Forty-First Annual

GEOSCIENCE DAY

PROGRAM AND ABSTRACTS

Indiana University of Pennsylvania
Geoscience Department

April 24, 2015
134 Weyandt Hall

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INDIANA UNIVERSITY OF PENNSYLVANIA
GEOSCIENCE DEPARTMENT

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Room 134 Weyandt Hall

Program Schedule

- **8:20 a.m. – Opening Remarks by Dr. Steve Hovan**
- **Session 1: Astronomy, Paleontology and Oceanography**
    - **8:30 - Tim Kennelly:** *Exploring Acheron Fossae*
    - **8:45 - Luke Tatarko:** *Observing Jovian Radio Emissions and the Effects of Solar Wind*
    - **9:00 - Tyler Allen:** *Upper Cambrian and Lower Ordovician Conodonts from the Jones Ridge Limestone, East-Central Alaska*
    - **9:15 - Jeremiah Thomas:** *Paleontology and Geology of the Ore Hill Member of the Upper Cambrian Gatesburg Formation in Centre County Pennsylvania*
    - **9:30 - Sierra Davis:** *Record of the Earliest West Atlantic Ice Sheet Beneath Ross Sea?*

— Coffee Break & Poster Sessions —

- **Session 2: Volcanology and Structure**
    - **10:00 – Megan Barlow:** *Crystal Size Distributions on Submarine Lava Flows at NW Rota-1, Mariana Arc*
    - **10:15 – Troy Berkey:** *Lava Flow Mapping in the Oregon Cascades: A Morphometric and Compositional Investigation*
    - **10:30 - Alisha Johnson:** *Determining Changes in Eruption Dynamics and Composition at NW-Rota 1*
    - **10:45 - Eric Peroli:** *Volume Change in the Bellefonte Formation by Examination of Stylolites and Veins*
    - **11:00 - Matt Magill:** *Volcanic Pressurization and Related Structural Fabrics at the Heart Mountain Detachment*
    - **11:15 - Katie Snyder:** *Where Do Forearc Slivers Form in Subduction Zones: Preliminary Study of Tectonics In Costa Rica*

— Lunch Break —

- **Session 3: Energy and the Environment**
    - **1:00 - Jon Greenawalt:** *Are Phase 1 Environmental Site Assessments Sufficiently Accurate for Effective Use in Real Estate Decisions?*
    - **1:15 - Jim Burt:** *Locating and Mapping Abandoned Gas Wells, Part 1– Establishing Baseline Electromagnetic Profiles for a Former Gas Well on the IUP Campus*
    - **1:30 - Jody Rotto:** *Locating and Mapping Abandoned Gas Wells, Part 2– Testing Baseline Electromagnetic Profiles on a Former Gas Well Near Glen Campbell, Pennsylvania*
    - **1:45 - Matt Wimer:** *The Impact of Price Changes on Oil & Gas Exploration and Development*
    - **2:00 - Melissa Jones:** *Modeling Overburden in New York State*
    - **2:15 - Leslie McConnell:** *A Comparative Study of Brine-Injection Induced Earthquakes*
- **Session 4: Featured Alumni Presentation**
    - **2:30 - Rich Parrish '75:** *A Life in the Oil-Patch: My Experiences since Graduating from IUP*

EXPLORING ACHERON FOSSAE

Tim Kennelly

Acheron Fossae is a Tharsis region of Mars that may still be tectonically active. In the past decade, there has been a great increase in the number of spectral and spatial images of Mars. By using high resolution THEMIS (thermal emission imaging system) images as well as other posted images of Acheron Fossae to determine where separate geological unit lie. By discovering the relative age of these units, a record of geologic history of the region can be constructed. GIS was used to create a map of Acheron Fossae that is divided into separate units of different ages and structures. Many regions of Acheron Fossae show signs of younger faults that cut through more recent surface features such as impact craters. These faults show that one of the oldest regions of Mars may still be tectonically active.

OBSERVING JOVIAN RADIO EMISSIONS AND THE EFFECTS OF SOLAR WIND

Luke Tatarko

Little is known about what effect solar wind has on Jovian radio emissions. These emissions are suspected to be caused by the influence of Io, Jupiter's nearest moon, on Jupiter's magnetic field. In order to observe Jovian radio waves, a decametric radio telescope was set up, which was operated when peak radio emissions were predicted. In order to identify significant magnetic field activity, local recordings of Jovian radio emissions have been compared to data collected from different parts of North America by using Radio Skypipe, a software program set up and run by NASA. If continuous radio data collected is collected in the future and compared to University of Michigan's Solar Wind Propagation Model, it can show what effect solar wind has on radio emissions coming from Jupiter. Studying these effects of solar wind on radio emissions will help with communication with current and future robotic planetary missions.

UPPER CAMBRIAN AND LOWER ORDOVICIAN CONODONTS FROM THE JONES RIDGE LIMESTONE, EAST-CENTRAL ALASKA

Tyler Allen

Recent sampling of the Jones Ridge Limestone in eastern Alaska produced conodont collections from 15 new horizons within approximately 120m of Cambrian and Ordovician strata within that formation. The conodonts improve age correlations of the trilobite faunas for which the Jones Ridge is well known with equivalent faunas in southern North America. Additionally, the conodonts provided the first opportunity to determine the position of some very important conodont zonal boundaries within the Jones Ridge trilobite succession. These include the bases of the Ordovician System, Ibexian Series, and *Eoconodontus* Zone. The latter boundary, recently proposed as the uppermost global stage of the Cambrian, was found to coincide with the boundary between the Trempealeauan 1 and Trempealeauan 2 trilobite faunas of previous studies. Additionally, relative abundances of conodont genera allowed comparison of the conodont biofacies in Alaska with those reported from elsewhere in Laurentian North America.

PALEONTOLOGY AND GEOLOGY OF THE ORE HILL MEMBER OF THE UPPER CAMBRIAN GATESBURG FORMATION IN CENTRE COUNTY PENNSYLVANIA

Jeremiah W. Thomas

The upper Cambrian deposits of central Pennsylvania demonstrate a remarkable interval of changing sea level on the shallow continental shelf platforms of North America. This is reflected in the Ore Hill member of the Gatesburg Formation identified and described in Bedford and Blair Counties of Pennsylvania. During recent mapping in the Mingoville Quadrangle of Centre County, geologists from the Pennsylvania Geological Survey discovered extensive exposures of limestone within the Gatesburg, on the flanks of Sand Ridge. These were described in detail and sampled for macrofossils to utilize trilobite biostratigraphy for correlation with the well-documented sections in Blair and Bedford Counties. The pattern in the geology and trilobite genera found in the Mingoville limestone exposures confirm it is the Ore Hill Member and extends its documented range roughly 110 kilometers to the North. However, trilobite faunas collected were all from the Elvinia Zone and Steptoean Stage of the Member and none were recovered from the Sunwaptan. The overall lack of rock exposures of Sunwaptan age, in the Mingoville Quadrangle, suggests a contrast in depositional conditions that resulted in less resistant strata to the north. Based on the general thickness of the Ore Hill and the thickness of the Eastern exposure on the Master's family property, along with the characteristic lack in trilobite fossils, these subzones are most likely represented.

RECORD OF THE EARLIEST WEST ANTARCTIC ICE SHEET BENEATH ROSS SEA?

Sierra Davis

A West Antarctic Ice Sheet from earliest Oligocene time (~35 Ma) has been modeled with Global Climate Models which incorporated paleotopography restored for rift-related subsidence and glacial erosion. Although isotopic data supports an Antarctic ice volume exceeding today's, stratigraphic evidence for the ice sheet advance has not been recognized beneath Ross Sea. We interpret a pre-~30 Ma erosional trough, 400 km-long by 50 km across, on seismic reflection profiles across Central Trough, located in western Ross Sea. Processes that can explain such a deep trough are then explored. In this preliminary study a tilted sub-aerially and wave-eroded basement unconformity is used to approximate post-~30 Ma vertical motions. One possible hypothesis is that the trough is evidence for advance of the earliest West Antarctic Ice Sheet onto the continental shelf at ~34 Ma.

CRYSTAL SIZE DISTRIBUTIONS ON SUBMARINE LAVA FLOWS AT NW ROTA-1, MARIANA ARC

Megan Barlow

NW Rota-1 is a submarine volcano located ~520 m below sea level in the southern Mariana arc, north of Guam. In 2009, rigid lava blocks were observed being forcibly pushed out of the active vent and were collected, among other things, to determine mineral textures and the extent of crystallization. The samples collected display a visible color banding in hand sample, that when analyzed at high magnification, appear to be due to variable microlite distribution. Mineral textures can be quantified using image analysis software to determine sample characteristics, such as crystallinity of the mineral phases present and crystal size distribution (CSD), which refer to the abundance and size of crystals in a particular area. To achieve quantitative data for CSD analysis, thin sections of NW Rota-1 samples were imaged using a scanning electron microscope. Scanning electron images were taken in both the more crystalline and the less crystalline bands to determine the extent of crystalline variation. Three out of four thin sections analyzed show that darker banding (dark brown) are more crystalline than areas lighter in color (tan, light brown) being less crystalline. These differences in microlite banding is likely due to variable cooling rates as the rigid lava is pushed up through the volcanic conduit. Interaction with seawater within the conduit would produce rapid cooling, thus limiting the extent of crystallization in some areas while other areas (untouched by seawater) may have remained warm, allowing for additional crystal growth and larger crystals. Alternatively, the one thin section that did not conform to trends and had odd coloring (red, gray, intermediate brown) could be due to gas rising from degassing magma and/or steam from seawater that may cool, reheat, or insulate the hot lava that when fluxing past the lava allow for variable crystallization.

LAVA FLOW MAPPING IN THE OREGON CASCADES: A MORPHOMETRIC AND COMPOSITIONAL INVESTIGATION

Troy Berkey

High resolution (1.0m) LiDAR (Light Detection and Ranging) DEM (Digital Elevation Model) data was extracted using swath boxes in order to construct cross sectional profiles for the andesitic (58.1-61.6 wt% SiO2) lava flows from the Davis Lake Volcanic field of Deschutes County, Oregon. The flow field consists of two cinder cones and four lava lobes spreading to the north, south, east and west. The oldest, and most deformed, cone had at least one large effusive event, while the younger cone showed very little deformation, suggesting it was likely emplaced after all effusive components. The lava flows produced a total volume of ~0.8 km3. To examine flow dynamics we measured flow thickness and flow width in ArcGIS by extracting cross sectional data with 50m wide swath boxes oriented normal to flow direction. Flow thicknesses inversely correlate with flow width and only deviate in very proximal and distal sections of the flow. Flow thickness ranges between ~8 and 153m and flow widths vary from as low as ~11m (distal) up to 1440m. The average width and thickness for each flow lobe were: North- width 1138m, thickness 153m; South- width 1009m, thickness 104m; West- width 690m, thickness 91 m; East- width 244m, thickness 45m. Assuming a mass effusion rate (10-80m3) and using our measured volume (~0.8km3), we have calculated an estimated emplacement duration of 115-926 days. The flow chronology was determined by evaluating the relationship between flow thicknesses and silica wt%, in conjunction with the principle of super position.

DETERMINING CHANGES IN ERUPTION DYNAMICS AND COMPOSITION AT NW-ROTA 1

Alisha Johnson

NW-Rota 1, a submarine volcano located 100 km north of Guam, has been sampled and observed during research cruises in 2004,2006,2009, and 2010. Changes in NW-Rota 1's eruption dynamics were documented through videos collected via the ROV, Jason II. In this study, samples and videos of the eruptions collected in 2009 were compared to those collected in 2006. Tephra samples were analyzed for grain size distribution through sieving and tephra componentry. Changes in the eruption dynamics for 2006 and 2009 were determined through video analysis, tephra compositions, and morphologies. The Eruption dynamics for 2006 were magmatically driven, cyclic, Strombolian style eruptions with gas bubbles rupturing and fragmenting magma. Tephra components for 2006 consisted of fluidal textures in the very glassy juvenile, juvenile, lithic, and elemental sulfur classifications (Deardorff et.al.,2011). The 2009 eruption was an effusive-gas driven eruption with cooling, quench granulation of magma in the conduit producing lava blocks that were being deposited on the flanks of Brimstone Pit with the remobilization of tephra. This eruption produced blocky morphologies within the 2009 components (juvenile, altered, altered with heavy sulfur, and elemental sulfur). Through the analysis of tephra components, morphology, and video documentation of the 2006 and 2009 eruptions of NW Rota-1, we were able to determine that NW Rota-1 transitioned from a Strombolian style eruption to an effusive-gas driven eruption. Tephra analysis can be used to determine the eruption dynamics of inactive submarine volcanoes based on the changes that were observed in the glassy, fluidal components (2006) and the altered, blocky components (2009).

VOLUME CHANGE IN THE BELLEFONTE FORMATION BY EXAMINATION OF STYLOLITES AND VEINS

Eric Peroli

The Bellefonte Formation is a dolomite of Ordovician age whose volume has been changed by tectonic or burial activity. Examining the relationships of stylolites and veins in exposures near the Water Street fault in North Hollidaysburg, Pennsylvania allows us to document depositional and tectonic history of this unit. Samples were cut perpendicular to bedding to document crosscutting relationships and ages of structures. In addition, geometries of the structures were identified by hand samples in three directions. Crosscutting relationships suggest that all stylolites are younger than veins and that veins may have developed in two different orientations, thus indicating two episodes of volume gain were followed by a period of volume loss. Stylolites were observed to be parallel to bedding, indicating that they are related to burial. If both sets of veins predate the stylolites, as inferred from cross-cutting, then the entire history of volume change may predate tectonic deformation of this unit.

VOLCANIC PRESSURIZATION AND RELATED STRUCTURAL FABRICS AT THE HEART MOUNTAIN DETACHMENT

Matthew Magill

The Heart Mountain Detachment (HMD) is an enigmatic feature of the northwestern Wyoming landscape. An allochthon encompassing 3400km2 slid 40-50km in a southeast direction across the land surface that dipped <3o. Considering this view, the mechanical enigma perplexing geologists today is how a coherent fault block could slide the proposed distance, on such a shallow dipping surface, with gravity as the single driving mechanism. Previous work suggests movement was coeval with Absaroksa (Eocene) volcanism causing volcanic pressurization at the base of the Ordovician Bighorn Dolomite. This mechanism suggests that volcanic pressurization is responsible for reducing the normal stresses at the detachment surface. My work aims to address the volcanic pressurization hypothesis by documenting the structural fabrics along the HMD. Thin section and SEM-EDS backscatter analyses indicate a carbonate rich matrix with numerous diopside phenocrysts, fragments of volcanic glass, opagues, and some muscovite. Pearl white, <1cm, sub-rounded grains are believed to be a dolomitic marble that formed from thermal metamorphism as a result of volcanic pressurization. Thermal metamorphism may also be responsible for both the formation of authigenic pyrite and creating composite grain material. Additional work will focus on defining kinematics and structural geometries for the shear zone. This will provide constraints on detachment related deformation and conditions causing allochthonous motion of the HMD.

WHERE DO FOREARC SLIVERS FORM IN SUBDUCTION ZONES: PRELIMINARY STUDY OF TECTONICS IN COSTA RICA

Katie Snyder

A forearc sliver has been suggested at the Cocos-Caribbean convergent boundary, where the Cocos ridge collides with the Caribbean plate. The relative plate motion here is nearly normal, however GPS data for eastern Costa Rica show motions parallel to the Middle America Trench, supporting a forearc sliver. Confirming the true boundaries of the forearc sliver is difficult due to active volcanism that masks the signature appearance of faults. Aerial photos and mapping have found a viable boundary for the forearc sliver to be Atirro-Río Sucio fault system as Montero et.al has described. GPS velocities are in agreement with the fault system. Published GPS models, seismic data, geologic mapping, and geochronology were analyzed for comparison with Montero's hypothesized sliver boundary and to establish a framework to guide further research.

ARE PHASE I ENVIRONMENTAL SITE ASSESSMENTS SUFFICIENTLY ACCURATE FOR EFFECTIVE USE IN REAL ESTATE DECISIONS?

Jon Greenawalt

Based on past industrial use, contaminants should be present at the Kovalchick property, designated for the construction of the IUP Kovalchick Center Athletic Complex Hotel. Possible latent contamination is customarily predicted by a Phase I Site Assessment. In this case, a comprehensive Phase II Site Assessment has already been compiled allowing a comparison of the accuracy of a Phase I Assessment to be determined. The property's historical uses include activities from industrial and commercial operations for over a century. Based on historical research, Phase I Assessment predicted the presence of metals, petroleum products, and other volatiles. However, it did not predict the presence of cobalt and thallium that was found by Phase II analysis. The Phase II Assessment showed that although many of the predicted contaminants were present, the levels were found to be substantially lower than expected. Phase I Site Assessments are therefore not always reliable at sites with a complex history, but they are sufficient to determine when a Phase II needs to be the next step.

LOCATING AND MAPPING ABANDONED GAS WELLS, PART 1 - ESTABLISHING BASELINE ELECTROMAGNETIC PROFILES FOR A FORMER GAS WELL ON THE IUP CAMPUS

Jim Burt

Natural gas extraction in western Pennsylvania has a long history with many older wells lacking complete closure records or accurate location information. This study used geophysical techniques to map a gas well installed on the IUP campus and allowed us to establish a baseline model for using these techniques out in the field. This campus well was removed, plugged and completed, making it an ideal test case for our project. The well was located and mapped using an electromagnetic profiler, ground penetrating radar and a magnetic locator which allowed us to detect and map buried metallic objects such as the casing from an abandoned oil and gas well. The electromagnetic profiler also measures the conductivity and susceptibility of the ground near the casing, allowing us to detect other parts of the well. Our study suggests that this is the best technique to locate all parts of abandoned oil and gas wells out in the field.

LOCATING AND MAPPING ABANDONED GAS WELLS, PART 2 – TESTING BASELINE ELECTROMAGNETIC PROFILES ON A FORMER GAS WELL NEAR GLEN CAMPBELL, PENNSYLVANIA

Jody Rotto

For over 150 years Western Pennsylvania has had over 270,000 oil and gas wells drilled prior to the state requiring drilling permits. Many of these wells have subsequently been abandoned without being plugged to prevent methane leakage into the subsurface and air. The purpose of the project is to locate these abandoned wells using various geophysical methods. This project focused on finding the best method to accurately locate old wells not visible on the surface. An Electromagnetic Profiler was used to detect the metal casing in the subsurface around the well site and a magnetic locator was used to pinpoint the top of the well casing. The EM profile at the location showed a change in the conductivity of the ground to be much lower compared to the high conductivity of the metal casing at the well site, which allowed us to locate the abandoned well location. The type of geophysical method used to find an abandoned wells is dependent on the geological factors present at each abandoned well location. The type of geophysical method that worked best at the Glen Campbell location was the electromagnetic profiler because of its large scanning area, ability to be used in rough terrain, and the rapid manner that data can be collected.

THE IMPACT OF PRICE CHANGES ON OIL AND GAS EXPLORATION AND DEVELOPMENT

Matt Wimer

Over the past year, the decreasing price of crude oil and natural gas has had a negative effect on exploration and development of our local Marcellus shale gas play. The goal of this study was to determine what effect price changes have on other shale oil and natural gas plays across the country. Future drilling activity as well as production of in-place oil and gas is controlled by the market prices. The study models the effect oil and gas prices have on exploration and development stages in oil/gas production within Texas, North Dakota, and Pennsylvania. Benchmark prices (Western Texas Intermediate and marketed natural gas prices) were correlated to drilling activity in order to identify stoppage and reduction points in the oil and gas industries through relation to permit and rig counts. A ten year analysis of rig and permits counts associated with oil and gas prices reveal that some play areas are strongly impacted by changes in the price of oil and gas while others seem to be much less sensitive. Conclusions from the data allow us to predict how the rig counts and permit counts will react to the changing oil/gas prices and provide a basis for future analysis of how exploration and development stages could thrive or be restrained by price.

MODELING OVERBURDEN IN NEW YORK STATE

Melissa Jones

Understanding the role of carbonaceous overburden on the sediments that lie below is key in understanding how basins function as reservoirs. Anonymous thermal characteristics have been observed in the Devonian shale of the Northern Appalachian Basin throughout southern New York State, suggesting that it was once overlain by thicker strata. Burial history models were used to predict the thickness of the existing and possibly eroded overburden, in order to identify what conditions are consistent with the existing thermal maturities. Comparison of the predicted overburden as determined by BasinMod2012 software to known vitrinite reflectance values from a previous study in the area were used as the basis of comparison. A minimal overburden that is carbonaceous (coal-bearing) can account for the thermal anomalies suggested by the vitrinite reflectance values. We conclude that this area was once buried under younger strata ranging from 500 feet of coal to 2000 feet of shale, and has subsequently been uplifted to its current surface location. Realistically the overburden was most likely a combination of the two lithologies.

A COMPARATIVE STUDY OF BRINE-INJECTION INDUCED EARTHQUAKES

Leslie Hipp McConnell

As Marcellus natural gas production has increased in Pennsylvania, operators have looked for cost-effective ways to dispose of brine wastewater, a natural consequence of produced gas and oil. In 2013 an injection well permit was approved by the United States Environmental Protection Agency (US EPA) granting a local operator permission to dispose of brine wastewater into a non-producing gas well in Grant Township, Indiana County. Similar wastewater-injection wells across the country, however, have been shown to cause earthquakes. An example, the Northstar I injection well in Youngstown, OH, is linked to a magnitude (Mw) 3.9 earthquake that occurred in 2011. To date, the largest magnitude earthquake associated with an injection well is the Mw 5.65 near Prague, Oklahoma, that occurred in 2011. The potential risk of induced seismicity in the Grant Township well can be estimated by comparing documented cases of anthropogenic seismicity in Texas, Oklahoma, and eastern Ohio to the proposed site in Pennsylvania. Based on comparison of radius of fluid migration, fault pathways to the basement rock, well-depth proximity to faults and to the basement rock, regulatory variation among states, and the history of local seismicity, Pennsylvania appears to have lower risk of induced seismicity than the other states. Grant Township may therefore be able to safely host a wastewater-injection well, as long as injection rates, volumes and pressures are held to industry standards.

NOTES: