics and physiology. He is a professor in the Department of Geosciences at Indiana University-Purdue University Fort Wayne in Fort Wayne, Indiana.

Dr. Nathaniel Putzig – Friday 2:30

"3-D Radar Imaging of the Martian Polar Caps"

Dr. Putzig is a Senior Research Scientist at Southwest Research Institute Department of Space Studies. He is currently focused on characterizing the global and regional near-surface properties of Mars through modeling and analysis of radar and thermophysical data from spacecraft in orbit around Mars. He has twelve years prior petroleum industry experience as an exploration geophysicist with expertise in prospect development and seismic data analysis.

Dr. Bennett Brabson – Friday 5:00

"Climate Change: Burning Questions for You Geologists"

Dr. Bennett Brabson is an Emeritus Professor of Physics at Indiana University Bloomington. He currently teaches a course on environmental physics. Some of his current research focuses on extreme value analysis, soil moisture and climate models, and climate change in Australia. He will give an introduction to climate science and give a description of the kinds of questions that climate scientists are able to answer and those they are not, as well as what we can learn about the future by looking at the past.

Presentations

Anisotropy in Fracture Clustering: A Lacunarity Study

Ankur Roy — *University of Tennessee, Knoxville*

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Abstract

The clustering of fractures can lead to preferential flow pathways influencing the equivalent permeability of a network. Quantification of the directional variability in clustering within a network is important for understanding anisotropy. Lacunarity, L is a parameter that can quantify the clustering of spatial patterns at different scales, r. We have recently employed L(r) to quantify clustering along the NS and EW directions of a set of synthetic and natural fracture maps and compared the results to the anisotropy in equivalent permeabilities. The present study provides a more robust computation of lacunarity for finding the clustering anisotropy of fracture maps. A scanline passing through the center of a square map was rotated every 15° and the lacunarity at each orientation was calculated. Rotating the scanline changes its length. Furthermore, the number of fractures encountered at different orientations will vary. To accommodate these two factors, a normalized value for the lacunarity, L*, was employed, and the weighted mean of this value, wmnl, was computed, the weights being the normalized scale, r*. The normalization was such that the values of both L* and r* varied between 0 and 1. A circular plot was constructed from the computed wmnl values in order to delineate the clustering anisotropy for any given map. A set of 7 nested natural fracture maps from the Devonian Sandstone, Hornelen Basin, Norway were analyzed using the circular wmnl plots. The results bring forth two important observations. First, distinct sets of fractures can be delineated when the maps are differentially clustered. Secondly, clustering anisotropy appears to decrease at larger scales suggesting that large scale fracture networks are more isotropic. This is because fractures become more randomized at these scales as observed in a previous study by our group. Finally, comparing circular wmnl plots with permeability ($1/\sqrt{K}$) anisotropy plots may delineate if anisotropy in clustering implies anisotropy in flow.

Understanding Spatiotemporal Variability of Fine Particulate Matter Concentrations in Indianapolis, Indiana

Ryan Sullivan — *Indiana University Bloomington*

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Abstract

Long-term exposure to elevated levels of fine particulate matter (PM2.5 particles with diameter ≤ 2.5 μm) is associated with reduced health and life expectancy in an estimated 2 million people globally and tens of thousands of people within the United States. Recent research has shown that even short -term exposure to high PM2.5 concentrations can prompt both fatal and nonfatal cardiovascular disease. Inhalation of PM is also being investigated as a possible conduit for human exposure to heavy metals. My research is focused on providing more detailed spatial and temporal characterization of PM2.5 concentrations in order to quantify true population exposure to and therefore health impact from PM2.5 in an urban environment. I will present over 1 year of direct observations of PM2.5 at two sites in Indianapolis and statistical analyses designed to quantify spatial and temporal variability of PM2.5 concentrations, and identify dominant sources of PM2.5. Preliminary findings indicate; (i) episodic occurrence of concentrations > 50 μg/m^-3, (ii) a clear bias towards the occurrence of higher extreme concentrations on weekdays (quantile-quantile analyses indicate substantial differences above the 90th percentile on weekdays and weekends), (iii) peaks in the power spectra at frequencies that are also dominant in carbon monoxide indicating a link to primary emissions associated with vehicular traffic, and variance on diurnal and synoptic scales which are likely linked to meteorological processes. I will also discuss more recent data from four distributed sites and outline a unique approach of mobile sampling collected during bicycle transects through the city, to be conducted in the summer of 2013, which will provide a dataset of higher spatial resolution.

How much heat is irrigation hiding from local climate records?

Tim Wright *Indiana University Bloomington*

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Abstract

Introduction of irrigation reduces temperature and increases atmospheric water content by increasing evapotranspiration and latent heat exchange. However, the spatial scales at which these effects are expressed are not well-quantified. This analysis is focused on comparison of air temperature and atmospheric moisture between irrigated and non -irrigated sites, and uses equivalent potential temperature (θ e) as a way of quantifying the total atmospheric heat content. The irrigated sites have higher θ e than non-irrigated sites because of the higher moisture content of the air, despite having lower air temperatures. Consistent with prior expectations, these differences were found to be greatest during the summer growing season and least during the winter, and indicate that while enhancement of irrigation may causes a downward trend in air temperature, and thus mask greenhouse gas induced temperature trends, the total atmospheric heat content is increased. Given atmospheric moisture content is not available from long climate records, these effects are also explored using potential evapotranspiration (PET) and daily maximum and minimum temperatures. PET is a good proxy for atmospheric heat content because it uses daily mean temperature and diurnal temperature range, which again are affected by overall atmospheric heat and moisture content. The transition to irrigated agriculture is found to coincide with a downward trend in PET. Drought usually results in increased PET when vegetation wilts and soils dry because of less available moisture. However, at irrigated sites, drought signals are dampened or absent. Therefore, accounting for irrigation or use of data collected away from the influence of irrigation will be better suited to synthesize drought signals and climate variation.

Metals Analysis at a Sulfate Reducing Bioreactor in Pike County, Indiana

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Abstract

Sulfate reducing bioreactor cells (SRBC) are a new technology for remediation of acid mine drainage (AMD). AMD is created when pyrite and other sulfides present in coal oxidize in contact with oxygen and water. The water seeping from mine refuse piles is thus concentrated in sulfuric acid and dissolved metals. The SRBC at the Blackfoot site in Pike County, Indiana, was constructed by diverting the flow from the seeps on site into a shallow pit lined with limestone gravel and hay. The SRBC is designed to promote biological reduction of sulfate to sulfide, which incorporates heavy metals as it precipitates, and to generate alkalinity by dissolution of limestone. This is the first study to measure metal concentrations at the Blackfoot site. Analysis of metal concentrations can be useful for assessing the performance of the SRBC. Water samples are being collected from ports throughout the bioreactor and from the inflow, outflow, and downstream near where the outflow joins a tributary of the Patoka River. Samples have been collected since February, 2011, as part of a larger Indiana Geological Survey monitoring effort, and analyzed for trace metal concentrations by ICP-MS. The Blackfoot bioreactor has proven to be highly effective for metal precipitation. Preliminary results show several toxic metals are above EPA limits at the inflow, but all are at acceptable levels at the outflow. However, mixing of untreated water with the treated water leads to slightly higher concentrations at the downstream station.

Relationships between porosity, organic matter, and mineral matter in mature organic-rich marine shale of the Belle Fourche and Second White Specks formations in Alberta, Canada

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Abstract

This study evolved from human need to satisfy the growing demand for energy consumption. In order to complement the energy supply coming from conventional resources, the study on relatively new unconventional energy resources was recently undertaken. This study evaluates the mid-Cretaceous Second White Specks (SWS) and Belle Fourche (BF) formation in Alberta, Canada as the potential emerging hybrid source rock/reservoir resources in North America. As the lithology represents tight, low-permeability shales, the study approach needs to be different from the one applied to conventional hydrocarbon reservoirs. The main focus is to understand the variations in porosity distribution and to discuss mineralogical and organic matter controls on porosity characteristics to determine the ability of these formations to represent a tight oil/gas play. Application of combined organic petrology, organic geochemistry, mineralogy, and porosimetry helps to interpret the depositional environment, to determine the kerogen type and total organic carbon content, to estimate the remaining hydrocarbon potential, also oil or gas proneness, and to enhance our knowledge about the pore size distribution in shales, i.e. factors which have overall control on hydrocarbons' producibility and their storage within the hybrid formations. Initial petrographic examinations document the marine Type II kerogen with limited terrestrial input. Vitrinite reflectance Ro (0.74-0.87 %) and Tmax values (438-446 °C) indicate a mid-maturity within the oil window. The relatively poor hydrocarbon potential expressed as a S2 value between 2.1 and 6.5 mg HC/g rock may result from the 60-83 % of kerogen conversion to hydrocarbons earlier in geologic history and subsequent migration to conventional sandstone reservoirs. However, the present day remaining TOCpd content is still relatively high (1.7-3.6 wt. %), and estimated 60-83 % transformation ratio suggests that hydrocarbons can be still trapped in these rocks.

Evaluation of Mineralogic and Petrographic Alterations in Intruded Pennsylvanian Coal and Associated Clastic Sediments

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Abstract

Pennsylvanian coal deposits are ubiquitous across the Illinois Basin and are exploited as natural energy resources. This study analyzes the local thermal alteration induced by dike intersecting the vitrinite-rich (92.2 vol. %) Springfield Coal Member, as well as the underlying paleosol and overlying black shale. Series of samples from all three horizons were collected to determine the maturity level via vitrinite reflectance (Ro) due to the heating caused by the intrusion. Ro within the coal itself increased from a background value of 0.62% at 5.5 m distance from the dike to 5.03% at the dike contact. Correspondingly, Ro increased from a background of 0.67 % at 3 m distance to 1.74 % in the paleosol at the contact, and from 0.45 % to 2.55 % in the black shale above the coal seam. Different lithological characteristics cause variable thermal conductivities of these rocks and limit the extent of contact metamorphism. Proximate and ultimate analyses of coal showed a s ignificant decrease in hydrogen and nitrogen content closer to the intrusion. The ash content increases within the contact aureole and then decreases within 0.5 m distance from the contact. Qualitative analysis of mineral matter via X-ray diffraction identified clays, feldspars, sulfides, carbonates and silicates. The calcite content increases with the decreasing distance from the intrusion contact in both coal and clastic rocks. Additional analysis of the total carbon content via an Eltra CS -2000 confirmed that trend for clastic sediments. Total sulfur content showed an overall decrease near the intrusion. Calcite and organic carbon decrease within the one meter from the intrusion contact in the coal. The carbonate content in both shale and paleosol also decrease near the intrusion contact. Mineral composition changes along thermal maturation, probably via dissolution and/or decomposition through limited fluid interactions along the contact.

Characterization of a Utica Shale Seismic Reflector Using Well Log Data and Amplitude Variation with Offset Analysis

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Abstract

We identify and characterize a seismic reflector associated with the Utica Shale from vibroseis seismic reflection data. The Utica is a middle-Ordovician shale and is underlain by the Trenton Limestone which is a strong reflector. To investigate the reflector, we used geophysical well log data, and NS-EW vibroseis seismic reflection lines collected by Wright State University at the Dominion East Ohio Gabor Gas Storage Field near Canton, Ohio. Sonic and density logs from selected wells were modeled using Hampson-Russell software using a wavelet extracted from the stacked and migrated seismic data. Acoustic impedance and reflectivity were computed for the logs, and the seismic wavelet at the appropriate time interval was extracted and convolved with the reflectivity to yield a synthetic seismic signature. We identified a prominent reflector from the top of the Utica Formation associated with a velocity and density low within the formation. To model the AVO response, gradient versus intercept plots were created using the two-term Aki-Richards approximation. Radon transform filtering was applied to normal moveout (NMO) corrected common depth point gathers processed to preserve amplitude. The gathers were transformed to amplitude vs angle of incidence gathers to examine potential amplitude variation with offset (AVO) effects. These gathers were examined for AVO type. The AVO type was determined to be Class II, showing a small normal incidence amplitude at near offsets changing to largely negative amplitudes at further offsets. In our seismic data, we also note some complex behavior in terms of multiple reflections and thin bed tuning, and our well logs show variations of density and velocity within the Utica, indicating that the seismic signature of the Utica changes very rapidly laterally.

Sedimentary Facies in the Upper Ordovician Maquoketa Group of Indiana: A Preliminary Analysis

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Abstract

The Upper Ordovician Maquoketa Group is a mixed carbonate-clastic succession in Indiana, laterally equivalent to the Utica Shale. Previous work on this succession has largely ignored small-scale (i.e., cm-scale) heterogeneities within the fine-grained mudstones. The purpose of this study is to identify facies distribution along more stringent sedimentary guidelines and how they relate to geophysical properties in the sub-surface using wire- line logs. Describing lithofacies variation of the Maquoketa from proximal paleo-sediment source (i.e., the Taconic mountains) to distal depositional zones at the edge of the Illinois Basin will be the primary objective. Detailed descriptions were made of three cores, from northeast to northwestern Indiana. In the proximal setting of Wells County, we find that, vertically, the lower Maquoketa Group consists of graptolitic dark pyritic mudstones. Upsection, light off-color cm-scale mudstone banding is observed, along with calcareous silt lags. Brachiopods, bivalves, and other fossils become common in the middle of the studied section. Alternating bioturbated black/gray shale cycles (2 to 70cm thick), are present in the upper half of the group. Before fading into a carbonate-dominated succession, the Maquoketa is capped by a heavily burrowed light-gray mudstone. Five shale sub-types are noted in this core. In the distal setting of Fulton and Lake Counties however, the variety of mudstones appear to diversify dramatically. The lithofacies variation becomes apparent moving westward (i.e., distal), as the shale sub-types vary in thickness and frequency, as well as change in the overall matrix composition of the group with regard to calcite cementation. This probably reflects depositional environment, indicating a shift to a deeper marine setting. What remain to be seen via petrographic characterization of polished thin sections is whether there is true change in the sub-types across the state or whether these are new shale sub-types.

Concentrated Animal Feeding Operations and Surface Water Quality

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Abstract

In recent years, a shift from family operated farms to concentrated animal feeding operations (CAFOs) has been observed. This has led to fewer farms overall with an increase in the amount of CAFOs present. CAFOs present a complex contamination situation due to the contents of the waste, which is stored on site and spread over agricultural fields as fertilizer. For this study surface water samples were collected upstream and downstream from four separate CAFO sites. Three had a sampling point situated adjacent to the CAFO site. Three hog and one beef operation comprised the four CAFO sites. Surface water samples were analyzed for multiple contaminants including antibiotics, macronutrients, micronutrients and bacteria. Seven different antibiotics, including tetracycline, chlortetracycline, oxytetracycline, tylosin, sulfamethazine, sulfadimethoxine, and sulfamethoxazole were analyzed using liquid chromatography tandem mass spectrometry. Tetracyline, gentamicin, sul famethazine and beta-lactam antibiotics were analyzed for presence/absence using IDEXX SNAP kits. An ion liquid chromatograph was used to quantify the nutrients nitrogen and phosphorous. Inductively coupled plasma mass spectrometry was used to determine concentrations of the micronutrients selenium, zinc, copper, iron, and manganese and the macronutrient potassium in surface water samples. Finally, a bacterial analysis was completed using IDEXX Quanti-trays and Colilert to test for total coliform and E. coli. Using the information gathered, this study attempted to answer the question: will surface water upstream from a CAFO be of better quality than downstream from a CAFO?

Seismic Attributes of the Clinton Interval reservoir in the Dominion East Ohio Gabor Gas Storage Field near North Canton, Ohio

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Abstract

Wright State University acquired two vibroseis sourced seismic reflection lines over the Dominion East Ohio Gabor Gas Storage field near Canton, Ohio. The data were gathered over a fully charged reservoir within the Clinton Interval. The wider purpose of the project was to determine seismic attributes to enable the development of the best portions of the reservoir and to possibly aid exploration efforts in Ohio. The Clinton Interval is a Silurian deltaic deposit that provides highly compartmentalized reservoirs of natural gas and oil. We find that there are direct indicators on the processed seismic data associated with high initial production from the reservoir now used as a storage field. A gas shadow interrupted the coherency of reflectors beneath the Clinton Interval. The zone of high production correlated with an instantaneous frequency anomaly. We further identify complex behavior of the adjacent Packer Shell reflector that we attribute to interference with a reflector within the Clinton Interval. We tentatively identify an AVO (amplitude vs offset) anomaly associated with the Clinton reservoir. There are an abundance of wells in the area that penetrate the Clinton Interval. Logs from these wells are readily available from the Ohio Department of Natural resources. Wells with sonic logs and density logs were supplied by the Ohio Geological Survey, and mapped using ArcGIS. Well logs were digitized with NeuraLog. We extracted a wavelet from the seismic reflection data to use in modeling. The wavelet was convolved with reflectivity coefficients calculated from various Clinton well sonic and density logs. These modeled traces were compared to the seismic data in an effort to find characteristics related to initial production. Preliminary results show that broadening of the lower side lobe of the Packer Shell reflection may be due to high velocity and high destiny portions of the Red and White Clinton.

Suitability of Offshore Wind Turbine Design Standards for America, Asia and Europe

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Abstract

Offshore wind characteristics are not well studied for offshore wind turbine design due to insufficient measurements at offshore locations. The current offshore wind turbine design standard IEC 61400-3 uses wind characteristics observed on lands and over European waters to define wind models for load estimation. To test the suitability of IEC 61400-3 for offshore wind turbine design in different areas, this study analyzes offshore wind measurements from America, Asia and Europe in terms of wind speed distribution, wind shear, turbulence intensity and 50-year return period wind speed. While the mean wind shears at all sites are similar and smaller than the standard value in IEC 61400- 3, individual wind shears exceeding the standard value are significant. Turbulence intensity characteristics at all sites differ from the specification in IEC61400-3. The observations show that turbulence intensity offshore reaches a minimum value at a moderate wind speed and then increa ses with wind speed at high wind speeds. The Charnock relation and Monin-Obukhov similarity theory are explored to characterize the relationship between turbulence intensity and wind speed offshore. The 50-year return period wind speeds are derived from annual wind speed distribution, peak over threshold method, and the extreme wind model in IEC 61400-3. The influence of tropical cyclones on the 50-year return period wind speed is also analyzed at some Asian sites.

Assessment of the Potential Role of LIDAR Data Collection in Climatology and Wind Power Meteorology: A Case Study

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Abstract

Presently, there are few techniques used to measure wind speed and compile wind climate data, and each technique presents limitations of application and accuracy. The purpose of this research study was to assess the usefulness of a particular measuring method in an Indiana-based case study. The method in question, LIDAR (Light Detection and Ranging), uses a laser to determine the speed of winds aloft by measuring the backscatter from atmospheric aerosols. A LIDAR sensor was used to measure wind speeds at varying heights (from 39 m to 199 m, consistent with wind turbine blade range) every ten minutes for a period of three months in December 2009 through March 2010 at the study site in northern Indiana. The resulting data were analyzed for temporal patterns of variables including wind speed, wind direction, wind shear, and turbulence intensity. The results were compared to calculated expected values to assess how closely measurements in this environment fit standard theories. Ultimately, the goal of the study is to better understand the potential role of LIDAR wind data collection in climatology and wind power meteorology.

Processing and Interpretation of Illinois Basin Seismic Reflection Data

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Abstract

An anonymous oil company released 2D dynamite reflection data from the Illinois basin to be reprocessed and interpreted by Wright State University. We were provided with results of previous processing as a benchmark to compare to our efforts and formation tops from the area of interest. The aim of the project is to exhaustively apply different seismic processing methods to the data to determine if any improvement in the imaging and interpretation may be accomplished. We further hope to investigate the application of attribute analysis to the data. We interpreted the processed section using wavelets extracted from the final migrated section and well log data from the Illinois Geological Survey. The raw shot records from this impulse data are dominated by guided (refracted) waves. A large number of shot records show a stationary seismic source generating coherent noise at the same receiver locations throughout the survey. Rather than simply edit the affected traces we investigated methods to filter this further source of noise to maintain the fold of coverage. We found that several F-K filters combined with iterative application of residual statics with velocity analysis was very effective in removing both the guided waves and the stationary-source waves on the raw shot records, resulting in improvement of the imaging. Farther interpretation of the seismic data will be performed to identify reflectors and potential hydrocarbon reservoirs.

The Long and the Shortwave of it

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Abstract

Air temperature and humidity levels are determined by the surface energy balance. Fundamental to calculating the energy balance at any point on earth's surface is an accurate measurement of incoming shortwave solar radiation. Measurements made at the earth's surface with radiometers properly represent the incoming solar radiation at a specific location; however, those measurements cannot easily be spatially extrapolated due to variations in atmospheric transparency. This project presents a technique that utilizes ceilometer measurements of cloud cover from automated weather stations located at U.S. airports to estimate atmospheric transparency across the continental United States and thus derive incoming solar radiation. Due to height limitations of the cloud cover measurements made by the ceilometers, significant errors can be introduced when high cirrus clouds are present in the atmosphere. A novel technique for error correction is employed that utilizes direct incident shortwave solar radiation measurements taken at more sparsely distributed Climate Reference Network stations. These direct measurements, though not as spatially dense as the ceilometer-based estimates, can be used to condition the estimated solar radiation values so they are more representative of the actual incident solar radiation at the earth's surface. The estimated values for solar radiation can then be used to compute the energy balance, including shortwave and longwave radiation, evapotranspiration and sensible and latent heat fluxes, as well as for estimating key parameters such as soil drying and potentially, drought.

Prediction of ultrafine particle concentrations based on satellite retrievals

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Abstract

High concentrations of ultrafine particles (UFP) negatively affect both human health and Earth's climate, thus accurate estimates of the spatio-temporal variability and absolute concentrations are urgently needed. Recent innovations in remote sensing technologies, and improvements in data retrievals for an array of atmospheric variables, offer the potential for predicting UFP concentrations based on data from satellite borne instrumentation. We present a physically-based statistical algorithm to estimate UFP concentrations across eastern North America using remotely sensed Aerosol Optical Depth, Ångstrom exponent, ultraviolet solar radiation flux, and ammonia and sulfur dioxide concentrations. The proposed algorithm is built and independently evaluated using an array of in situ observations over eastern North America. The algorithm is able to capture up to 60% of the variability in daily measured UFP number concentrations, and is thus applied to generate seasonal UFP concentration estimates across eastern North America. Major findings from this work include: (i) UFP number concentrations can be accurately predicted at remote locations using data from satellite-borne instrumentation, (ii) consistent with prior research, UFP concentrations are relatively coherent across large spatial scales over eastern North America, (iii) NPF intensity peaks during spring and summer months when the photochemical production of nucleation precursors is maximized. The resulting UFP concentrations are also cross-evaluated with simulations from a global aerosol microphysics model. This comparison indicates a negative bias in the model output relative to the satellite driven proxy, but similar spatial and seasonal variability. This comparison emphasizes the value of the satellite-based UFP proxy in global and regional model evaluation exercises and in efforts to identify regions where future in situ data collection should be prioritized.

Carbon isotopes as a basis for evaluating alkalinity generation over time with a sulfate-reducing bioreactor in south-central Indiana

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Abstract

Bioreactors provide passive treatment of acid mine drainage (AMD), sequestering metals and sulfides and producing a net alkaline outflow. However, ongoing studies in Indiana indicate that bioreactors do not perform as optimally as expected. Carbon isotopes provide a means of evaluating how alkalinity is generated inside a bioreactor. We are currently monitoring a large (220m long x 90m wide x 2m deep) bioreactor and aim to identify how alkalinity is being generated over time. If the alkalinity is being produced solely by the dissolution of the limited supply of limestone in the substrate, then the life span of the bioreactor is severely limited. Samples collected from 32 ports inside the bioreactor and at the outflow are being analyzed for temperature, conductivity, pH, Eh, alkalinity, iron (II) concentration, sulfide concentration, and d13C of dissolved inorganic carbon (DIC). There are two end member competing mechanisms producing the alkalinity. These mechanisms are limest one dissolution and microbially mediated sulfate reduction. Because of the large difference between the 13C content of limestone (d13C = 0‰) and organic matter(–24‰), we propose that the d13C of DIC should reflect the relative importance of these two reaction pathways as the bioreactor evolves over time. Low DIC d13C values indicate a dominance of the microbially mediated sulfate reduction pathway compared to the inorganic production of alkalinity. Preliminary results indicate that d13C ranges from -2.1 to -9.6 within the bioreactor even though it has been operational for only 2 months. The temporal trends in the d13C signatures will facilitate determinations of the rate of consumption of the substrate, and provide reclamationists important information concerning the optimum ratio of the components that may yield improved bioreactor performance and lifespan.

Thermobarometric Constraints on Loading and Exhumation Rates of the Narragansett Basin, Rhode Island.

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Abstract

Microprobe analysis of garnet bearing assemblages in the Narragansett basin of Rhode Island indicates a range in temperatures and pressures from 500^{0}C to 675^{0}C and 6.75kb to 9.5kb. Thermobarometric estimates were calculated using garnet-biotite Mg exchange, garnet-plagioclase Ca exchange reactions, and the winTWQ 2.3 software developed by R.G. Berman (2007). 7 samples contained the mineral assemblages needed to calculate both pressure and temperature while 2 additional samples provided only temperature. Four samples analyzed in detail are from Prudence Island (PI), southeast of Davisville (Da), Bonnet Shores (BS), and Stook Hill (SH). PI garnets, at the garnet isograd, show core to rim zoning of X(prp) 2- 4% and X(grs) 21-12%. These compositions yield core-rim temperatures and pressures of 500^{0}C - 7kb and ~500 ^{0}C - 7.25 kb. Da garnets are euhedral with core-rim compositions of X(prp) 8-2% and X(grs) 12- 30%. Core compositions yield temperatures and pressures of 625^{0}C and 8.25 kb while rims show 500^{0}C and 5.5 kb. BS contains euhedral garnets with core-rim compositions of X(prp) 3.5-5% and X(grs) 14-8%. These yield core-rim conditions of 575^{0}C - 9kb and 545^0 C - 9kb. Our SH samples contain abundant 0.1 -0.2 mm euhedral to subhedral garnets with a core -rim composition of X(prp) 9-8% and X(grs) 5 -6%. These yield conditions of 675^{0}C and 9.5 kb in the core falling to 550^{0}C and 5kb in the rim. Core pressure and temperature estimates create a smooth trend from lower garnet grade rocks (PI) to kyanite/sillimanite grade (SH). Given a depositional age of ~305 Ma (Lyons, 1978) and peak T at ~280 Ma we estimate a typical loading rate of ~1.25 mm/yr. 40Ar/39Ar cooling ages (Dallmeyer, 1982) indicate that the high grade assemblages within the Stook Hill region passed through biotite closure temperatures of 300^{0}C at 245 ± 3 Ma. Using these ages, and the corresponding pressures, we estimate an exhumation rate of less than 0.5 mm/yr.

There and Back Again: An Amphibolite's Tale. Polymetamorphism in the Bronson Hill Terrane, CT.

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Abstract

Amphibolites in the Bronson Hill terrane, Connecticut, preserve high-grade syntectonic fabrics.40Ar/39Ar geochronology (Wintsch et al., 2003) indicates peak metamorphic conditions during the Alleghanian Orogeny. Some rocks preserve a coarse-grained, undeformed, granofelsic texture while others contain a distinct NNW-plunging amphibole lineation. The rocks studied are composed of amphibole + plagioclase + epidote + quartz + ilmenite with and without garnet. There are two pargasitic amphibole populations: (1) elongate, lineated pargasite showing prograde chemical zoning with Si decreasing and Al and Ti increasing from core to rim; (2) blocky unlineated pargasites showing retrograde zonation with Si increasing and Al and Ti decreasing from core to rim; The lineation clearly truncates and deforms the blocky texture. Because the prograde texture is cutting a retrograde texture, we conclude that there are two separate metamorphic events in these rocks. Edenite-richterite thermometry (Holland & Blundy 1994) yields pargasite crystallization temperatures between 650 and 690 °C. A third population of low temperature well lineated cummingtonite amphibole with ~7.8 Si cations p.f.u. exists in some samples. Cummingtonite occurs with plagioclase (An30) and exhibits retrograde zonation with Si increasing Al decreasing from core to rim. We propose the reaction pargasite + garnet yields cummingtonite + plagioclase for cummingtonite appearance. With a positive Vr, this reaction is consistent with growth during decompression. Garnet zoning record changing P-T conditions, with increasing Ca, Mg, and Mn suggesting prograde growth before peak temperature as well as before, during, and after peak pressure. Using the amphibole-garnet-plagioclase-quartz thermobarometer (Berman, 1991) we calculated core pressures and temperatures of 2.6 kbars and ~450 °C to rise to 6.9 and ~685 °C in the rims. These results confirm and constrain the PTt path modeled by Wintsch et al. in 2003.

A Late Devonian Age for the Chester Shear Zone, Central Maine: Evidence from 40Ar/39Ar Age

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Abstract

The age of cleavage in the meta-sediments of the Smyrna Mills Formation and Madrid Formation has been constrained by 40Ar/39Ar analysis. These metasedimentary rocks contain muscovite in four textural populations: 1) detrital muscovite up to 75 μm long distributed among fine to medium silt-size quartz and albite grains; 2) authigenic muscovite finely intergrown with chlorite to form stacks up to 100 μm in diameter; 3) muscovite intergrown with chlorite defining a cleavage (S1) parallel to bedding plains (S0); and 4) muscovite and chlorite intergrowths defining a cleavage (S2) oblique to S0 and S1. Backscattered-electron (BSE) petrography shows that the micas in the youngest fabric (S2) truncate the detrital, authigenic and S1 micas. Step heating experiments from seven samples all yield sigmoidal age spectra. These age spectra have a hump-shape in low-temperature steps, indicating 39Ar recoil, consistent with the fine grain size and intergrown nature of the matrix. Following this hump, in steps interpreted to be unaffected by recoil, apparent ages climb steadily from minimum apparent ages as young as 385 Ma to maximum ages as old as 470 Ma. The samples with the lowest minimum apparent age-steps are those in which the cleavage-forming mica populations dominate. In contrast, the oldest apparent age-steps are from samples that have the highest modal abundance of detrital micas as observed from BSE petrography. We interpret the Middle to Late Devonian minimum apparent age-steps to be the maximum crystallization age of (S2) micas. The age of the detrital micas appears to be at least Early Ordovician and most probably reflects a Cambrian or older cooling age in an unidentified provenance area. We speculate that the fabric in Chester Shear Zone was produced by inboard strain localization during the Late Devonian activity of the Norumbega Fault Zone.

Deformation-Induced Development of Kyanite and Fibrolitic Sillimanite in Monzodiorite Orthogneiss, southwest Connecticut

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Abstract

An orthogneiss in Newtown, CT, is unusual in that it contains large kyanite (Ky) blades and fibrolite (Sill) needles. The average composition of the gneiss, determined by XRD and Rietveld refinement, represents a monzodioritic composition, suggesting that the protolith was probably not a metasediment as mapped. In outcrop, euhedral, ≤8cm Ky blades produce a strong N55W lineation. Ky in thin section is subhedral with inclusions of rutile (Ru), biotite (Bt), and quartz (Q). Ru inclusions within Ky are ~5% by volume, occurring randomly and in trails. These Ky grains commonly form sharp contacts against Bt and Plag. Sill, when intergrown with Bt, is fibrous, anastomosing, and also occurs with anhedral ilmenite (Ilm). Bt is subhedral and forms a weak foliation. Plag is anhedral, and quartz is present as anhedral grains in the matrix and as ovoid inclusions in Ky. These textures suggest several reactions. Ky truncation of Bt and Plag supports the reaction Bt + Plag =>Ky (Vrxn=-83%). Interlobate contact between Plag and Ky shows 2Plag =>Ky (Vrxn=-78%). Optical continuity of Bt inclusions within and surrounding Ky suggests replacement of Bt by Ky. EMP analysis of Bt gave a formula of KFe0.73Mg1.7Ti0.07Al1.8Si2.7O10(OH)2. The expected volume of Ru in Ky created by replacing Bt is 3%, comparable to the ~5% seen in thin section and supports replacement of Bt by Ky and Ru: Bt =>Ky + Ru (Vrxn=-68%) . Similarly, Bt interfingered with Sill and Ilm suggests a Bt replacement reaction: Bt =>Sill + Ilm (Vrxn=-47%) . The interfaces of these minerals and the immobility of Al3+ and Ti+4 suggest local replacement of Bt and Plag by specific Al- and Ti-phases. Ky and Ru formed in high-P conditions, whereas lower-P, high- T conditions formed Sill and Ilm (Ernst and Liu, 1998). The large - Vrxn and local growth of aluminosilicates in an orthogneiss suggest that reactions are facilitated by local strain, causing mobile ions to leave the reaction site on local, chemical-potential gradients.

A Geochemical and Petrological Study of Mafic Dikes and Intrusions Associated with the Eagle Ni-Cu-PGE Deposit in the Baraga Basin, Upper Michigan

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Abstract

The Baraga Basin in northern Michigan is comprised of Paleoproterozoic meta-sedimentary rocks that host a number of mafic intrusions and dikes, including the Eagle sulfide ore-bearing intrusion (1107.3 ± 3.7 Ma). The Eagle intrusion hosts a high grade Ni-Cu -PGE ore deposit, and is part of a belt of mafic intrusive bodies extending from northwest to southeast across the Baraga Basin. This belt is bracketed to the north and south by similar-trending Cu-depleted mafic dikes. A large number of Cu-enriched mafic dikes (of the Baraga Dike Swarm) are present within the basin, and are oriented northeast-southwest. Also present is a series of Cr- and Ni-enriched mafic dikes which trend northwest-southeast. Samples from various types of mafic dikes and intrusions were analyzed for PGE. The data shows that the Cu -depleted mafic dikes are also depleted in all PGE+Au, suggesting that depletion of chalcophile elements may have resulted from magmatic rather than hydrothermal processes. Furthermore, mafic intrusive bodies located along the Eagle trend and between the Cu -depleted dikes, specifically the Boulderdash and Roland Lake intrusions, show extremely low Pd/Ir ratios and high Pt/Pd ratios relative to the more abundant Cu-enriched dikes located throughout the Baraga Basin. A comparison of Boulderdash and Roland Lake shows that the two intrusions have similar Pt/Pd and Pd/Ir ratios, but with Boulderdash being more depleted in all PGE. Additionally, Roland Lake appears to be related to a more primitive parental magma, crystalizing olivines ranging from Fo 75 to Fo 85, while olivines in the Boulderdash intrusion range from Fo 61 to Fo 69. Boulderdash also shows a small population of Fo 55 olivine crystals, suggesting a possible mixing of two different magmas. Roland Lake olivines show a much steeper positive correlation on a Ni vs Fo plot than olivines in the Boulderdash intrusion. However, both intrusions show a nearly identical slope on a Mn vs Fo plot. The parental magma to the Cu-depleted dikes likely experienced large scale sulfide saturation via crustal S contamination, while the Cu-enriched dikes' parental magma likely did not. The Roland Lake and Boulderdash parental magmas are more primitive than the Cu-enriched and -depleted dikes, and do not appear to have undergone extensive sulfide saturation.

A step towards confidently using Ni isotopes as a paleoproxy in the Great Oxidation Event

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Abstract

The causes of the Great Oxidation Event (GOE), which transformed our atmosphere from a reducing to an oxidizing environment, are still poorly understood. In 2009, Konhauser et al. hypothesized that a significant and abrupt decrease in oceanic Ni concentrations may have triggered a reduction in methanogenic activity, resulting in a collapse of atmospheric methane production. Methanogens require Ni for production of methane. Their decline likely opened an ecological niche which oxygen producing organisms filled. In a separate study, Cameron et al. (2009) demonstrated that modern methanogens fractionate Ni isotopes. Cameron's discovery suggests the possibility of tracking ancient methanogen activity by using Ni isotopes in the rock record. However, other natural processes are likely to have fractionated Ni isotopes. It will be impossible to correctly interpret Ni isotope records in sediments, and hence better understand the role of methanogen decline in driving the GOE, unless we identify and quantify the fractionation effects for these other processes. One likely abiotic fractionation process is the sorption of dissolved Ni to ferromanganese crusts. To determine whether this process fractionates Ni isotopes, experiments were set up with varying amounts of dissolved Ni in water adjusted to oceanic pH and containing suspended birnessite particles (K-0.5 Mn(3+) Mn(4+) O-4•1.5H-2 O). Samples were shaken for 24 hours to allow dissolved Ni to react with the birnessite mineral surfaces. Ni sorbed to birnessite was separated from dissolved Ni via filtration. Following analysis, dissolved Ni isotope ratios were compared to sorbed Ni isotope ratios. Adsorbed Ni was 1.4‰ lighter than dissolved Ni, δ60/58 Ni, regardless of the fraction of Ni adsorbed. This result is encouraging, since a constant offset from seawater would make interpretation of Ni isotopes in ferromanganese crusts straightforward.

UNCOVERING EAST ANTARCTIC BEDROCK USING DETRITAL ZIRCON GEOCHRONOLOGY AND PEBBLE LITHOLOGIES AT MOUNT HOWE, SCOTT GLACIER

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Abstract

Till from the flanks of Mount Howe, the southernmost outcrop in the world at the head of the Scott Glacier, Antarctica, places direct new age and lithologic constraints on unmapped, ice covered East Antarctic bedrock and will ultimately be used to interpret paleodrainage regimes linked to sediments in the Ross Embayment. Nine moraine crests were sampled along a 2 km transect from the modern ice edge toward exposed bedrock, where rock weathering increases away from the ice margin. Cosmogenic ages on boulders in the moraine field indicate most of the moraine complex formed over the last 100ka, but ridges close to the headwall may be much older. Pebble across the transect show minimal statistical variation, averaging 60% mafic igneous, 30% metamorphic, and 10% sedimentary lithologies dominantly from local Ferrar and Beacon Supergroups. Faceting and striations on pebble surfaces reveal that up to 40-50% of the pebble fraction of the till was subglacially transported, an d a minimum of 15% are exotic lithologies. Nearly 80% of cobbles collected from a non -random survey expose several exotic rock types, including vesicular olivine basalt, quartzite, and four different compositions of granite. Guided by backscatter electron imagery of detrital zircons, 657 ages from U-Pb isotopes of detrital zircons from 8 sequential moraine crests were determined by laser ablation-inductively coupled plasma mass spectroscopy (LA-ICPMS). Distinct age populations were identified at 185-190Ma, 255-270Ma, 355-365Ma, 550-580Ma, and 2740Ma. Mid-transect, a 1010-1040Ma peak is statistically different from the remaining samples. The 185Ma population differs from the typical East Antarctic signature found at sites along the Transantarctic Mountains, and is likely derived from a zircon-bearing phase of the Ferrar Supergroup. Ages illustrate that crystalline basement is not being extensively eroded in the Scott Glacier catchment.

Recent Seismicity in Southern Illinois and Southern Missouri: Initial Results from the EarthScope OIINK Flexible Array Experiment

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Abstract

We examined 175 days' continuous seismic records, from July 29, 2011 through January 20, 2012, from stations in a study area encompassing the eastern Ozark Plateau in Missouri and the southern Illinois Basin. The records came from 23 flexible-array stations of the OIINK (Ozark, Illinois, Indiana and Kentucky) network, 21 transportable array stations of USArray, 7 New Madrid array stations, and 1 GSN station. These records yielded thousands of events, of which, 44 earthquakes with mb $\geq$ 2.0 occurred within the study area. Active quarries and coal mines dominate the catalog. To focus primarily on earthquakes, we generally ignored events that happened during the hours of 16:00 to 23:00 UTC, the time interval during which most blasting takes place. Of the remaining events, 443 events were classified as blasts because their records displayed relatively large amplitude, low frequency Rg waves compared to those of unambiguous earthquakes. About 25 of the 44 earthquakes were located within the New Madrid seismic zone, south of the array. A significant number of the remaining events cluster along the boundary between the Ozark Plateau and the Illinois Basin. Notably, these events occur at depths of between 10 and 20 km, the transition zone from upper to middle crust. This depth range is greater than that of the earthquakes elsewhere in and around the Ozark Plateau, where foci generally lie at depths of < 5 km. Our preliminary results indicate that the character of seismicity varies.

Zinc isotope fractionation during adsorption on birnessite

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Abstract

In the ocean, zinc (Zn) is an important micronutrient. Zn is a component of regulatory proteins and several enzyme classes that mediate the uptake of carbon and phosphorus. Thus, the biogeochemical cycles of Zn may influence the observed primary productivity and species composition of a region. The cycling of Zn is dictated by a complex series of abiotic and biotic reaction pathways. These reaction pathways include adsorption reactions at the mineral/water interface, as nanoparticles of oxyhydroxide minerals are known to adsorb significant amounts of Zn. Adsorption reactions tend to fractionate the isotopes of adsorbate metals. Thus, Zn isotope distribution in natural waters and sediments may help to elucidate the role of adsorption reactions in governing the cycling of Zn. Before Zn isotopes can provide insight into the control of adsorption on Zn cycles, quantification of the effect by fractionation is required. This work aims to quantify the mechanism and degree of Zn isotope fractionation during adsorption onto synthetic birnessite (KMn2O4· 1.5H2O) . Our simple-system experiments involve mixing solutions of 130 ppb of Zn with aliquots of birnessite suspension (proportions varied to give a range of surface coverage) and a fixed pH near that of seawater at ~8.5. The mixtures react for 48 hours. The recovered dissolved Zn and adsorbed Zn are then separated and isotopically analyzed on a Nu Plasma MC-ICP-MS. Preliminary results exhibited fractionation during absorption on birnessite surfaces, with enrichment of light zinc isotopes on the mineral surface. The complexity of the system will be increased in additional experiments by including inorganic salts and simple organic ligands to mimic the speciation of Zn in natural seawater.

Development of a Globally Applicable Model for Near Real-time Prediction of Seismically Induced Landslides

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Abstract

Substantial effort has been invested to understand where seismically induced landslides may occur in the future, as they are a costly and frequently fatal threat in mountainous regions. Though some regional efforts have succeeded, no uniformly agreed-upon method is available for predicting the likelihood and spatial extent of seismically induced landslides. We are developing a statistical model for estimating landslide distributions in near-real time around the globe for use in the loss forecasts of the U. S. Geological Survey (USGS) Prompt Assessment of Global Earthquakes for Response (PAGER) system. Here we use outputs of ground shaking from the recently produced USGS ShakeMap Atlas to develop an empirical landslide probability model by combining these uniform estimates of the shaking with broadly available landslide susceptibility proxies, such as topographic slope, surface geology, and climate parameters. We include earthquakes for which digitally-mapped landsli de inventories and well-constrained ShakeMaps are available. Using logistic regression, the resulting database is used to build a predictive model of the probability of landslide occurrence. The landslide database includes observations from the Guatemala (1976); Northridge, California (1994); ChiChi, Taiwan (1999); and Wenchuan, China (2008) earthquakes. The performance of the regression model is assessed using both statistical goodness-of-fit metrics and a qualitative review of whether or not the model is able to capture the spatial extent of landslides, to determine which combination of the proxies (and which representation of the values for each proxy) provides the optimum prediction of landslide- affected areas and minimizes the 'false alarms' associated with non-landslide zones. Combined with near-real time ShakeMaps, we anticipate using our model to make generalized predictions of whether or not (and if so, where) landslides are likely to occur for earthquakes aroun d the globe.

Teleseismic Residual Analysis of the North American Midcontinent Cratonic Platform using data from an EarthScope FlexArray Experiment

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Abstract

We completed an analysis of ~100 teleseismic earthquakes recorded by the EarthScope Ozark-Illinois-Indiana-Kentucky (OIINK) FlexArray Experiment to better understand the structures underlying the Illinois Basin and Ozark Mountains. We deployed a network of 70 broadband seismometers at a 25-km grid throughout southern Missouri, Illinois, and Indiana. Data from the OIINK array was combined with that of the EarthScope Transportable Array and the regional broadband seismic networks. We measured teleseismic P-wave arrival times for an 8-month period (May 2012 to Dec. 2012) using a multichannel array cross-correlation method in a program called dbxcor. We found that travel-time residuals could be reliably determined for most teleseismic events with magnitudes greater than 4.7 at distances from 60 to 90 degrees. We analyzed the spatial distribution of relative residual times for individual events by plotting residuals as a function of station position. The most commonly observed pattern, independent of source location or depth, was for negative (early) residuals (up to -0.7 sec) for sites in the Ozarks and westernmost portion of the Illinois Basin, and more positive (late) residuals (up to +0.5 sec) in the central and eastern Illinois Basin. Considerable scatter is observed in the residual pattern, and we are using statistical methods to infer average patterns of residual distribution. We interpret the observation of negative residuals in the west and positive in the east as largely the result of the relative high velocity of the igneous and metamorphic rocks of the Ozark Mountains relative to those of the sedimentary rocks that comprise the Illinois Basin. These differences may also result from systematic differences in crustal thickness and mantle velocities between the two areas. Additional work is planned to examine consistency of residuals from different source regions and to produce an initial tomography model from residuals.

Ambient Temperature P–V Equation of State for Garnet Sand of Pfeiffer Beach

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Abstract

Synchrotron powder X -ray diffraction analysis was performed on a natural beach-sand garnet from Pfeiffer Beach, Big Sur, California. Specifically, the garnet was found to be an almandine as determined by major-elemental analysis using EDS/SEM. The ambient-pressure lattice parameter, a, was found to be 11.529 Å. The lattice parameter and, accordingly, unit-cell volume were determined through isothermal compression to 19 GPa in a symmetric diamond anvil cell, in which helium served as a nearly hydrostatic pressure-transmitting medium. Using a least squares fit of the data to the Birch–Murnaghan equation of state, the isothermal bulk modulus was determined to be 171.35 ± 0.73 GPa when dK/dP was fixed at 4.2. We compare these findings with previous elasticity measurements of garnets along the pyrope–almandine join, and we report our measurements in relation to prior work on bulk modulus–volume–cation valence systematics [e.g. Fan et al., 2009].

Stable Ni isotope fractionation in systems relevant to BIF formation

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Abstract

An important event in the evolution of life was the rise of atmospheric oxygen during the Proterozoic. Preceding the rise in O2 was a decline in atmospheric methane concentrations, likely due to decline of methanogenic Archaea. Based on Ni concentrations in banded iron-formations (BIF), Konhauser et al. (2009) hypothesized that mantle cooling during the Archaean reduced the amount of Ni present in igneous rocks and in oceans, causing a Ni shortage for methanogens. Methanogens use Ni for cofactor F430, a catalyst during methanogenesis. To confirm Konhauser's hypothesis, a proxy for methanogen productivity is necessary, in order to determine whether a decline in methanogen populations correlated with the observed decrease in Ni in rocks from the Archaean. Ni isotope ratios recorded in BIF (oceanic sediments consisting of layered iron oxides and cherts) may provide evidence of a decline in methane production. Cameron et al. (2009) have shown that methanogens preferentially assimilate light Ni isotopes. Thus Ni isotopes in BIF have potential use as biomarkers for methanogenesis. During BIF deposition ferrihydrite was the dominant Fe oxide precipitating. Thus we investigated experimentally the relationship between Ni isotopes in solution and Ni associated with ferrihydrite. We conducted two series of experiments: adsorption of aqueous Ni onto surfaces of synthetic ferrihydrite and the coprecipitation of aqueous Ni with ferrihydrite. Preliminary results indicate that light isotopes are preferentially associated with ferrihydrite in both adsorption and coprecipitation experiments, with an average fractionation of 0.4‰ in terms of δ60/58 Ni. Future experiments will investigate whether the observed isotope fractionations reflect kinetics or equilibrium, thus determining whether or not BIF provide a straightforward record of Ni isotopes of the water mass.

Receiver Function Estimation for Array Processing

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Abstract

Different from the conventional receiver function estimation which is based on deconvolving the vertical component from the horizontal components for each three-component seismogram, in seismic arrays it is possible to generate a more robust wavelet for deconvolution, since the first P arrival recorded on the vertical components of different seismograms are identical to each other. The dbxcor program from Pavlis and Vernon [2010] could generate a robust stacking of the vertical components for each events, which is the wavelet for the deconvolution operation. To further make the deconvolution operation reliable, the multi-taper spectrum estimation [Park and Levin, 2000] is applied, which is using multiple Slepian tapers to stabilize the spectrum of the wavelet and the horizontal components. Comparing with one of the conventional receiver function estimations, water-level deconvolution, the preliminary test for this method on parts of the USArray data shows better results. The ultimate objective of this project is to run as a part of the SEISPP library to process any three-component seismic array data.

Structural evolution of the J-Fold Anticline; A multi-scalar approach to modeling kinematic fold evolution in the Cordilleran fold-thrust belt, southwest Montana

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Abstract

The NE corner of the London Hills Structural Complex (LHSC), referred to herein as the Highway 2 field (HW2) area, is located on the SE margin of the Helena salient in Gallatin Co., SW Montana. The most prominent structural feature in the HW2 area is the Late-Cretaceous J-fold, a fault driven, east trending, double hinged anticline plunging to the northeast. The purpose of this study is to produce a model for the HW2 area that describes both the kinematic evolution and the mechanical behavior of the J-fold. This will be accomplished by conducting a multifaceted examination of the J-fold using high-res terrestrial laser scanning (TLS) combined with detailed field measurements of kinematic indicators, and laboratory analysis of microstructures in thin section. Preliminary geometric models, based on angular relationships, suggest three potential folding mechanisms for the evolution of the J-fold; first-mode fault-bend folding, second-mode fault-bend folding, or a combi nation of fault-bend and fault-propagation folding. Ultimately, the HW2 study will use the light detection and ranging (LiDAR) point clouds obtained by TLS with the micro- and mesostructure distributions along the fold to produce a complete model for the evolution of the J-fold.

Isotopic fractionation of cadmium during adsorption to manganese oxide

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Abstract

Cadmium is toxic to most life forms, yet there are some diatoms that substitute Cd for Zn in their carbonic anhydrase enzyme [1]. Diatoms fractionate Cd isotopes [2]; thus Cd isotopes might serve as a proxy for Cd usage in the past, if we can find where isotopic signals are preserved. Horner et al. (2010) measured Cd isotopes in 15 ferromanganese crusts from the Atlantic, Pacific, Indian, and Southern Oceans and reported that all values were within error of a few analyses of deep water, suggesting that Cd isotopes preserved in ferromanganese sediments could serve as a proxy for biological use of Cd in ancient oceans. Before we can apply such a Cd isotope proxy, we must first understand the process of Cd incorporation into marine sediment to verify that Mn crusts faithfully record the Cd isotopic composition of the ocean. To address this question, we conducted two sets of Cd adsorption experiments at low and high ionic strength. Particles of synthetic birnessite (~Mn O2) were mixed with varying concentrations of Cd-bearing solution for 24 hours. The dissolved and adsorbed Cd were separated by filtration. After purification via column chromatography, samples were analyzed with multicollector ICP-MS. Our experiments revealed fractionation during adsorption, with lighter isotopes preferentially adsorbed. Fractionation at low ionic strength displayed a clear equilibrium effect. At high ionic strength, the magnitude of fractionation varied with the proportion of Cd adsorbed, suggesting a kinetic or Rayleigh effect. The difference between low and high ionic strength results may result from different speciation of Cd in solution; Cd makes chloro-complexes in artificial seawater. These results indicate the need to better comprehend abiotic fractionation of cadmium if its isotopes are to provide a reliable paleoproxy. [1] Price & Morel (1990) Nature 344, 658. [2] Lacan et al. (2006) Geochim. Cosmochim. Acta. 70, 5104.

Constraining Potential Locking Area on the Creeping Segment of the San Andreas Fault

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Abstract

The San Andreas Fault has historically been known for producing large earthquakes, especially in the Los Angeles and San Francisco areas. However, it is currently unclear whether the region between these two areas, a 150-km long section of the fault extending from Parkfield north, could also produce large earthquakes. This section of the fault is known to be creeping at the surface, and in some areas may move at nearly the deep slip rate. Our current research utilizes GPS and InSAR data to constrain the bounds on locking of the fault at depth to estimate potential for producing large earthquakes, using a block model to compute slip rates on the fault segment between Parkfield and San Juan Bautista. The degree of locking along the fault trace can then be estimated and potential accumulation of strain across the plate boundary estimated. The results will be an improved understanding of potential earthquake hazards in this region.

Carbonate Textures of the Davis Formation and their Relationship to Diagenesis

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Abstract

The Davis Formation of southeast Missouri was deposited in the Late Cambrian (Furongian) and is primarily composed of interbedded dolostones and shales. Representing a back reef facies formed at the edge of the St. Francois Mountains, the Davis Fm. is part of a transgressive sequence that has experienced extensive alteration following deposition (Gregg and Shelton, 1990). Previous work has shown that the underlying Bonneterre Formation, which is composed of dolomitic carbonates, shales, and hosts the sulfide-rich Viburnum Trend, is enriched in iron (Gregg and Shelton, 1989). It has been suggested in several studies that the Davis Fm. acted as a barrier to fluid flow, which may have impeded alteration such as dolomitization and ore mineralization (Appold and Wenz, 2011, Gerdemann and Myers, 1972, and Panno and Moore, 1994). This would have likely prevented the Bonneterre and Davis Fms. from acquiring similar degrees and patterns of Fe-enrichment during diagenesis. However, recent analyses show that the Davis Fm. surrounding the St. Francois Mountains is enriched in iron. Analysis of X-ray diffraction patterns via Bruker's EVA and TOPAS indicate the presence of an Fe-enriched carbonate within the Davis Fm. Backscatter images obtained using a scanning electron microscope show this phase tends to be interstitial to coarse dolomite rhombs. Therefore, the Fe-carbonate is the result of late-stage diagenesis, possibly by the fluids that mineralized the Bonneterre Fm. This assessment is complicated by the presence of an anomalously calcitic outcrop of the Davis Fm. TOPAS models show a lack of dolomite or ferric dolomite as the dominant carbonate phase. Backscatter images of these samples show irregular grain boundaries and embayment of dolomite by calcite, indicating that the calcite present is also the result of late-stage diagenesis and dedolomitization. It is as yet unclear whether the dedolomitizing fluid is genetically related to the fluid providing Fe-enrichment.

Estimates of long-term fault-slip rates in southern California by using non-block viscoelastic sheet models

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Abstract

Fault slip rate estimates from geodetic data are becoming increasingly important for earthquake hazard studies. In order to estimate fault slip rates, GPS-constrained kinematic models such as elastic block models are widely used. However, kinematic block models are inherently non -unique and provide limited insight into the mechanics of deformation. Furthermore, assumed discrete tectonic blocks may not exist everywhere as not every region of the western US displays mature, through-going geologic structures that naturally divide the crust into tectonic blocks. For example, the eastern California shear zone and regions of the Basin and Range Province are best described as broad zones of interacting, discontinuous fault strands.

We are building towards mechanical models of present-day surface motions in which deformation is a response to plate boundary forces, gravitational loading, and rheological properties of the lithosphere. To model long-term fault-slip rates in the southwestern US, we populate an elastico-visco thin sheet (plane stress) with thin viscous shear zones (faults) and impose far-field plate motions and gravitational loading to compute the long-term fault slip rates and crustal motions.

The effect of grain size on river delta process and morphology

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Abstract

Delta morphology is traditionally explained by differences in fluvial energy and wave and tidal energy. It has been suggested that grain size influences delta morphology, but these models are largely qualitative, leaving many questions unanswered. Here we use numerical modeling to quantify how changes in the grain-size distribution of the incoming sediment load affect delta processes and morphology. We conduct 33 runs varying only the grain-size distribution's median (0.01 – 1 mm), standard deviation (0.1 – 3 φ), and skewness (-0.7 – 0.7). The model setup includes a river carrying constant discharge entering a standing body of water devoid of waves, tides, and sea- level change. The results show that delta morphology undergoes a transition as median grain size and standard deviation increase while changing skewness has little effect. At low median grain size and standard deviation, deltas have elongate planform morphologies with sinuous shorelines characteri zed by shallow topset gradients ranging from 1 x 10^-4 to 3 x 10^-4, and 1 - 8 stable active channels. At high median grain size and standard deviation, deltas transition to semi -circular planform morphologies with smooth shorelines characterized by steeper topset gradients ranging from 1 x 10^ -3 to 2 x 10^-3, and 14 - 16 mobile channels. The change in delta morphology can be morphodynamically linked to changes in grain size. Results show that grain size can control the delta topset gradient, which reaches a dynamic equilibrium through time. Vertical sedimentation rates adjust to maintain topset gradients, which affects channel avulsion frequency and overbank flow, and ultimately sets the number of channel mouths long the delta shoreline. The number of channel mouths and advection lengths of varying grain sizes set the depositional pattern along the shoreline, which translates into shoreline rugosity and delta shape patterns.

Reaction and textural softening in the Newtown orthogneiss, Sandy Hook, CT

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Abstract

Petrographic analysis of the mylonitic granodioritic Newtown gneiss (western Connecticut) reveals both prograde and retrograde metamorphic paths preserved in schistosities and arrested partial replacement reactions. The gneiss contains a magmatic assemblage of microcline phenocrysts set in a matrix of plagioclase+quartz+hornblende+biotite. This is overprinted by a retrograde schistosity (Sn) that strikes SSW and dips moderately to the NW. Prograde metamorphism is preserved in garnets that show an increase in Mg and Ca content from core to rim. Where most strongly developed, the Sn fabric is defined by mm-thick bands of contiguous biotite folia and ribbons of K-feldspar+plagioclase+quartz, interpreted to be derived from the amphibole-rich matrix and microcline phenocrysts, respectively. Amphibole is truncated and replaced by foliated biotite, suggesting the syntectonic dissolution-precipitation reaction: 2 Amphibole + 3 Quartz + 4 K^+ + 6 Fe^{2+} + 7 H_2O → 5 Biotite + 8 H^+ + 4 Ca^{2+} Microcline phenocrysts may show plagioclase+quartz myrmekitic mantles or may form ribbons, where they are embayed and replaced by plagioclase+quartz. Both textures suggest progress of the reaction: Microcline + Ca^{2+} + Na^+ → Plagioclase + Quartz + K^+ The overall retrograde reaction is: K-feldspar + Amphibole + H_2O ± Garnet → Biotite + Plagioclase + Quartz + Sphene and is an example of significant softening by dissolution-precipitation. The pluton crystallized in the early Silurian (Sevigny & Hanson 1995) . A regional amphibole cooling age of ~360 Ma (Dietsch et al., 2010) constrains the deformation as coincident with either the Salinic or Acadian orogeny. Folding of pre-kinematic pegmatites and a biotite lineation trending 330/10 indicate top-down northwest displacement. Poles to the planes of post-kinematic pegmatites are approximately parallel to the biotite lineation, suggesting these deformations are consistent with a single extensional direction and a single orogenic exhumation "event."

Floodplain Distributary Channels: A Case Study of Streams in Indiana

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Abstract

Traditionally floodplains have been considered passive sediment filling depocenters, where sediment is deposited by advection as the floodwaters enter the floodplain. Floodplain topography, in this view, is the result of morphodynamic behavior of the river, for example the repeated formation of meander cut-offs. However some studies suggest that floodplains are their own morphodynamic entities acting independent of the parent river system. This study explores the variability in floodplain morphologies in Indiana, USA with the ultimate goal of understanding the processes that control the development and evolution of floodplains. This will be accomplished by analyzing 1.5 meter digital elevation models (DEMs) derived from airborne LiDAR, ground penetrating radar, and numerical modeling of floodplain formation and evolution using Delft3D, a morphodynamic, physics-based model. To effectively use these tools to understand the processes that drive floodplain formation an d evolution, it is essential to first address how to accurately define what a floodplain is and what is the breath of floodplain morphologies.

Mapping chemical heterogeneity of shale with micro-FTIR

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Abstract

Shale's fine-grained texture, presence of diverse organic matter types, and complex mineralogical composition create analytical challenges that can be met only by using high-resolution techniques. In situ micro-FTIR (Fourier Transform Infra-Red spectroscopy) is a novel, powerful and nondestructive tool to investigate and map the chemical heterogeneity of finely dispersed organic matter and minerals in shales. In this study, four New Albany Shale (Devonian and Mississippian) samples of different maturation levels (vitrinite reflectance [Ro] values ranging from 0.58 to 1.41 vol. %) were analyzed by micro-FTIR mapping. Relative abundances of organic matter and minerals (carbonates, quartz, and clays) were mapped across selected micro-scale regions based on carefully screened characteristic peaks. The observed proportions of general mineral groups (clays, carbonates, and quartz) and organic matter across micro-scale regions are consistent with corresponding bulk compositional percentages. In addition, distributions of organic matter revealed in chemical maps provide indirect evidence to help evaluate organic porosity of shales. Organic matter domains show high interconnectivity in two early mature samples (Ro 0.58 and 0.68%). However, the interconnectivity of organic matter dramatically decreases in the late mature sample (Ro 1.15%), but interestingly shows a reversal of interconnectivity increasing in the postmature sample having Ro of 1.41%. Porosity in organic matter accounts for a significant portion of total porosity in our studied shale samples. We suggest that increased interconnectivity of organic matter domains results in higher connectivity of pores, forming migration paths for oil and gas in shale. Therefore, in situ micro-FTIR is not only a powerfu l asset for investigating heterogeneity of shales, but, in combination with complementary porosimetric techniques, strengthens our understanding of porosity systems in shales.

Frictional parameters on the creeping San Andreas Fault inferred from the 1983 Coalinga-Nuñez and 2004 Parkfield earthquakes

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Abstract

We use the creep meter and GPS time series data to infer frictional parameters on the creeping section of the San Andreas Fault (SAF) near the Parkfield, California. The creep meter data show that surface creep rate was abruptly retarded at five creep meter locations for 1-6 years following the 1983 Coalinga- Nuñez earthquakes just northwest of Parkfield. From Monte Carlo inversions of the data using spring-slider models with rate and state friction, we find that the retarded creep episode is explained with near-neutral-strengthening with friction parameter, $\sigma(a - b)$ of 3×10^{-6} - 3×10^{-2}, MPa. This is at least an order of magnitude lower than previous inferences from afterslip studies at Parkfield and other locations around the world (Hearn et al., 2002; Perfettini and Avouac, 2004, 2007; Miyazaki et al., 2004; Perfettini et al., 2005; Hsu et al., 2006; Barbot et al., 2009). We show, through forward models and spring-slider inversions GPS measurement of the 2004 Parkfield afterslip episode, that the friction parameters inferred from the 1983 Coalinga-Nuñez transient and Parkfield afterslip are entirely inconsistent. Spring-slider and finite-fault afterslip models of the 2004 afterslip event using friction parameters inferred from the 1983 transient predict excessive amounts of rapid afterslip in the days following the 2004 earthquake. Our preliminary analyses of models of fluid-infiltrated shear zones suggest that dilatancy-induced strengthening of the fault following the 2004 earthquake may be one plausible explanation for the apparent discrepancy.

Phase Stabilities and Hydration/Dehydration Behavior of Na2Mg(SO4)2*nH2O System Under Mars-Relevant Conditions

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Abstract

An increasing inventory of hydrous evaporite and silicate minerals has been identified from orbital and lander data on Mars. Several hydrous sulfate minerals are thought to occur on Mars, based on spectral, chemical, and geomorphic observations (e.g., CRISM, OMEGA, and Mars Exploration Rover results). We are examining the behavior of hydrous minerals on Mars and their potential participation in the H2O cycle to augment and complement these data. With limited liquid water stability on the martian surface, hydration and dehydration of hydrous minerals with changes in temperature (T) and relative humidity (RH) during a Mars day can have a significant influence on the bioavailability of water and potentially on atmospheric H_2O. This research focused on the $Na_2MgSO_4 \cdot nH_2O$ system, predicted by King et al. (2004) to occur on Mars. Our experiments intended to investigate hydration between blödite (n=4), konyaite (n=5), and a decahydrate (n=10). Blödite was analyzed by X-ra y powder diffraction (XRD) under controlled RH-T conditions to investigate its hydration/dehydration to these other known phases. Deliquesced blödite was exposed to low temperatures (T<30°C), which produced a new higher-hydrate (n=16) Na_2MgSO_4 phase. The intermediate phases (n=5 & 10) were not observed. This new phase was first observed at -10°C (47-78% RH), it formed within minutes, and it persisted on decreasing T to at least -30°C. This low-temperature hydration behavior has previously been documented in the $MgSO_4 \cdot nH_2O$ system through the conversion of epsomite (n=7) to meridianiite (n=11). Hydration of MgSO4·7H2O to meridianiite (11 hydrate) causes a 23% weight change, and hydration of blödite to the n=16 phase causes a 39% weight increase. Thus, this reaction could potentially have a significant influence on the Mars daily water cycle, depending on abundance. Blödite and the 16-hydrate add to the list of hydrated phases that could contribute to the martian min eral H_2O storage inventory.

High-resolution passive sampling of methane in the water column of lakes in Greenland: insights into carbon cycling on ancient Mars

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Abstract

Thermokarst lakes along the ice-free margin of Greenland act as a reasonable analog for lakes on early wet Mars. A multi-institution NASA field campaign is currently collecting data on the aqueous chemistry of 7 small (<1 km2) lakes aligned along a narrow valley extending 6km from the Russell Glacier to Søndre Strømfjord in southwestern Greenland. Unexpectedly distinct chemistry among the lakes is evident despite close proximity. This project aims to create a high -resolution profile of methane concentration and carbon isotopic composition using passive diffusion sampling for two lakes. Commercially available Passive Diffusion Bags (PDBs) will be deployed at 0.5-meter intervals in Upper Epidote Vein Valley Lake and South Twin Lake during the summer of 2013. Prior to deployment, equilibration time for methane diffusion and isotopic fractionation associated with diffusion across the PDB membrane will be experimentally determined. The PDBs will be deployed in duplicat e vertical strings in both lakes for the determined equilibration time, which is expected to be a maximum of 2 weeks. Methane will be stripped from water samples by vigorous agitation and analyzed using a Los Gatos Research Methane Carbon Isotope Analyzer at a field laboratory in Kangerlussuaq, Greenland. PDB results will be compared to Kemmerer grab-sample results obtained after the PDBs have been removed from the water column. Passive sampling will allow a high-resolution profile to be obtained rapidly and without the advective disruption associated with grab-sampling. The anticipated two-week equilibration time will minimize biases caused by sampling during a single day. Methane concentrations and isotopic compositions from the diffusion samples will allow for a better understanding of methane dynamics within thermokarst lakes on Earth and will inform our understanding of plausible carbon-cycling mechanisms in seasonally ice-covered paleolakes inferred for warm climate intervals early in Mars' history.

Distribution of glycerol dialkyl glycerol tetraethers in lacustrine sediments from southwestern Greenland: How GDGTs record past climate records?

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Abstract

Understanding likely scenarios for Earth's future climate can benefit from assessment of the variations and rates of changes of climate in both the recent and more ancient past. The key approach in reconstruction of paleoclimates is the ability to decipher biological or geochemical proxies that record environmental changes, such as temperature variations. One proven measure is use of the abundances of glycerol dialkyl glycerol tetraethers (GDGTs) to determine paleotemperatures through proxies such as TEX86 and MBT/CBT that can be applied in investigation of sediment cores. These proxies constitute the focus of my project, which is focused on lakes around Kangerlussuaq, southwestern Greenland, and has two main objectives. First, to produce a GDGT-based paleotemperature record based on sediment cores from two lakes. Second, to validate the veracity of these GDGT-based proxies by comparing the paleotemperature reconstructions for two lakes with significantly different water chemistries. Preliminary results have confirmed the presence of branched GDGTs in sediments from Lower Lake, Kangerlussuaq, Greenland, which will allow assessment of paleotemperatures from determination of values for the MBT/CBT index. Further research plans involve compiling an extended GDGT-based paleotemperature record for Lower Lake to be complemented by determination of a comparable history for Upper Lake. Detailed chronologies for these lake sediments will rely on radiocarbon dating to constrain the temporal framework for the paleoclimate records. These lakes in southwestern Greenland present a unique opportunity to obtain paleoclimate records that can elucidate past climate changes in this region, while also advancing understanding of the use of GDGTs as molecular proxies.

Methane dynamics associated with a small arctic lake, southwest Greenland: Implications for Mars

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Abstract

Methane (CH_4) is a strong greenhouse gas that contributes 20 times more per molecule to the greenhouse effect than carbon dioxide (CO_2). Wetlands and lakes are the largest natural source of CH_4 to the atmosphere and northern wetlands and lakes are thought to contribute from 6 – 25% of Earth's annual atmospheric CH_4 inputs. Particularly underrepresented in studies of CH_4 cycling in Arctic environments are Greenlandic lakes. The area around Kangerlussuaq, Greenland is lake rich with lakes covering 14% of the land surface. The CH_4 dynamics of soils in southwest Greenland are additionally understudied. The goals of this work were to: determine if elevated CH_4 concentrations could be measured in the atmosphere associated with a small southwestern Greenlandic lake; address how atmospheric CH_4 concentration is related to atmospheric variables in the vicinity of a small Greenlandic lake; present the first measurements of CH_4 concentration from a small southwestern Gre enlandic lake; and present the first in situ measurements of CH_4 concentration in Greenlandic soils. Potentilla Lake is 8 m deep, has a surface area of 1.8ha, and has a long axis of roughly 280m. It is situated outside of Kangerlussuaq, Greenland (N 67° 04.888', W 050° 21.084') . Atmospheric CH_4 concentrations in the vicinity of the lake were measured by an open-path tunable diode laser, a cavity ring - down spectrometer, and a gas chromatograph equipped a flame ionization detector. Meteorological variables were measured with a Davis Vantage Vue meteorological station. Epilimnetic, metalimnetic, and hypolimnetic water samples were sampled with a Kemmerer. Soil pore-gasses were sampled with a soil-gas sampling probe. Potentilla Lake and its catchment represent a complex environment with patches of methanotrophy (CH_4 consumption) and methanogenesis (CH_4 production). Possible diffusion of CH_4 through rock fractures of Potentilla's north shoreline may shed light on habitable martian environments.

Methane cycling in small, thermokarst lakes in Southwestern Greenland as an analog for early, wet Mars

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Abstract

Since the putative-discovery of methane in the martian atmosphere in 2003 there has been debate concerning geochemical or biogeochemical pathways for the origin and destruction of volatile hydrocarbons on Mars. On Earth, methane emissions are predominantly derived from thermal cracking of ancient organic matter in the deep subsurface or from microbial methanotrophic metabolism in low-salinity aquatic environments such as wetlands and lakes. Detailed study of methane cycling in thermokarst lakes on the ice-free margin of Greenland provides an appropriate analog for plausible martian ecologies in seasonally ice-covered paleolakes. We concentrate on a chain of 7 small lakes (<1 km^2), spanning a distance < 6 km along a narrow valley overlying a structural shear zone and extending from the Russell Glacier to the Søndre Strømfjord in southwestern Greenland. Due to close proximity we anticipated similar physical parameters and methane concentrations. Here, we describe the preliminary results from four weeks of fieldwork in summer 2012, concentrating on aquatic chemistry combined with methane concentrations and isotopic compositions of methane through the water profile of the lakes. Similarly stratified thermal properties are observed between small lakes at a study site on the ice-free margin of southwestern Greenland. Despite their close proximity, there are substantial variations in the aqueous chemistry of these lakes with no unifying trends observed between depth, surface area, and aquatic chemistry. Dissolved methane concentrations reflect the positions of the thermocline and oxycline in each lake, however variations are observed in CH4 concentration and δ13C-CH4 between lakes. In the absence of thoroughgoing drainage systems, small lakes embedded in thermokarst operate independently despite close proximity. The physiochemical diversity observed is likely due to ecological and hydrogeochemical factors such as differences in bedrock and vegetation.

Cycling of Volatiles in Triton's Icy Crust with Implications for Planetary Volcanism

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Abstract

Triton's surface is covered by volatile ices including nitrogen, carbon monoxide, and methane. Solid or liquid volatile compounds on the surface of a volcanically active planetary body suggest a magmatic-tectonic distillation process that concentrates the volatiles in surface reservoirs. On Earth, the hydro-tectonic cycle transfers water from the Earth's interior to its oceans. Similarly, on Io, a theo-tectonic cycle transfers sulfurous compounds from Io's interior to its surface. Volatiles that are solid or liquid in crustal reservoirs will be transported into the subsurface as the crust recycles to the convecting mantle. As the slab penetrates the mantle, the interior thermal gradient melts the volatiles in the reservoir, distilling the compounds to shallow depths. The liquid or vaporous volatiles remain in the lithosphere until they are assimilated by a rising magma plume. Volatiles assimilated into a rising melt will then likely aid in the eruption of m agma onto the surface. Therefore, other volcanically active bodies with solid or liquid volatiles on its surface should exhibit a similar self-sustaining process where cycling of volatiles in the lithosphere aids in planetary resurfacing and crustal recycling. Here, I investigate this process by examining the geothermal gradient of Triton's crust using previously estimated ammonia concentrations in icy satellites and a true shell thickness model. I determine that the volatile ices on Triton's surface will melt at shallow depths in the lithosphere and will likely aid in the eruption of cryomagmas, resulting in a "cryo-tectonic" cycling of its crust. Triton's geologically young surface suggests this cycle has been occurring since its gravitational capture by Neptune, which implies Triton's lithosphere may be differentiated into compositional layers directly associated with the volatile's melting depths. I speculate a similar process may be occurring on other bodies suspected of volcanic activity, such as Pluto.

Geometric morphometric insights into the ecomorphological variation of artiodactyl distal phalanges

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Abstract

Hooved mammal locomotor morphology indicates habitat type and substrate use, and has been used extensively to predict paleohabitat. Many studies used modern zoo specimens to determine the relationship between bone shape, habitat, and substrate. We explore whether a zoo specimen can be used in place of a wild-caught individual. Forelimbs and hindlimbs in quadrupeds likely bear weight differently and have different biomechanical interactions with the ground. Because of this, there is a chance the distal phalanx (PH3) (i.e. the bone located within the hoof), which is in direct contact between the animal and the substrate it traverses, may have a variable shape within an individual or between species. Potential variation in wild populations could be altered when an animal is placed into captivity, and whose man-made habitats consist of cement or other hard materials the animal would not naturally interact with. Deer were analyzed in this study because they populate a wide range of habitats, are commonly kept in zoos and have visually similar morphology among hooves. Four deer species were analyzed to explore shape variation using geometric morphometrics. Within each species we sampled one wild caught and one captive individual. Fifty landmarks around the bottom surface of the PH3 were Procrustes superimposed and subjected to a principal components analysis. PC1 explained 53.5% of the total variance and represents the shape trajectory of a straight PH3 to an angled PH3. PC2 explained 20% of the total variance and represents the trajectory of a thin, tapered PH3 to blocky, robust PH3 morphology. With a larger sample size, greater variation in the sample among factors will be detectable. Early results show no variation exists between limb PH3 in an individual and deer PH3 morphology is best explained by substrate and habitat interaction with phylogeny following closely behind. In addition, studies interested in PH3 ecomorphology may use capti ve animals within their sample.

Homo erectus in China: Paleoenvironment, Subsistence, and Technological Adaptations Reflected in a Nihewan Basin Faunal Collection

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Abstract

The focus of my study is Donggutuo, a 1.1 million year old archaeological site in the Nihewan Basin of China located approximately 100 miles west of Beijing. The current analysis consists of 2153 faunal specimens, some of which display surface damage including cutmarks, percussion marks, and carnivore toothmarks. Specifically, I first look at the animal taxa present at this site, and then I analyze how they were utilized by Homo erectus. The paleoenvironment at Donggutuo is suggested to have been colder and more variable than at earlier African, western European, and South Asian sites, and the identification of a species of woolly rhinoceros at this site supports that theory. I hypothesize that this challenging environment necessitated new behavioral and dietary adaptations for the resident hominins. I expect to find evidence of greater carcass utilization at Donggutuo because wasting food resources would be precarious in an environment in which alternative food res ources are scarce. This increased utilization would result in more numerous cutmarks and higher proportions of bones broken for marrow extraction. Additionally, I suggest that the collection will include higher proportions of large prey species compared to sites with more amenable climates, as larger animals would have provided greater resource returns. Testing these hypotheses will help paint a picture of the behavior of hominins as they adapted to a new geographic area outside of Africa.

Morphological Disparity of Mesozoic Mammals Through Time

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Abstract

Mesozoic mammals never attained the extensive range of adaptations that have been explored by their Cenozoic relatives. However, early mammal taxonomic diversity and morphological disparity appears to have fluctuated considerably over their 150 million year history. Here, we offer an analysis of morphological disparity, which measures how anatomically different early mammals were through time, with an additional focus on how the patterns relate to ecological and environmental changes. A discrete character matrix was used to create a time-sliced principal coordinates analysis, allowing for examination of morphospace occupation through time. This data is supplemented with measures of disparity that are based on a geometric morphometric analysis of jaw shape, tooth measurements, and taxon-free diversity curves that group genera by dental functional type. Two major conclusions are reached: morphological disparity levels of mammals 1) gradually increased with time throug h the Early Cretaceous and 2) bottlenecked during the mid-Cretaceous before partially rebounding in the late Late Cretaceous. The morphological disparity patterns are compared to ecological, climatic, and biogeographical changes during the Mesozoic Era. Most notably, we examine the diversity patterns of plants and insects and their possible correlations with mammalian changes. The Jurassic diversification of mammals corresponds temporally with increases in plant diversity (especially conifers and ferns), radiations of several insect orders, and early rifting of Pangaea. The disparity bottleneck of the mid-Cretaceous corresponds to the taxonomic rise of angiosperms, high rates of ecological disturbances, taxonomic turnover of many tetrapod groups, and high global temperatures. Causation of the mammalian changes in morphological disparity is speculative, but this study produces a framework for future analyses of mammalian disparity and the factors affecting that disparity.

Assessing the Potential for Ontogenetic Ecomorphology in Theropods: A Case Study Using Allosaurus fragillis from the Cleveland-Lloyd Quarry

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Abstract

Observations of changing morphology through ontogeny have been recognized in several different dinosaur species, including theropods, and more recently ceratopsians and pachycephalosaurs. In the majority of this research, these changes were documented for the purpose of solving alpha taxonomic problems associated with genus or species-level identification or patterns of organismal growth, but not directly answering functional or ecologic community-based questions. Given some of these changes occur in functionally significant portions of the skeleton (hind limb proportions, dentition, and skull shape), there exists the potential that morphological differences of a given species at different stages of growth allowed for ecological niche partitioning between adults and juveniles, such as prey specialization among carnivorous theropods. To assess the degree that functional morphology would change with growth, a geometric morphometric analysis was performed to quantify s hape variation in the maxilla and compared with measurements from the hind limb and dentition in specimens of Allosaurus fragillis at various ontogenetic stages. Preliminary results indicate that while the previously demonstrated patterns of decreasing cursoriality through ontogeny are observed, skull and dental morphology is conserved relative to other large -bodied theropods. These results have implications for factors governing the functional evolution of theropod skull shape, the ecologic structure of dinosaur communities and potential interspecific niche partitioning as well as intraspecific niche partitioning based on growth and age.

The Ecology and Distribution of Foraminiferal Assemblages Living on the Seafloor of the Southern Californian Bight

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Abstract

In an ongoing investigation examining seafloor ecosystem responses to environmental change, living (Rose Bengal stained) foraminifera were examined from surface sediments (0-1 cm) collected by multicorer along a depth transect (300-3000 meters) in the Southern Californian Bight. Foraminifera (single-celled organisms) are among the most abundant organisms in the deep sea, and are very responsive to changes in their environment. As a result, living foraminifera are used as environmental indicators of modern marine habitats, and their fossil record provides a means to assess environmental conditions of the past. Use of foraminifera to evaluate paleoenvironments depends upon accurate information about the relationships between living foraminifera and environmental variables, including dissolved oxygen, sediment grain size, and temperature. Sampling locations included oxygen minimum zone sites with bottom water values from 0.47 ml/L to 1.50 ml/L, temperatures ranging from 2.9 C to 7.1 C, and grain size averages from 23.9μm to 105.7μm. The oxygen minimum zone has traditionally been thought of as a relatively homogeneous habitat, dominated by a limited number of specialist species. Results from this study revealed that foraminiferal species abundances were variable between sites, potentially as a result of habitat heterogeneity. The most common calcareous species, *Uvigerina* spp., was relatively abundant (up to 697 specimens per 50cc) at all of the sites examined except one. Although less abundant, *Hoeglundina elegans* and *Cassidulinoides waltoni* also occurred at a majority of the sites. Species that dominated at least one site included *Cassidulina* spp. And *Pyrgo* sp. *Planulina wuellerstorfi,* an epifaunal species (lives exclusively at or above the sediment-water interface) is considered to be an indicator of well-oxygenated environments. However, this species was abundant at 1000 meters, where dissolved O_2 levels were relatively low (0.47ml/L) . The distribution of epifaunal species appears to be influenced by sediment grain size, while temperature differences between sites did not appear to affect foraminiferal distribution patterns in this region. Results of this study demonstrate that some species can thrive in lower oxygen conditions than previously thought, and that habitat variability may appreciably influence foraminiferal assemblages under oxygen-poor conditions. These findings yield information critical for predictions of ecological responses to future environmental changes, and provide modern analogs that have important implications for assessments of paleoenvironmental changes in ancient oceans.

High Resolution Record of Bulk δ13C in a Marine Core at the Edge of the IPWP During the Last Deglaciation

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Abstract

The Indo Pacific Warm Pool (IPWP) drives the most significant center of atmospheric convection on the planet that anchors the zonal Pacific Walker Circulation and meridional Hadley circulation. The IPWP is the single largest source of heat and moisture to the global atmosphere and so its history is important for predicting global climate change. Understanding the paleoclimate record of this area could help us to better understand the current climate fluctuations in the area and better judge whether the causes of the dramatic climatic changes that are presently occurring. A 34 m long piston core, MD012382, was recovered from near the present shoreline of Cenderawasih Bay along the north coast of Papua Province, Indonesia. Because rivers that drain the highest portion of the New Guinea central range that reach 5000 m all drain into this bay, sedimentation rates are very high. Samples from the MD82 core were decalcified in order to analyze the bulk organic matter in the sediment for N, organic C, and δ13C. The results show a major change in δ13C during the last deglaciation. This project aims to figure out the causes of the changes in bulk δ13C.

Microhabitat Preferences of Benthic Foraminifera Associated with Hydrate Ridge Methane Seeps

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Abstract

Vertical distribution patterns of living (Rose Bengal stained) benthic foraminifera with in sediment(0-3cm) were compared in methane seep and adjacent non-seep habitats from Hydrate Ridge off the Pacific coast of Oregon. Foraminifera are single-celled organisms that have been used as indicators of methane seepage. Marine methane seepage of the past has been linked with climate change. It is important to understand the influences of seepage on modern ecosystems, and to have a modern analog to potentially evaluate ancient seepage from fossil foraminifera. Samples were collected using the Remotely Operated Vehicle Jason2 at Hydrate Ridge north and south. Foraminiferal assemblages collected within bacterial mats from active methane seep environments at Hydrate Ridge north(600m) had similar vertical distribution patterns to those outside the active seep areas. Similar taxa were present at seep and adjacent non-seep environments including: Uvigerina peregrina, Cassidulina spp., Bolivina spissa and Bulimina tenuata. Foraminifera from non-seep habitats of Hydrate Ridge south(813m) were dominated by U. peregrina and agglutinated species. These results suggest that appreciable variability exists in foraminiferal populations at Hydrate Ridge. These findings are consistent with those of other continental margins where habitat heterogeneity strongly influences seafloor ecosystems. Previous studies have noted that there are appreciable differences in geological characteristics between Hydrate Ridge North and South (Torres et al.,2004). Methane and dissolved oxygen concentrations at Hydrate ridge north were more than double the concentrations found at Hydrate ridge south. This is indicative of the difference in maturity of the North and South summits of Hydrate Ridge. The North is more mature with older more well developed sediments and precipitated carbonate pavement. This could account for the difference in assemblages observed at Hydrate Ridge No rth versus Hydrate ridge South.

Inferring locomotor capabilities of the extinct terror bird Gastornis using Geometric Morphometrics

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Abstract

Gastornis was a large flightless bird that lived in the lush Eocene forests of North America and Europe, a member of the family Gastornithidae. These so-called "terror birds" are part of the order Anseriformes, whose living members include ducks, geese and swans. Terrestrial locomotion was an important part of their survival, and estimating their locomotor capabilities is an important part of understanding their ecology because of their terrestrial adaptations. Using geometric morphometric (GMM) analysis I compared the shape of the distal end of the tarsometatarsus of 11 species of modern day birds ranging from flightless and terrestrial to aerial. Landmarks were taken, three each, around the metatarsal trochlea II, III and IV, one at the point where the metatarsal trochlea III ends, and one on either side of the peak of curvature towards the proximal end. I Procrustes superimposed the landmarks and subjected them to a principle components analysis. The result s illustrate differences in shape between the functional groups, with distinct groupings found in the shape of this bone for truly aerial, truly terrestrial, and birds that are often aerial but spend a considerable amount of time wading or walking. The more flat and fused distal ends indicate birds relying on flight, and the more wide spread and separated, indicates it is more likely terrestrially adapted; this change in shape is what describes the principle component 1 (PC1). When the data set for Gastornis was added to this plot, it fell close to the large terrestrial birds such as emu and rhea. Based on these data an estimated running speed may be obtained by regressing the principal component scores against the known maximum running speeds of the modern large flightless birds.

Inner Mongolian Early Cretaceous Plants

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Abstract

Inner Mongolia is located in the northern China. Early Cretaceous sediments in the Inner Mongolian Huolinhe Coal-bearing Basin (60 km by 9 km) contain abundant, well-preserved plant fossils. The Huolinhe Formation consists of six members. The coal consists of lignite. The Huolinhe Formation is above late Jurassic volcanic rocks and covered by Quaternary sediments. The Huolinhe Coal flora reflects typical middle Early Cretaceous (Barremian) vegetation of north central China. In northeast China similar age sediments with plant fossils occur. The plants in the Huolinhe Formation share both similar and different elements from those further east. The flora is composed of Bryophyta, Pteridophyta and Gymnospermae. These fossils are :Bryophyte: Thallites sp., Horsetails : Equisetites. Ferns: Ruffordia , Coniopteris ,Eboracia , Onychiopsis , Cladophlebis , Acanthopteris, Bennettitales : Pterophyllum , Nilssoniopteris, Ginkgos: Ginkgo, Ginkgoites, Baiera , Sphenobaiera, Phoenicop sis, Stenorachis, Conifers: Pityostrobes, Metasequoia, Schizolepis, Elatocladus, Brachyphyllum, Podozamites, Conites, Carpolithes and Radicites. The Barremian age of the Huolinhe flora is similar to other Middle Early Cretaceous floras in Northeast China. These floras include the Heilongjiang Province, Jixi group, which has similar elements such as Coniopteris burejensis and Acanthopteris gothani . In Liaoning Province, the Fuxin Formation, shares taxa, such as Thallites, Coniopteris burejensis , Eboracia lobifolia and Baiera manchurica . The flora reflects an extinct climate that probably was similar to a warm temperate and humid, with seasonal variations. It probably was equable to the extent that it lacked extremes typical of an extant warm to cool temperate seasonal climate.

SPECIES DELIMITATION BASED ON THE LIMITS OF CLIMATE AND MORPHOLOGY IN PALEONTOLOGY: A GEOMETRIC MORPHOMETRIC ANALYSES OF *CHRYSEMYS PICTA*

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Abstract

Aquatic turtles have great promise as paleoclimatic indicators. Their ectothermic physiology gives them sharp geographic boundaries defined by winter cold, and their freshwater environment and diet give the istopic signature in their bones a clear relationship to the signature of precipitation within their environment. The North American pond turtle, *Chrysemys picta,* originated in the Miocene and persists to the present day, with its northern boundary following isothermic lines around New Brunswick, along the northern Great Lakes, and into southern Saskatchewan and Manitoba. This species is not homogenous; however, it is divided into four subspecies *C.picta picta* (Atlantic seaboard), *C. p. marginata* (Midwest), *C. p. bellii* (upper Great Plains and northwoods), and *C. p. dorsalis* (southern Mississippi River drainage). The latter group has an entirely different climatic regime and has been considered a distinct species by many authors. The possibility of distinguishing these four phylogeographic groups, especially, *C. p. dorsalis*, based on its shell, was examined in this study. Seventeen landmarks were taken on the plastrons of individuals within each of the four subspecies. A Principal Component Analysis of the Procrustes superimposed landmarks shows morphological variation within *C. picta* is determined by subspeciation. Differentiation of subspecies accounts for ~8% of the total morphological variation. *C. picta picta* was determined to be marginally more similar to *C. dorsalis* than to the other subspecies. Compared to morphological differentiation between subspecies, there is considerable within group variation. While there are phenotypic differences between subspecies, a reasonable sample size is necessary to distinguish them. Future work tracing the differentiation of *C. picta* in relation to the climatic transition from Miocene to Quaternary will have to be based on more than individual specimens.

Geometric morphometric analysis of wing shape of nine species from Tribe

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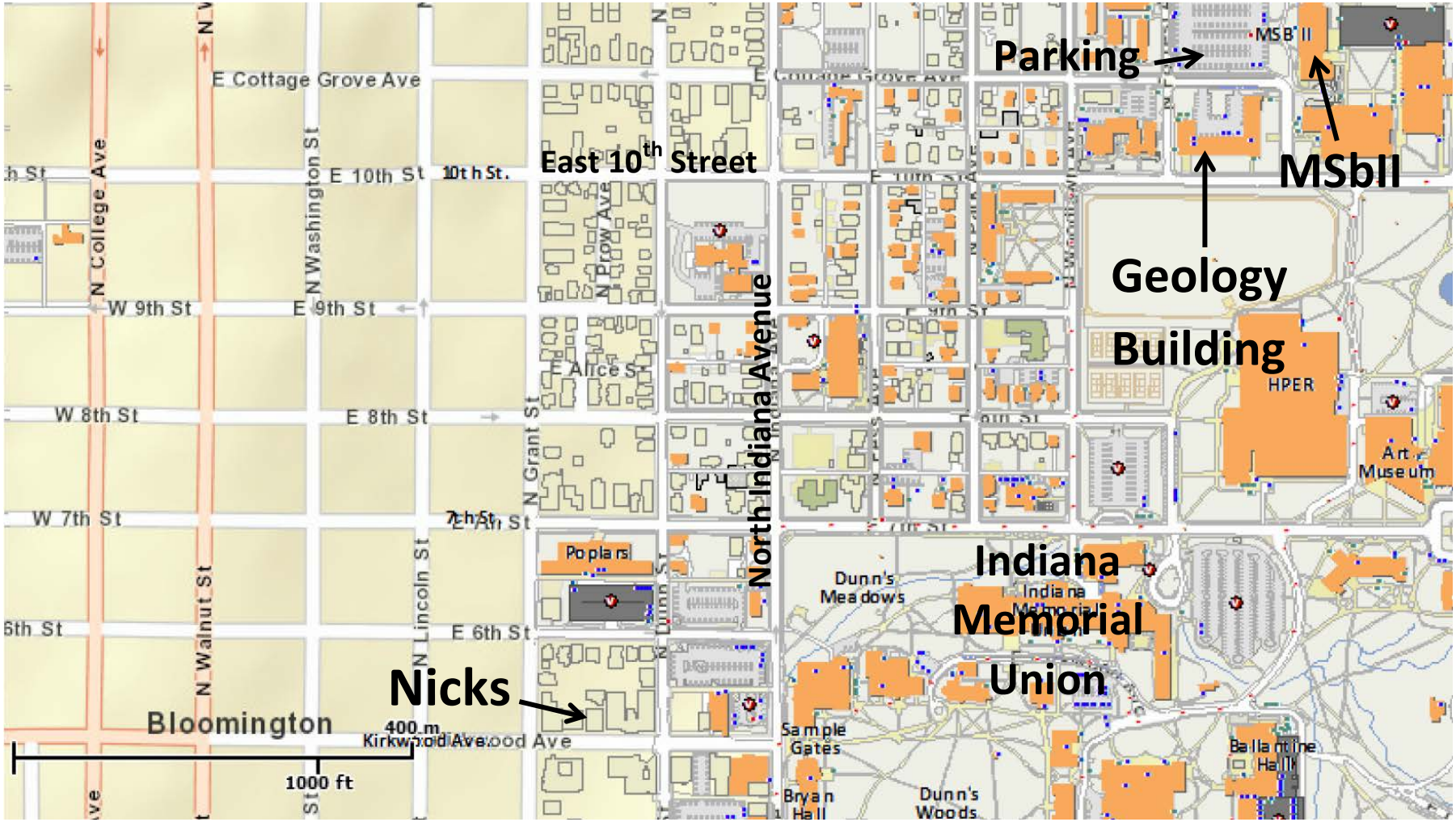
Abstract

Antlions, or Myrmeleontidae, are members of the insect order Neuroptera. Antlion wings vary substantially among genera and species in their venation and in the outline of the shape of the wing. Venation is widely used in diagnostic characters in taxonomic descriptions of the Myrmeleontidae; however, wing shape has seldom been used for taxonomic identification or phylogeny in antlions. The aim of this study is to evaluate wing shape variation, and to test whether the specimens can be discriminated at species level or genus level. Six landmarks and two hundred semi-landmarks were collected from the right forewing of 88 specimens of nine species of the tribe Myrmeleontini from China. Analysis of wing size shows that Hagennomyia eurystictus and Myrmeleon immanis had the largest and smallest wing centroid sizes respectively. A one-way ANOVA of mean centroid size showed significant differences between species variations ($F = 14.75$, $p < 0.001$). manova, canonical variate ana lysis (cva), and discriminate function analysis (dfa) were used to discriminate nine species based on wing shape. Overall wing shape significantly differed between most species and 81.8% of specimens could be correctly assigned based on wing shape. a tree based on procrustes distance shows three Hagennomyia species formed one group and four Myrmeleon species were clustered as another group. The result of cluster analysis agrees with the current taxonomic system except only two Euroleon species were not well clustered. That indicates geometric morphometric based on wing shape can represent a useful approach for discriminating antlion species. Wing shape may contain significant phylogenetic signal for phylogeny studies of Myrmeleontidae.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