Fortieth Annual

GEOSCIENCE DAY

PROGRAM AND ABSTRACTS

INDIANA UNIVERSITY OF PENNSYLVANIA
GEOSCIENCE DEPARTMENT

April 25, 2014
Room 134 Weyandt Hall

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Program Schedule

- **9:00 a.m. – Welcome and Introduction by Dr. Steve Hovan**
- **Session 1: Earth History and Surface Processes**
    - **9:15– Zachary Tolbart:** *Trilobite Biostratigraphy Near the Base of the Proposed Lawsonian Stage" Across Southern North America (Western Laurentia)*
    - **9:30 – Samantha Ritzer:** *Discharge in California Rivers Associated with Pacific Decadal Oscillation*
    - **9:45 – Sage Wagner:** *Morphometric Analysis for Characterizing Submarine Drainage Networks: Upper East Scotian Slope*
    - **10:00 – Nicholas Gressang:** *Dissolved Material Flux into Yellow Creek Reservoir: Laurel Run Indiana, PA*
- **10:15 – Coffee Break and Poster Viewing**
- **Session 2: Environmental Applications**
    - **11:00 – Alexander Patterson:** *Environmental Site Assessment of the Former Josephine Iron Works in Indiana County, Pennsylvania*
    - **11:15 – Nicholas Zbur:** *Effects of Dual-Phase Extraction on Benzene/MTBE Concentrations for a Site with a Historic Underground Petroleum Release*
    - **11:30 – Shannen Stiffler:** *Energy Consumption Analysis of Indiana University of Pennsylvania Residence Halls*
- **11:45–1:15 p.m. Lunch Break**
- **Session 3: Geologic Models**
    - **1:15 – Michael Stoehr:** *Stream Flow Imaging of an EmRiver Em2 Stream Table*
    - **1:30 – Dennis J. Carpinello:** *Models of Hypothetical Stream Contamination from Hydraulic Fracturing of the Marcellus Shale in Indiana County, Pennsylvania*
    - **1:45 – Thomas Paronish:** *Analysis of Field Based Fault Kinematic and Structural Fabric Data from Southwestern Taiwan to Determine Stress Geometry During Early Mountain Building*
    - **2:00 - W. David Watkins:** *Potential Causes for Along-Strike Variability of Slow Slip Events*
    - **2:15 - Jerome Kay:** *Thermal Maturity Modeling of the Marcellus Shale: Impact of Variable Geothermal Gradients on Estimates of Eroded Overburden*
- **2:30 - 3:30 p.m. – Alumni Lecture: Kalin McDannell ('08)** PhD Candidate, Lehigh University *"Landscape Evolution in the Hangay Dome, Mongolia"*

Trilobite Biostratigraphy Near the Base of the Proposed "Lawsonian Stage" Across Southern North America (Western Laurentia)

Zachary, TOLBART and John Taylor

The lowest occurrence (first appearance datum, or FAD) of the conodont *Eoconodontus notchpeakensis* Miller has been proposed to define the base of the uppermost of ten global stages within the Cambrian System. The formal proposal also recommends a potential global stratotype section and point (GSSP) at Sneakover Pass in western Utah, and a name for the new stage and age, the "Lawsonian". The exact position of this boundary cannot always be determined by recovery of *E. notchpeakensis*. Therefore other fossil groups and correlation methods are needed to trace the boundary around the world. Our research focused on trilobite faunas and the relationship of ranges for species in several rapidly evolving Laurentian genera to the FAD of *E. notchpeakensis* in intensively sampled measured sections in western Utah, central Texas, and northern Virginia.

Detailed biostratigraphic range charts across the base of the Lawsonian Stage, constructed from data extracted from the literature and numerous new collections from the Notch Peak Formation in Utah and the Wilberns Formation in Texas, reveal useful successions of species within at least a dozen genera in both locations. Each of these genera contains at least one species whose limited range makes it useful for determining the approximate position of the base of the Lawsonian. The highest occurrences of some species fall just below the proposed stage boundary, while the FAD's of others lie just above it. A few species characterize the boundary interval by having short ranges that span the base of the Lawsonian. However, attempts at compositing all the data from Texas, Alberta, and Utah showed that there is some regional variance in trilobite ranges that caused limits the utility of the trilobites on a continent-wide scale. Recovery of conodonts *Proconodontus serratus* and *Proconodontus tenuiserratus* from the Conococheague Formation in the Shenandoah Valley of Virginia refined the placement of the base of the Lawsonian within the trilobite-based zonation established for that formation, indicating that it lies somewhere within the *Pelthopeltis "obtusus"* Zone. The utility of trilobites demonstrated in this study strongly supports the proposal to utilize the FAD of *E. notchpeakensis* as the base of the tenth global Cambrian stage, with the Sneakover Pass section designated as its GSSP.

Discharge In California Rivers Associated With Pacific Decadal Oscillation

Samantha R. RITZER and Katie Farnsworth

The Pacific Decadal Oscillation is marked by an anomalous change in the ocean surface temperature from a long standing average. These changes occur in 20-30 year cycles of either cold or warm ocean surface temperatures. The PDO, as it is called, has implications for the weather and climate conditions of the Pacific west coast, including the river systems of California. It is thought to cause snowpack and precipitation values in our study area to fluctuate to above average during warm PDO or below average with cold PDO in a similar time frame correlating with PDO cycles (Mantua et al., 1997). To look at this, we are using daily discharge (cfs) data obtained by the USGS gauging stations for six rivers and streams in California spanning approximately four degrees of latitudinal distance. The data sets were all required to cover from at least 1947-1998 to give a continuous set over two PDO cycles, one warm and one cold. Each of the gauging station sites were carefully chosen above any human-built dams to ensure that the data set would be unregulated and show the correct peaks. The rivers in our data set are characterized by the water source that drives them, either snowpack/snowmelt or precipitation depending on their greatest average discharge peak during the water year. Via statistical analysis of warm and cold discharge peaks vs. average, we are able to conclude that our data is relevant for several of the important (spring) months of the year. With further statistical analysis and a more solidified conclusion this could have implications for determining PDO cycle start and end, preparing communities for long periods of below average water distribution, or gaining a better understanding of interplay between river processes and oceanic changes.

Morphometric Analysis for Characterizing Submarine Drainage Networks: Upper East Scotian Slope

Sage WAGNER and Katie Farnsworth

Modern, clastic deepwater systems in low latitudes have been extensively studied based on their hydrocarbon potential, but less is known about pro-glacially influenced deepwater environments. This project will focus on detecting relevant morphological changes along the East Scotian Canyon System (ESCS), offshore Nova Scotia. Submarine drainage networks were extracted from a multi-beam bathymetry dataset of 25-meter grid size and were analyzed in ArcGIS to provide a morphometric methodology to characterize submarine drainage networks at fine resolution scales.

Following the Horton-Strahler method, main morphometric parameters (number of streams, streams length, and axial slope gradient) were calculated for each stream segment. Quantitative analyses used for terrestrial fluvial drainage networks such as drainage area, drainage density, stream frequency, basin relief and accumulated stream length parameters were conducted to characterize the system. This work has the potential to expand existing models for deepwater processes and resulting submarine drainage networks to high-latitude margins influenced by proglacial sedimentary processes.

Dissolved Material Flux Into Yellow Creek Reservoir: Laurel Run Indiana , PA

Nicholas C. GRESSANG and Katie Farnsworth

The amount of dissolved material within a stream fluctuates corresponding to the rise and fall of stage level. This material is added via run -off, groundwater or through the dissolution of the surrounding channel. By observing flux of dissolved material and total dissolved solid (TDS) concentrations, we are able to develop a better understanding of the timing and origin of the added material. The dynamic relationship between stream stage level and TDS concentration often results in higher concentrations of material during higher discharge.

Laurel Run was selected for analysis of discharge and TDS concentrations. Laurel Run lies within the Blacklick Creek watershed in Indiana, Pa, and empties into Yellow Creek reservoir. Field measurements were made continuously with a Solinst CTD as well as instantaneous velocities with a SonTek FlowTracker Handheld ADV. The velocities obtained by the measurements of these streams were used along with the cross-sectional area to calculate discharge to model a discharge-stage level rating curve. This curve was applied to average monthly discharge, TDS concentration, and dissolved sediment flux data in order to distinguish seasonal patterns. Analysis reveals that increased discharge results in lower TDS concentrations, indicating that dilution of dissolved material occurs with larger amounts of water. Seasonal analysis shows that summer months have the largest flux of dissolved material.

Environmental Site Assessment of the Former Josephine Iron Works in Indiana County, Pennsylvania

Alexander Q. PATTERSON and Karen Rose Cercone

Located in southern Indiana County, Pennsylvania, Blacklick was once the home of a large steel and iron plant. The plant was closed in the early 20th century and was left idle for many years before any removal of equipment was done. It is not completely known what environmental hazards from the mill may be associated with these or any remaining material. The site is located adjacent to a public trail as well as Two Lick Creek and before the land is used for any other recreational purpose or land transactions it must first undergo a preliminary site assessment (PSA). A PSA is required for all land transactions and is a semi-quantitative survey of possible environmental risks. The research for conducting the PSA requires 1: obtaining historical records from historical societies, government agencies, newspapers and the company if available, 2: Visual inspection of the site, 3: interviews with any former employees, 4: any previous data collected.

Initial results at the Josephine Works site suggest that there is risk from arsenic and lead, among other contaminants found from a report on the soil previously conducted. These chemicals are probably remnants of slag piles or steel pickling sludge ponds that remained on the site for many years before most were removed. Given the known contamination of the site, the conclusion of preliminary site assessment is that environmental cleanup should be performed by mass removal of contaminated soil before any site development can occur.

Dual-Phase Extraction And Its Effects On Benzene And MTBE Concentrations For A Site With An Underground Petroleum Release, Brookville, PA

Nicholas S. ZBUR and Karen Rose Cercone

Dual-phase extraction (DPE) is the process of removing both vapors and fluids from the subsurface. This is completed by equipping strong vacuums to drilled monitoring wells with screened intervals. This process is effective at removing hydrocarbons in the liquid-phase, the dissolved-phase, and the vapor-phase; It is particularly effective at removing free-phase hydrocarbons. The site in question is a former Gulf service station located on Main Street in Brookville, PA. There was an underground petroleum release sometime before 2006. The site was monitored with quarterly groundwater sampling since the release. In March 2013, it was decided that dual-phase extraction would be the Remedial Action Plan due to observed high concentrations of benzene and MTBE. There were a total of 12 events and sampling was done after every other event. The data showed that certain wells experienced an unexpected rebound in contaminant levels following each event. As a result, the site will require many additional dual-phase extractions compared to a typical gas station clean-up.

This study investigated what geologic and hydrologic factors could account for higher contamination levels and extended clean-up time-frame. The hydrologic gradient decreases from north-east to southwest across the site, pulling contamination from the source to an off-site monitoring well which shows the strongest rebound effect. This well is also deeper, suggesting that the plume may have entered a lower aquifer in the section. The bedrock here is Pennsylvanian-age Pottsville Group; the materials that underlie the site consist of clays, sand and silt with a dominance of sand. Sand has a much higher transmissivity compared to shale, which would explain why the contamination spread so widely and penetrated more deeply than is typical. Because the dual-phase extraction wells are located up-gradient from most of the plume, it is more difficult to remove the benzene and MTBE by vacuuming.

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Energy Consumption Analysis of the Indiana University of Pennsylvania Residence Halls

Shannen R. STIFFLER and Steve A. Hovan

From 2006 to 2011, the Indiana University of Pennsylvania campus completed the Residential Revival, a construction project to replace the traditional style dorms with new, suite-style residence halls. These 8 halls were granted LEED Certification and equipped with system gauges to monitor the use of steam, water, electricity, and total energy (a combination of all three energy sources) within the suites, providing a new opportunity to study utility and energy consumption in campus residence halls. In this study, we examine the influence of weather and structural factors associated with energy consumption.

This research was conducted throughout the 2013-2014 academic year, with data also collected from February 2013. Data was collected from all eight residence halls, but Wallwork Hall was used as the primary display of results due to highly consistent data outputs. Time-series of weather variables, such as temperature fluctuations were collected, along with daily, monthly, and annual comparisons of steam, water, electricity, and overall consumption. Structural variability of the buildings, including differences in living space square footage and amenities square footage was also documented. Chilled water data was often inconsistent, resulting in the omission of this data for much of the analysis.

Weather factors were responsible for some of the variability in energy consumption. Although there was a notable decrease in electricity during colder periods, an increase in both overall energy and condensate usage appeared. However, increased electricity could be related to darker periods during the time of year, rather than temperature. With daily consumption patterns, prominent peaks and troughs of consumption appear. Peaks for all energy sources, with the exception of chilled water, occur around 11am-1pm, and 11pm-1am, or roughly every 12 hours. All sources of energy, with the exception of condensate, displayed apparent lows in usage between 6am-8am. Structural variability was taken into consideration regarding the square footage of the four residence halls which contain larger amenities spaces from offices, as well as to record whether larger buildings consume more total energy. When total energy per square foot was taken before and after consideration of amenities space, no major changes of consumption per square foot appeared. As expected, consumption was generally higher in buildings with larger square footage.

Stream Flow Imaging Of An EmRiver Em2 Stream Table

Michael STOEHR and Katie Farnsworth

In studying fluvial geomorphology many variables can be taken into account. The way a stream moves over time is something that is hard to fathom over human time scales. The EmRiver Em2 stream table helps to model the way a stream will behave in reaction to varying conditions. The table is on a slope to allow the stream to move downhill and base level can be changed to simulate different topography conditions. The Em2 table uses ground plastic as sediment so that the density and permeability are consistent with the discharge of the table. The table is controlled by an electronic controller that controls water discharge and can also run hydrographs that simulate flash floods and megafloods. A channel was created by hand and by using a camera we were able to show, using time-lapse video, how the stream will migrate across the landscape and how its sediment will move through the channel based on the water discharge and duration. Creating the channel by hand creates a place for the stream to flow and allows it to act more naturally rather than creating its own channel and then moving across the landscape. The time lapse was taken by placing a camera over the stream table using a tripod and setting a shot interval for a specified time. By linking the pictures together we can see how the stream moved over the course of the hydrograph and once the hydrograph stops it will show how the stream was able to shape the landscape. By looking at the way the streams move during different hydrographs we can see how streams interact with the landscape under different scenarios such as flash floods and megafloods. Imaging the EmRiver Em2 stream table can help us understand and study fluvial geomorphology.

Models Of Hypothetical Stream Contamination From Hydraulic Fracturing Of The Marcellus Shale In Indiana County, Pennsylvania

Dennis J. CARPINELLO and Karen Rose Cercone

Hydraulic fracturing, when combined with horizontal drilling, has made extraction of the natural gas reserves found in the Marcellus Shale much more feasible. A byproduct of this method is flowback in the form of brine, which has extremely high salinity and contains high concentrations of various elements, including radium. Proper disposal of brine has been a focus of public attention, considering that, in 2010, 55% of wells were located within 300 meters of streams. While public concerns may be reasonable, we argue that anything other than catastrophic displacement of flowback fluids into streams would result in minimal impact on their overall drinking water quality.

We set out to determine if the concentrations of specific contaminants, Total Dissolved Solids (TDS), sulfate, barium, and total radium found in brine extracted from a Marcellus gas well in Indiana County, Pennsylvania would exceed Pennsylvania Maximum Contaminant Levels (MCL's) for drinking water if introduced into streams of various discharges. Although we modeled different stream discharges, we used data from Blacklick Creek for present stream levels of each contaminant. To model the amount of brine introduced into the streams, we used a range of 5,500 cubic feet (storage tank) to approximately 30,000 cubic feet (three impoundment ponds) for the brine that would be displaced. In our models, the rate of flow of brine varied from one minute (catastrophic displacement) to one year (low-level long-term discharge). The amount of time required for contamination to exceed MCL's ranged between 1 hour and 1 day and was never more than 1.5 days even in the most extreme cases. This suggests that long-term low-level discharge of flowback water would rarely pose a problem for stream health and that only catastrophic displacement events similar to the recent tank spill in West Virginia would result in stream pollution.

Analysis Of Field Based Fault Kinematic And Structural Fabric Data From Southwestern Taiwan To Determine Stress Geometry During Early Mountain Building

Thomas J. PARONISH, Jonathan C. Lewis, and Jian-Cheng Lee

We analyzed unpublished field-derived fault kinematic and structural fabric data from southwestern Taiwan compiled by co-author Lee and his collaborators. Analyses across the western foothills eastward into the slate belt reveal evidence for ongoing tectonic escape to the southwest accommodated by brittle structures. The results are consistent with published paleostress analyses and geodetic inversions. In particular, existing inversions of fault-slip data suggest E-W compression overprinted by WNW-ESE compression. Furthermore, inversions of GPS data suggest active SW-directed extension.

We find that the intensity of deformation increases from west to east within the structurally dominate orthogonal joint sets. In the western exposures of unmetamorphosed sedimentary rocks, joints appear consistently oriented whereas toward the east they begin to fan about a subvertical axis. The fanning suggests either rotation of the rocks in a fixed stress field or a rotating stress field. In the easternmost exposures, deformation is dominated by strike-slip faults, thrust faults, and mineralized veins in rocks with a weak cleavage. In the features south of the Chishan Transfer Fault Zone, we find deformation is dominated by strike-slip faults oriented in sets E-W and WNW- ESE, along with unconstrained thrust and normal faults due to rapid uplift of weakly consolidated sediments. These features show some local heterogeneity but overall appear to record extension N-S to NNE-SSW; suggesting the possibility of tectonic escape.

Potential Causes For Along-Strike Variability Of Slow Slip Events

David W. WATKINS, Harmony V. Colella, Michael R. Brudzinski, Keith B. Dieterich, and Keith B. Richards-Dinger

Slow slip events (SSEs) are observed in subduction zones around the world and exhibit a wide range of recurrence intervals, durations, and spatial extents. A ubiquitous feature of SSEs is the along-strike variability of these characteristics. However the cause and long-term effects of such variability is poorly understood. Additionally, it is unclear whether such variability and segmentation of SSEs persists beyond human time scales. Here we employ the earthquake simulator RSQSim to model a megathrust, which consists of seismogenic, slow slip, and continuous creep sections. The slow slip section is segmented to explore potential causes of along-strike variability in recurrence intervals, durations, and spatial extent, by varying parameters such as the effective normal stress, frictional properties, and convergence rates. RSQSim enables simulations of long histories of SSEs over all orders of magnitude, which allows for robust characterization of the effects of variation in parameters. Preliminary results show even small variations in these parameters have a significant effect on observable characteristics of SSEs, which begins to illuminate the primary controls on along-strike variability. For example, a decrease in the effective normal stress from 9MPa to 3MPa results in a decrease in the mean recurrence interval and event duration from 35 to 15 months and 44 to 16 days, respectively, but increases the mean propagation speed from ~7 km/day to ~24 km/day. In simulations with a segmented fault the same trends in recurrence interval are visible within sections, but are impacted by interaction with adjacent segments.

Thermal Maturity Modeling Of The Marcellus Shale: Impact Of Variable Geothermal Gradients On Estimates Of Eroded Overburden

Jerome Z. KAY and Karen R. Cercone

Thermal maturity is a measure of a rock's thermal state in terms of hydrocarbon. A mature rock will produce oil whereas as an over mature rock will produce gas. For a rock to reach thermal maturity, it must be buried in depth with increasing pressure and temperature.

The Marcellus Shale in Pennsylvania has a high thermal maturity and therefore produces natural gas. However, thermal models show that the current burial thickness would only allow it to reach a thermal maturity sufficient to generate oil in some locations. This suggests that the Marcellus Shale was buried much more deeply in the past than it is today, and that it then got eroded away. An alternate explanation could be that the 'missing overburden' never existed at all and that the Marcellus Shale had been 'cooked' by overlying coal beds, resulting in a higher thermal maturity.

To understand the cause of the current thermal maturity, we analyzed several wells in Pennsylvania where thermal maturity has been determined throughout the section by the United States Geological Survey. Our models tested whether additional overburden would help the Marcellus Shale achieve its current state of thermal maturity.

Among the ten modeled wells, five appear to match the thermal maturity of the Marcellus Shale with existing overburden. Three well models predicted a lower thermal maturity at the Marcellus Shale than the current thermal maturity of the Marcellus Shale. To match the current thermal maturity, shale and coal were added as eroded overburden in the models. The models show that more shale would be needed as overburden than coal to match the current maturity of the Marcellus Shale, due to shale being a better heat conductor. Two of the well models predicted a higher thermal maturity than the current thermal maturity of the Marcellus Shale. These locations of wells either had a sandier overburden, a lower than average geothermal gradient, or the thermal indicators provided in these areas may not be accurate.

2014 Alumni Keynote Address

Landscape Evolution in the Hangay Dome, Mongolia

Kalin McDannell ('08)

The development of intracontinental high elevation topography is a long-standing geodynamic problem. The Hangay Dome is a broad upland in central Mongolia characterized by a high elevation (>3000 m), low relief landscape within the greater Mongolian Plateau (2000 m avg. elevation) of central Asia. The Hangay Dome lies between the thick Siberian craton to the north and the active Himalaya deformation front to the far south. Initial detrital apatite (U-Th)/He samples from the Selenga River drainage basin (north of the Hangay Dome) yield average ages of ~140 Ma and granitic bedrock apatite ages range from ~95-170 Ma. These low-temperature data in conjunction with K-feldspar MDD $^{40}Ar/^{39}Ar$ ages of ~200-230 Ma, raise questions about when this preserved, epeirogenic landscape was uplifted and how it has responded to minimal exhumation (regarding morphology and distribution of rates) since the Mesozoic. Alpine cirques and intact moraine deposits are indicative of a more recent, climate-driven erosional signal in the higher peaks in the western Hangay. Initial, regional apatite helium age-elevation patterns suggest long-term thermal stability of the upper crust and lowering of relief. Pecube thermo-kinematic modeling indicates that a recent (since 5 Ma), regional uplift signal would produce younger, Early-Mid Cenozoic cooling ages in lower elevations of the Selenga River drainage basin. Modeled 250 Ma of low exhumation rates of 0.03 mm/yr generate cooling ages in agreement with preliminary geomorphic and geochronologic results. These cooling data all reveal the Hangay Dome is an old, relict landscape with minimal exhumation since the Mesozoic and topography since at least the Mid-Cenozoic. This is contrary to previous work, which suggests that central Mongolia has undergone recent, significant rock uplift in the past ~10 Ma.

NOTES: