
QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

VGS Website: http://www.uvm.org/vtgeologicalsociety/

| SPRING 2013 | VOLUME 40 | NUMBER 2 |
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***The Vermont Geological Society's***
***Spring Meeting***

***April 27, 2013, 8:00 AM***
***Room 110, Aiken Center***
***University of Vermont, Burlington, VT***

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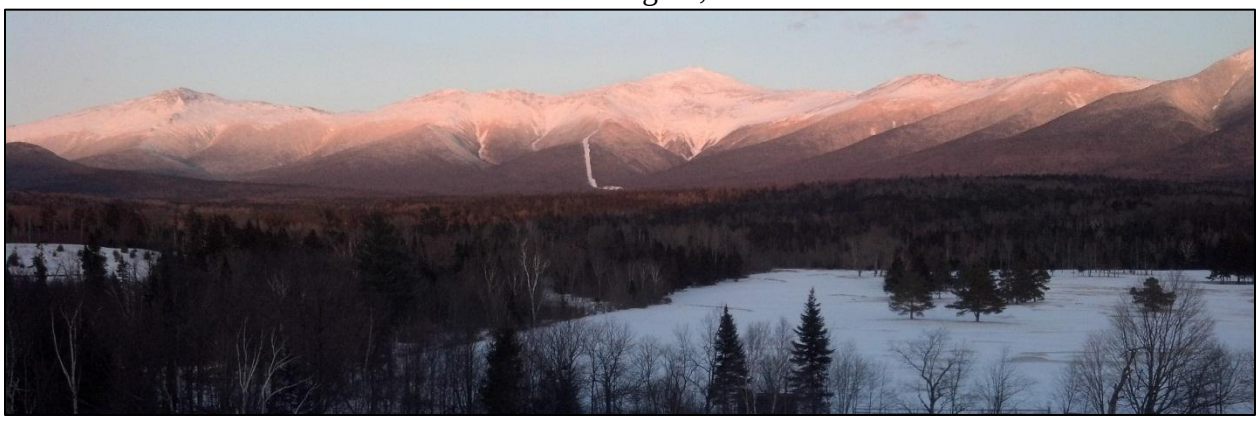
# PRESIDENT'S LETTER

Mt. Washington, NH



The 2013 Geological Society of America- Northeastern Section Meeting (NEGSA) was held at the Mt. Washington Hotel in Bretton Woods, New Hampshire from March 18-20. I heard that the attendance for the meeting was ~1200, which was the second highest ever for this section meeting. For the first time that I can remember, there were so many abstracts for talks submitted, that a 15 minute time limit was implemented, rather than the usual 20 minutes. The view from the back porch of the hotel was absolutely spectacular, particularly around sunset (above) and sunrise. Congratulations to Brian Fowler (Mt. Washington Observatory), Dyk Eusden (Bates College), Thom Davis (Bentley College), and Mark Van Baalen (Harvard University) for organizing such a superb meeting. NEGSA 2014 is in Lancaster, Pennsylvania.

I just figured out that I have attended 20 out of the last 21 NEGSA meetings, missing only the 1997 meeting, and this does makes me feel like a veteran (old). At this meeting, it was particularly nice to see all the familiar faces, great research, and large numbers of students. After the formal programming concluded each day, I always looked forward to the interaction with other geologists. Impromptu discussion sessions were easily initiated at the Mt. Washington Hotel, because of the long corridor on the lobby level, which was lined with couches, tables, and chairs on either side.

Mt. Washington Hotel; Alain Tremblay and Jon Kim discussing VT-Quebec connections.

The Vermont Geological Society (VGS) and the Lake Champlain Research Consortium (LCRC) will have joint meetings on Saturday April 27, 2013 at the Aiken Center of University of Vermont. The VGS symposium will be in room 110 of the Aiken Center whereas the LCRC

symposium will be in room 102. Both symposia will run concurrently and will have a break at 10:00 am in a common area where LCRC posters will be displayed. A light breakfast of coffee, juices, and pastries will run from 8:00 – 8:30 am and during the 10:00 am break in Room 103. LCRC and VGS will share the food and beverage costs.

Respectfully submitted,
Jon Kim, President

## ADVANCEMENT OF SCIENCE COMMITTEE REPORT

No proposals were submitted to the Vermont Geological Society Research Grant Program by the April 1, 2013 deadline. The next round of proposals are due on October 1, 2013. Students and secondary school teachers are encouraged to apply to the VGS Research Grant Program. Downloadable Research Grant Program applications are available from the Society's website at http://www.uvm.org/vtgeologicalsociety/. Applications and questions should be addressed to: Jon Kim, Vermont Geological Survey, 1 National Life Drive, Davis 2, Montpelier, VT 05620-3920; e-mail: jon.kim@state.vt.us, phone: (802) 522-5401.

The following 2012 VGS grant recipients presented their work at the NEGSA in Bretton Woods:

Natashia Pierce, Master's Degree candidate at the University of Cincinnati
"Compilation of Geochemical Data of Meta-Volcanics from the Rowe-Hawley Zone of Western New England are Consistent with Backarc, Arc, and Forearc Regions of One Composite Arc" (Talk).

Juliet Ryan-Davis, Undergraduate Student at Middlebury College
"Origins of the Moretown Formation, Vermont: A Detrital Zircon Study" (poster).
Award- $700.00

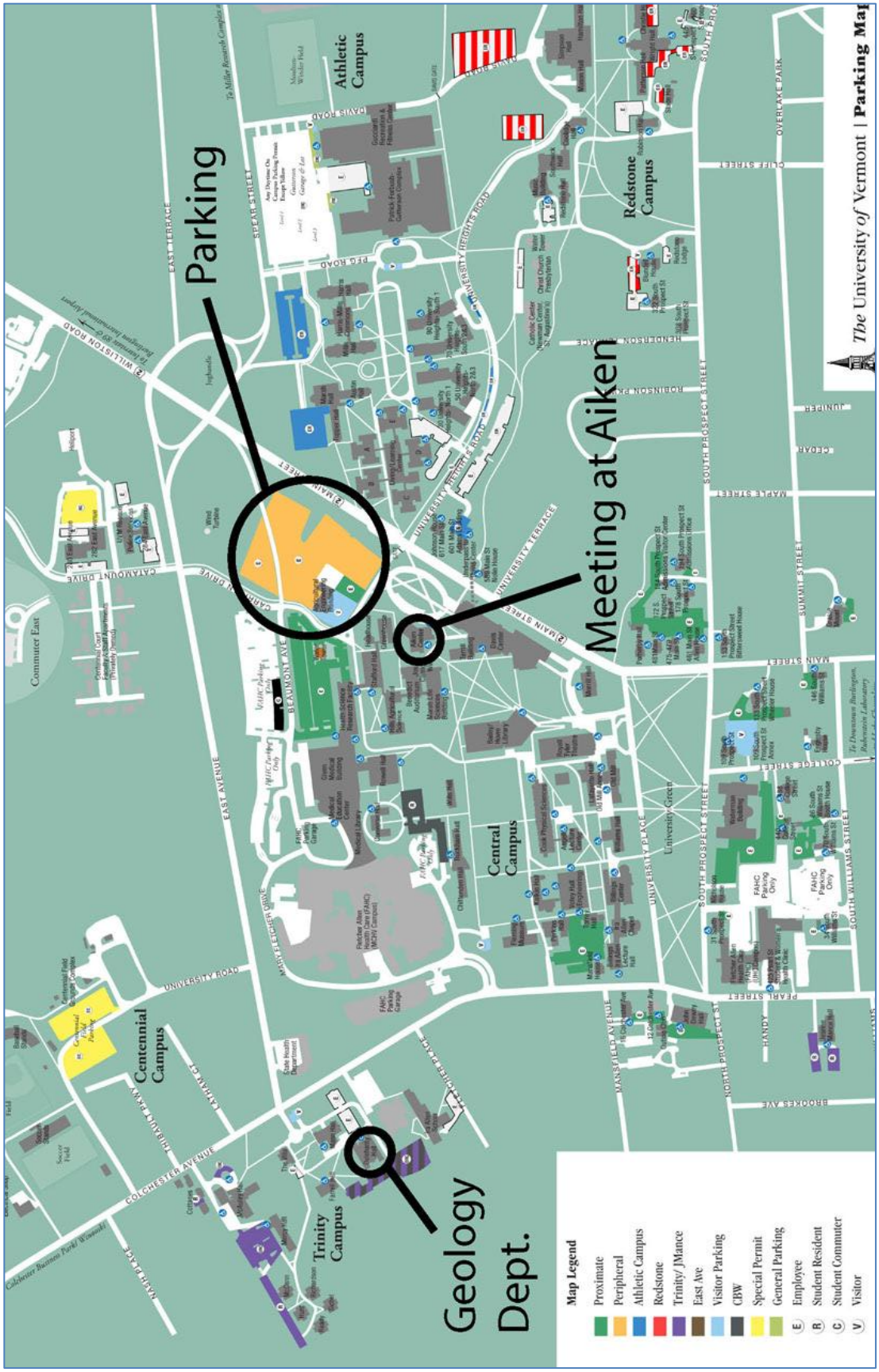
Eric Weber, Undergraduate Student at the University of Vermont
"Comparison of Ductile Structures from the Southern Terminus of the Hinesburg Thrust Fault with those from Central Flap, West-Central Vermont (poster).

We will hear talks by Juliet and Eric at the VGS Spring Meeting on Saturday April 27.

Respectfully submitted,
Jon Kim, Chair

**ANNOUNCEMENT: JUDGES NEEDED FOR MEETING:** We need three people to judge the student presentations at the VGS portion of the meeting. Please contact Jon Kim at 802-522-5401 or jon.kim@state.vt.us if you are willing to serve.

Also, we will be having an Executive Committee meeting after the presentations. This meeting is open to all members. Larry Becker, State Geologist, will be there to discuss geologist licensure (see Public Issues, p. 18).


Parking
Meeting at Aiken
Geology Dept.
The University of Vermont | Parking Map
Athletic Campus
Redstone Campus
Central Campus
Centennial Campus
Trinity Campus
Commuter East
Map Legend
Proximate
Peripheral
Athletic Campus
Redstone
Trinity/ JMance
East Ave
Visitor Parking
CBW
Special Permit
General Parking
Employee
Student Resident
Student Commuter
Visitor

# 2013 SPRING MEETING PROGRAM

8:00 AM COFFEE & REFRESHMENTS

8:30 AM Juliet Ryan-Davis: ORIGINS OF THE MORETOWN FORMATION, VERMONT: A DETRITAL ZIRCON STUDY

8:45 AM Emily Wei: SUMMERTIME HYDRODYNAMICS AND SEDIMENT DYNAMICS OF MISSISQUOI BAY, LAKE CHAMPLAIN

9:00 AM Sarah Studwell, Peter Ryan, and David West: ARSENIC CONCENTRATION WITHIN VARIABLY METAMORPHOSED SHALES OF THE TACONIC SEQUENCE, VERMONT AND NEW YORK

9:15 AM Parker Richmond: GROUND PENETRATING RADAR AS A METHOD FOR DISTINGUISHING FRACTURES AND HIGH ANGLE FAULTS

9:30 AM Patrick Dyess and Laura Webb: THE QUARTZ WASHING MACHINE: INSIGHTS INTO THE USES AND EFFECTIVENESS OF THE TITANIUM IN QUARTZ THERMOBAROMETER

9:45 AM Joshua Johnson: THE SPANISH CREEK MYLONITE: A NEWLY IDENTIFIED REGION OF HIGH STRAIN WITHIN THE NORTHERN MADISON RANGE, SW MONTANA

10:00 AM BREAK, COFFEE & REFRESHMENTS

10:30 AM Steven Gohlke, Barbara Tewksbury, and Charlotte Mehrtens: EVIDENCE FOR AN EARLY CENOZOIC TECTONIC EVENT IN SOUTHERN EGYPT AND THE SIGNIFICANCE OF DEFORMATION BANDS ON THE SEIYAL FAULT, WESTERN DESERT, EGYPT

10:45 AM Lisa Luna, Will Amidon, Burch Fisher, and Doug Burbank: U-PB ZIRCON AGES FROM TUFFS AND DETRITAL SEDIMENT: A NEW EVOLUTIONARY MODEL FOR THE RÍO IRUYA CANYON, NORTHWESTERN ARGENTINE ANDES

11:00 AM Annika Silverman: MULTI-PROXY RECONSTRUCTION OF POST-GLACIAL ENVIRONMENTAL CHANGE FROM A CORE OF SOLDIER LAKE, NEVADA

11:15 AM Clara St. Germain: NATURAL PROCESSES IN AN INDUSTRIAL SETTING: SEDIMENTARY AND HYDRO-DYNAMICS OF THE BUFFALO RIVER, N.Y.

11:30 AM Daniel Hobbs: DEVELOPING GEOCHRONOMETERS: DIFFUSION OF

HELIUM IN CALCITE, ARAGONITE, AND DOLOMITE

11:45 AM Eric Weber, COMPARISON OF DUCTILE STRUCTURES FROM THE SOUTHERN TERMINUS OF THE HINESBURG THRUST FAULT WITH THOSE FROM THE CENTRAL FLAP, WEST-CENTRAL VERMONT

12:00 PM Abigail Ruksznis, Keith Klepeis, and Marjorie Gale: VARIATION IN TWO STYLES OF ACADIAN THRUST FAULTING IN THE PINNACLE FORMATION, RICHMOND, VT

12: 15 PM JUDGING AND AWARDS PRESENTATION

12:30 PM EXECUTIVE COMMITTEE TO FOLLOW CONCLUSION OF STUDENT MEETING

## LAKE CHAMPLAIN RESEARCH CONSORTIUM PROGRAM (RM. 102)

8:25 AM Opening remarks – Jason Stockwell

8:30 AM Suzanne Ball: CHANGES IN MYSIS DILUVIANA POPULATION DEMOGRAPHICS IN LAKE CHAMPLAIN BETWEEN 1975 AND 2012

08:45 AM Chelsea Mitchell: DIVERGENT DIEL VERTICAL MIGRATION IN MYSIS DILUVIANA: IS IT A PLASTIC OR FIXED BEHAVIOR?

09:00 AM Peter Euclide: ASSESSING TEMPERATURE SENSITIVITY OF PELAGIC VS. BENTHIC-CAUGHT MYSIS DILUVIANA

09:15 AM Janet Bering, Abigail Borah, Charlie Koch, Avery Shawler: REGIONAL AQUATIC INVASIVE SPECIES PREVENTION IN THE LAKE CHAMPLAIN BASIN

09:30 AM Michelle Trimper: EXPLORING THE SUSTAINABILITY OF THE FUNDING NETWORK FOR AQUATIC INVASIVE SPECIES IN THE LAKE CHAMPLAIN BASIN

09:45 AM Kali Blankenship: VARIATION IN LITTER DECOMPOSITION BETWEEN NATIVE SPECKLED ALDER AND NON-NATIVE EUROPEAN BUCKTHORN: AN EXPERIMENTAL STUDY IN PLATTSBURGH, NY

10:00 AM Break and Poster Session

11:00 AM Justin Geibel: INFLUENCE OF DRAINAGE WATER MANAGEMENT ON PHOSPHORUS LOSS FROM A TILE-DRAINED FIELD IN NORTHERN NEW YORK

(Lake Champlain Research Consortium, Rm 102, continued)

11:15 AM Patrick Bousquet: THE EFFECTS OF URBANIZATION ON STREAM BED SEDIMENT SIZE AND BENTHIC MACROINVERTEBRATE COMMUNITIES

11:30 AM Emily Wei: SUMMERTIME HYDRODYNAMICS AND SEDIMENT DYNAMICS OF MISSISQUOI BAY, LAKE CHAMPLAIN

11:45 AM Peter Isles: HIGH TEMPORAL RESOLUTION MONITORING OF CYANOBACTERIAL BLOOM DYNAMICS AND NUTRIENT LIMITATION IN MISSISQUOI BAY

12:00 AM Rebecca Gorney: DIETS AND DIET OVERLAP OF INVASIVE WHITE PERCH AND ALEWIFE IN MISSISQUOI BAY, LAKE CHAMPLAIN, AND IMPLICATIONS FOR THE ZOOPLANKTON COMMUNITY

12:15 AM Trevor Gearhart:AN EVALUATION OF FATTY ACID PROPAGATION THROUGH MULTIPLE TROPHIC LEVELS AND ITS APPLICATION TO QUANTIFYING ECOSYSTEM CHANGE IN LAKE CHAMPLAIN

12:30 PM Katherine Ritchie: CYANOBACTERIA BLOOMS AND ESSENTIAL FATTY ACID TRANSFER THROUGH THE FOOD WEB OF LAKE CHAMPLAIN

## LCRC POSTER SESSION, 10 AM - 11 AM

Justin Andrews: Establishing a DNA Database for the Genus Rana in the New York Lake Champlain Basin

Siobhan Levere: DNA Barcoding in Fungi (Mushrooms); Establishment of a Genetic Database within the Lake Champlain Basin as well as the Adirondack Park

Maxwell Marsh: Finding Biodiversity and Searching for Invasive Species in the Lake Champlain Basin Using Environmental DNA (eDNA)

Sean McNamara and Clare Abercrombie: Testing for Coyote-Wolf Hybrids in a Vermont Population of Eastern Coyotes

Bich (Alex) Nguyen: Effect of Biochar on Lettuce (Lactuca sativa) and Basil (Ocimum basilicum) Germination

Beth Rutila: Seasonal Changes in the Phosphorus Composition of Missisquoi Bay Sediments

Sarah Studwell: Arsenic Concentration within Variably Metamorphosed Shales of the Taconic Sequence, Vermont and New York

Kerry Monahan: Observing Abnormal Bat Behavior at Aeolus Cave

# 2013 ABSTRACTS

## ORIGINS OF THE MORETOWN FORMATION, VERMONT: A DETRITAL ZIRCON STUDY

Juliet Ryan-Davis, Geology Department, Middlebury College, Middlebury, VT 05753

The tectonic history of the Vermont Appalachians can be refined with the aid of geochronological data. The Moretown Formation of Vermont has been interpreted as sediments deposited in the fore-arc basin of the Cambrian-Ordovician Shelburne Falls arc. This study uses detrital zircons to provide new information on the provenance of the Moretown sediments. Zircons have been separated from ten samples taken from the Moretown Formation of northern Vermont. U-Pb ages were determined on 75 to 100 zircons per sample using the LA-ICP-MS at Rensselaer Polytechnic Institute. Age distributions represent a signature of the range of ages of zircons from sources that contributed to the sediment. The age signatures of the Moretown, and some rift related sediments of Vermont, are compared to age signatures of potential source regions to determine the sedimentary provenance. The Late Proterozoic, rift-related Hazens Notch Formation shows, as expected, a dominant Laurentian (Grenville) signature. Ages from Moretown samples have a strong peak at 600 Ma, suggesting a peri-Gondwanan source component, likely mixed with a Laurentian Grenville component. This result indicates more provenance sources than the exclusively Laurentian signature postulated by previous work on the Moretown in southern Vermont and northern Massachusetts. Such a distinction could indicate that the Moretown is not the same along strike and that there is variation in local sources of zircons, or that tectonic models that explain the origin of the Moretown sediments need to be revised to incorporate the peri-Gondwanan signature.

## SUMMERTIME HYDRODYNAMICS AND SEDIMENT DYNAMICS OF MISSISQUOI BAY, LAKE CHAMPLAIN

Emily Wei, Geology Department, Middlebury College, Middlebury, VT 05753

The relationship between circulation currents, suspended sediment concentration, and sedimentation rates were investigated as part of a larger 5-year project studying the causes of eutrophication in Missisquoi Bay, a shallow bay (4 m) in Lake Champlain (Vermont and Quebec). Previous studies collected hydrodynamic modeling was based on a single month of ADCP data in the western arm of Missisquoi Bay and cores were taken from only the southeastern area. This study looks at the first 2 months of currents, wind forcing, and water level variations at five sites to better understand sediment resuspension and deposition. North-south and east-west centimeter-scale diurnal oscillations of lake level were observed and were not linked to the calculated ~30 minute surface seiche. Currents were obtained from Acoustic Doppler Current Profilers (ADCPs) indicate that after consistent wind forcing, both cyclonic and anticyclonic circulation patterns were set up. Unique to this very shallow bay was the degree of directional shear (in depth) as high as 180 degrees that occurs during periods of thermal stratification and neutral lake levels. Sediment properties and magnetic susceptibility measurements of five push cores vary, indicating that sedimentation rate is not constant throughout the bay. Implications of our results will provide other investigators insight into how phosphorus and nitrogen are being moved throughout the bay.

## ARSENIC CONCENTRATION WITHIN VARIABLY METAMORPHOSED SHALES OF THE TACONIC SEQUENCE, VERMONT AND NEW YORK

Sarah Studwell, Peter Ryan, and David West, Geology Department, Middlebury College, Middlebury, VT 05753

Elevated levels of naturally occurring arsenic have been found in bedrock wells throughout the Taconic region of southwestern Vermont. Previous studies have shown arsenic concentrations in groundwater are generally higher in the lower grade Giddings Brook slice than in the higher-grade Bird Mountain slice. This study aims to examine the role of metamorphic grade on arsenic concentration in black, pyritiferous shales, slates, and phyllites, which are common rock types in bedrock aquifers of this region. Two equal sample groups were established based on metamorphic grade. The lower-grade sample set is composed of rocks from the autochthon or Giddings Brook slice, and the higher-grade sub-set is composed of rocks from the Bird Mountain slice. In total, 30 samples were collected and analyzed for whole rock major and trace element geochemical analysis, and XRD and SEM-EDS analysis of mineral compositions.

ICP-MS data show that arsenic concentrations in the lower-grade samples range from 5.6 to 51.7 ppm, with an average of 26.9 ppm. In the higher-grade samples, arsenic concentrations range from 1.1 to 30.3 ppm, with an average of 13.8 ppm. Certain fluid-mobile elements (e.g., Pb, Ni, Zn) are also depleted in the higher-grade rocks. SEM-EDS analysis of pyrite-rich, high-arsenic samples revealed the presence of distinct Zn-bearing (sphalerite), and Cu- (chalcopyrite) minerals, but no distinct As-bearing minerals (e.g., arsenopyrite) were found. This suggests that arsenic may be disseminated as a trace element in other sulfide minerals such as pyrite, instead of forming its own distinct minerals. Analysis of REE distributions between the two sample sets suggest similar bulk rock compositions prior to metamorphism, allowing the lower-grade samples to act as a proxy for the protolith compositions of higher-grade samples. Therefore, the observed 48 % depletion in arsenic, and similar depletion in other trace minerals from the lower- to the higher-grade sample set may be attributable to mobilization during prograding metamorphism. This data is consistent with data from other depositional basins, including the Connecticut Valley-Gaspe belt, where biotite and garnet zone phyllites and schists contain 85 % less As and Pb than unmetamorphosed shale equivalents.

## GROUND PENETRATING RADAR AS A METHOD FOR DISTINGUISHING FRACTURES AND HIGH ANGLE FAULTS

Parker Richmond, Geology Department, University of Vermont, Burlington, VT, 05401

This paper investigates the application of ground penetrating radar (GPR) to mapping folds and fractures in the hanging wall of the Champlain Thrust at Mt. Philo State Park, Charlotte, Vt. This location offers a unique opportunity to compare GPR profiles taken on an ideal flat surface to a vertical outcrop face that parallels the transect. East-West GPR transects were conducted in the upper parking area using a high frequency 200 MHz antenna. Target features such as fractures and folds were documented in geologic transects conducted along cliff faces directly below the parking area and above the Devil's Chair Trail, approximately 40m from the GPR transects. There, outcrops primarily consist of Lower Cambrian regularly bedded Monkton Quartzite and structural data were collected to allow projection of the cliff face structures into the GPR

profiles. Where fractures project into the GPR profiles discontinuities associated with offset of reflectors are observed. Fold hinges of the observed synclines and anticlines project above the GPR profiles, but fold limbs can be identified from dipping layers. High angle faulting documented by previous work at Mt. Philo may be responsible for offset of target features. This paper offers insight on characterizing high angle faults previously mapped as fractures.

## THE QUARTZ WASHING MACHINE: INSIGHTS INTO THE USES AND EFFECTIVENESS OF THE TITANIUM IN QUARTZ THERMOBAROMETER

Patrick Dyess and Laura Webb, Geology Department, University of Vermont, Burlington, Vermont, 05405

Investigations into the applications of the Titanium in Quartz, "TitaniQ", thermobarometer have provided insight into the P-T-D cycle, from basin deposition through Acadian metamorphism, of the central Rowe Hawley Belt. In addition, evidence shows the importance that both structural and metamorphic processes play in the recycling of inherited quartz in metapelites.

Sampling was conducted along a structural transect from Rochester to Bethel, Vermont; incorporating a sequence of interbedded phyllites, quartzites, and calcic schists that have been exposed to both Taconic and Acadian conditions. Cathodoluminescence (CL) imaging on quartz was conducted to qualitatively assess [Ti] zoning within grains. Microprobe spot analyses and X-ray mapping of garnet porphyroblasts was performed to estimate peak P-T conditions. Secondary ion mass spectrometry (SIMS) analyses were conducted to determine [Ti] for TitaniQ calculations.

Petrology and microstructures record two major prograde events resulting from the Taconic and Acadian orogenies. CL imaging of quartz grains reveal zoning of darker cores and brighter rims as well as some uniform grains. A positive relationship between intensity at $\lambda = 415$ nm and [Ti] is known, indicating that zoning represents an increase in [Ti] from core to rim. SIMS analyses of quartz grains indicate a spread of [Ti] from 0.4 – 157 ppm. 5% of these analyses have [Ti] signatures above the peak metamorphism evidenced by garnet P-T-X diagrams and stability fields.

High [Ti] samples can only be described as inherited grains with titanium contents similar to those of high grade origins. Lack of dynamic recrystallization textures, low peak P-T conditions during garnet growth, and slow volume diffusion rates of Ti into quartz requires alternative mechanisms for quartz equilibration. Solution transfer during fabric development produces new quartz growth at lower P-T conditions and consequently equilibrates with lower [Ti]. Additional quartz is introduced during quartz producing metamorphism.

Integration of structural, petrologic, geochemical and thermodynamic models suggest that while most quartz experienced reworking during the development of Taconic schistosity, and during Acadian metamorphism and fabric development, some quartz grains retained their relict signature.

## THE SPANISH CREEK MYLONITE: A NEWLY IDENTIFIED REGION OF HIGH STRAIN WITHIN THE NORTHERN MADISON RANGE, SW MONTANA

Joshua Johnson, Geology Department, Middlebury College, Middlebury, VT 05753

Recent fieldwork in Archean rocks of the Northern Madison Range in southwestern Montana has revealed a zone of high strain approximately 2 km long and at least 1 km wide. A multipronged structural approach incorporating fieldwork, microstructural analysis, and geochronology have been applied to studies of this mylonite. The dominant rock type in this area is multiply deformed granitic orthogneiss with variable porphyroclastic character. Thin section petrography reveals the presence of high-temperature microstructures such as quartz ribbons and polygonal, recrystallized feldspar grains in certain samples while others have distinctly lower grade microstructural assemblages characterized by weak to no shape preferred orientation and strong undulose extinction in quartz. Microstructural differences therefore confirm field observations of strong strain gradients within this zone and delineate three distinct structural realms. Strong quartz crystallographic preferred orientations in mylonitic samples indicates prism <a> slip and deformation conditions of ~ 500 °C. Zircon U-Pb ages indicate an igneous protolith age of ~ 2800 Ma and suggest a Pb-loss event at ~ 1790 Ma. These ages do not link this episode of mylonitization to the Early Proterozoic Big Sky Orogeny, but they do not preclude such a connection either.

## EVIDENCE FOR AN EARLY CENOZOIC TECTONIC EVENT IN SOUTHERN EGYPT AND THE SIGNIFICANCE OF DEFORMATION BANDS ON THE SEIYAL FAULT, WESTERN DESERT, EGYPT

Steven Gohlke, Geology Department, University of Vermont, Burlington, VT, 05405,
Barbara Tewksbury, Geosciences Department, Hamilton College, Clinton N.Y. 13323, and
Charlotte Mehrtens, Geology Department, University of Vermont, Burlington, VT, 05405

This study seeks to determine the relative timing of events that contributed to the formation of an enigmatic structural feature in Egypt's Western Desert known as a Desert Eye. This Desert Eye is a structural dome (500 m by 1,000 m) consisting of shallowly dipping bedding, and is cut by the Seiyal Fault, part of a regional E-W basement trend. The primary goal of this research is to constrain the timing of deformation band formation on the Seiyal Fault. Cataclastic deformation bands are associated with faulting in porous rocks, such as the field area's Taref Member of the Nubian Sandstone.

Field data on the abundance and orientation of deformation bands and calcite veins were collected where the Seiyal Fault outcrops 70 km SW of Aswan in January 2012. The complete slip history of this fault is unknown, but it may be possible to determine if the motion recorded by the deformation bands matches its modern, dextral strike-slip movement.

At the thin section scale, grain attributes were measured in order to quantify differences between the poorly sorted, quartz arenite host rock and the deformation bands within it. SEM images show a decrease in mean grain size within the deformation bands ranging from 37-75% relative to the host rock. Measurement of the long axis orientation of grains shows a preferred alignment exists within the deformation bands. There are also many examples of calcite veins overprinting deformation bands indicating extremely high pore fluid pressure.

Field-scale cross-cutting relationships show that folding occurred prior to deformation band formation. The presence of soft sediment deformation (seismites) suggests seismicity during the Late Cretaceous deposition of the Taref Member. A strong subsidence signal from the burial history model indicates tectonic instability in the Early Paleocene. This likely caused movement along basement faults, resulting in deformation band formation at shallow (300-800 m) depths. CL imaging shows no authigenic quartz cement fragments within deformation bands, meaning they formed in unlithified sediment. Thin sections stained with Alizarine Red (ARS) show later pore-filling calcite cement haloes are coeval with calcite veins of Late Eocene age or younger. This research supports the presence of a previously unrecognized Early Paleocene tectonic event in southern Egypt.

## U-PB ZIRCON AGES FROM TUFFS AND DETRITAL SEDIMENT: A NEW EVOLUTIONARY MODEL FOR THE RÍO IRUYA CANYON, NORTHWESTERN ARGENTINE ANDES

Lisa V. Luna, William H. Amidon, Geology Department, Middlebury College, Middlebury, VT 05753, and George B. Fisher, Douglas W. Burbank, Department of Earth Sciences, University of California-Santa Barbara, Santa Barbara, CA 93106-9630

The relationship between climate, tectonics, and erosion rates in mountainous terrain remains poorly understood over long timescales. Although studies of modern systems allow comparison across modern climatic and tectonic gradients, long-term records are required to test the importance of disequilibrium landscape conditions created by global climate cycles and long-term climate trends. To address the question of erosion rate response to changes in tectonic activity and climate cycling, we are developing a 9 Ma record of temporal variations in paleo-erosion rates from cosmogenic nuclides in the Río Iruya watershed of the northwestern Argentine Andes. The 100 m deep Río Iruya canyon is an extraordinary section of ~7500 m of sedimentary rock deposited in the Andean foreland basin during growth of the sub-Andean fold and thrust belt and only recently re-exposed when the river overwhelmed a flood control canal in 1898. Minimal post-burial cosmogenic production, along with published paleomagnetic stratigraphy data, makes the Río Iruya canyon an exceptional location to develop a long-term record of erosion rates. However, understanding the ages of the exposed sediments and the evolution of the watershed over time is a critical prerequisite to estimating and interpreting cosmogenic erosion rates. To refine the current stratigraphic framework, this study presents LA-ICPMS U-Pb zircon dates from three new interbedded ashes at 7.01 +0.10/-0.04 Ma, 4.07 +0.07/-0.03 Ma, and 2.77 +0.05/-0.06 Ma. We additionally constrain sedimentary provenance and interpret watershed evolution through kernel density estimation plots from two modern and four paleo-detrital zircon samples.

## MULTI-PROXY RECONSTRUCTION OF POST-GLACIAL ENVIRONMENTAL CHANGE FROM A CORE OF SOLDIER LAKE, NEVADA

Annika Silverman, Geology Department, Middlebury College, Middlebury, VT 05753

A core was retrieved from Soldier Lake, a glacial pond at 2775 m asl in the Ruby Mountains of northeastern Nevada, to reconstruct a record of post-glacial environmental change. The core

penetrated to a depth of 415 cm below the sediment-water interface. Four AMS radiocarbon analyses, one on terrestrial plant material, one on charcoal, and the deepest two from concentrated pollen indicate that the core extends to 26.1 cal ka BP. A layer of tephra encountered at a depth of 190 cm was correlated with the Mt. Mazama eruption by geochemical fingerprinting. These four radiocarbon dates and the tephra date supported the construction of a depth-age model which aided the comparison of Soldier Lake with other paleoclimate records from the region. Multi-proxy laboratory analysis of the Soldier Lake core included measurements of magnetic susceptibility (MS), water content, loss on ignition (LOI), grain size distribution (GS), and carbon to nitrogen ratio (C/N). MS values are high in the bottom quarter of the core ($70 \times 10^{-5}$ SI units), reflecting higher levels of inwashing of iron-bearing minerals, and probably indicates a glacial flour source. After ~13.9 cal ka BP MS values fall to zero and remain there with the exception of a slight peak ($20 \times 10^{-5}$ SI units) centered around the Mazama tephra layer. Before ~13.9 cal ka BP, LOI and C/N values remain close to zero, but a significant rise in LOI and C/N corresponds to the MS decrease ~13.9 cal ka BP, indicating a period of decreasing glacial runoff and increasing ecosystem productivity. LOI and C/N decrease around the tephra layer and then increase until ~3 cal ka BP when they both exhibit a slight trough. After ~3 cal ka BP, LOI increases continuously and then rapidly in the past ~400 cal yr BP, whereas C/N stays close to the Holocene mean and then decreases rapidly ~400 cal yr BP. Mean grain size exhibits cyclic variability throughout the record, with values oscillating between 7 and 70 μm. The overall trend in GS distribution indicates there is a higher concentration of fine GS (mostly silt) and small mean GS before ~17 cal ka BP. After this time, fine GS concentrations and silt percentages decrease, giving rise to an increase in sand percentages and an overall increase in mean GS. An exception to this trend is the fine GS associated with the Mazama tephra layer. Soldier Lake data overlap with trends observed in other records from the region, namely the early Holocene period of productivity found in the Overland Lake record from the southern Ruby Mountains, and the most recent warm periods observed in the Blue Lake (Louderback and Rhode, 2009) and Stella Lake (Reinemann et al., 2009) records from eastern Nevada.

## NATURAL PROCESSES IN AN INDUSTRIAL SETTING: SEDIMENTARY AND HYDRO-DYNAMICS OF THE BUFFALO RIVER, N.Y.

Clara St. Germain, Geology Department, Middlebury College, Middlebury, VT 05753

The lower 9 km of the Buffalo River, which flows from the east along the southern border of Buffalo, NY before discharging at its mouth into the eastern end of Lake Erie, has been designated as a Great Lakes area of concern (AoC) due to poor water quality, degraded riparian and river habitat, and sediment contamination. Over a century of rapid industrial growth and subsequent deterioration in the area directly surrounding the river has caused its natural state to become extremely altered as it has been and continues to be manipulated to fit into a man-made setting. The current Remedial Action Plan (RAP) for this AoC centers on sediment remediation and therefore understanding the hydrodynamics and subsequent sediment transport processes within the river is key. The current understanding of the river's dynamics has been interpreted primarily from sediment movement and deposition trends via Sediment Trend Analysis (STA), side scan imaging, and three-dimensional modeling. These studies have revealed that a highly dynamic transport system within the river including both downstream and upstream flow regimes has developed due to the impact of seiche events. The development of a standing wave, known

as a seiche, along the long axis of Lake Erie, initiates rapid changes in lake level causing water to be forcibly driven up into the Buffalo River channel at its mouth resulting in the creation of this unique bidirectional flow regime within the river. As the hydrodynamics of the river have primarily been reverse modeled from sediment trends, an examination of data collected by Acoustic Doppler Radar Profilers (ADCPs) greatly enhances this database of knowledge by sampling the vertical water column and horizontal cross-section velocities of the river in multiple strategic locations at short time intervals of 30 minutes or less over an extended period of time. This hydrologic data, in collaboration with other databases including the aforementioned studies as well as concurrently collected measurements of temperature, meteorological, lake level, and updated side-scan survey imaging data, reveals new trends and creates a more comprehensive image of this dynamic setting which may enhance our ability to efficiently remediate this AoC as well as other similarly affected areas in the future.

## DEVELOPING GEOCHRONOMETERS: DIFFUSION OF HELIUM IN CALCITE, ARAGONITE, AND DOLOMITE

Daniel Hobbs, Geology Department, Middlebury College, Middlebury, VT 05753

Many modern geochronology techniques suffer from highly time-consuming and labor intensive mineral separation procedures which are required to ensure reliable and repeatable age determinations. $^{3}$He cosmogenic dating and $^{4}$He thermochronology of calcite, aragonite, and dolomite have the potential to provide relatively fast and simple dating techniques that are widely applicable to a range of fields and study environments. However, the primary limitation to applying such geochronometers is the poor helium retention observed in many natural carbonates and the lack of understanding regarding helium diffusion behavior in these minerals. More knowledge of what controls He retention in calcite is required to identify types of calcite which are reliably retentive and therefore useful for geochronology. One of the first steps to improving our understanding of helium diffusion in calcite is to identify basic trends in diffusion behavior, such as anisotropic diffusion. Nuclear Reaction Analysis (NRA) and Elastic Recoil Detection (ERD) were used to produce direction-specific diffusion coefficients for the major crystallographic axes of calcite, aragonite, and dolomite. This data highlights anisotropic $^{3}$He diffusion in calcite and relatively low $^{3}$He diffusion rates in aragonite and dolomite. Interionic porosity and minimum aperture size have previously been correlated with anisotropy in apatite, titanite, rutile, and zircon and are thus compared to the recently collected $^{3}$He diffusion rates of calcite, aragonite, and dolomite.

## COMPARISON OF DUCTILE STRUCTURES FROM THE SOUTHERN TERMINUS OF THE HINESBURG THRUST FAULT WITH THOSE FROM THE CENTRAL FLAP, WEST-CENTRAL VERMONT

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In west-central Vermont, the Hinesburg Thrust (HT) emplaced Neoproterozoic-Cambrian rift clastic and early drift stage metamorphic rocks of the hanging wall onto Cambrian-Ordovician carbonate and clastic sedimentary rocks of the footwall, during the Ordovician Taconian

Orogeny. The HT extends for ~75 km along-strike and terminates at both its northern and southern ends in map-scale, west-verging, overturned, tight folds. The fault is comprised of conspicuous promontories ("flaps") and recesses along its length. Relative displacement along the HT is greatest in the central flaps and least along the ends.

In the field area, that lies at the southern terminus of the HT, lithologies in the hanging wall consist of phyllitic quartzites, massive metagraywackes, quartz pebble conglomerates, and marbles of the Pinnacle Fm; phyllites and phyllitic quartzites of the Fairfield Pond Fm; and phyllitic quartzites of the Cheshire Fm. Since the HT "ends" in the Cheshire Fm, other Cheshire lithogies, including stratigraphically higher massive quartzites, are also found in the footwall, as well as massive dolostones of the Dunham Fm.

In the hanging wall of the HT in the field area, two major foliations are present: 1) an older composite bedding-parallel fabric ($S_1$-$S_2$) defined by alternating quartz and mica domains and rootless reclined isoclinal folds with fold axes that plunge down dip (and collinear stretching lineations), and 2) a well-developed crenulation cleavage ($S_3$) that is axial planar to tight, west-verging, gently-plunging folds, with strong crenulation lineations. Although footwall structures are similar to those of the hanging wall near the thrust zone, the intensity of the older structures diminishes to the west and large-scale $F_3$ folds become dominant. Based on regional correlation, $S_1$-$S_2$ is Taconian and $S_3$ is Acadian (Devonian).

We defined meso and micro scale structures at the southern terminus of the HT, which is a segment of minimum relative displacement. We compared these structures with those described by Strehle and Stanley (1986) in the central flap of the HT, a segment of maximum relative displacement. We investigated kinematics, grain distortions, and textures to infer conditions of deformation and metamorphism at both segments.

## VARIATION IN TWO STYLES OF ACADIAN THRUST FAULTING IN THE PINNACLE FORMATION, RICHMOND, VT

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The goal of this study is to investigate the variation in the styles of Acadian thrust faulting in the Pinnacle Fm. (CZp) located on the western flanks of the Green Mountain anticlinorium. This formation forms part of the Proterozoic to Cambrian rift clastic section on the upper plate of the Hinesburg thrust and lies roughly 0.5 km west of the Underhill – Brome thrusts. The unit contains foliated to massive muscovite-chlorite-biotite schist and metawacke and phyllite with beds of pebble to cobble conglomerate. It sits unconformably on Proterozoic basement to the south (Ripton area) and is interbedded with Tibbit Hill metavolcanics to the north. A continuous 50 m roadcut, on which this study is based, exhibits two domains defined by distinctive structural relationships.

The eastern domain is comprised of layers of pebble-bearing metawacke and chlorite schist with quartz-calcite veins. The oldest visible foliation is an early penetrative disjunctive pinstripe cleavage ($S_2$) defined by alternating muscovite-chlorite and quartz-feldspar domains that are

axial planar to Taconian isoclines. This foliation is deformed by open, asymmetric, west-verging, upright folds ($F_3$). Cross cutting the crenulation cleavage ($S_3$) are a series of discrete ~1m wide ductile thrust zones defined by the truncation of the pinstripe, an intensification in the size of the pressure shadows on the pebbles, and the transposition of $S_3$ parallel to the thrust surface.

The western domain is composed of muscovite-chlorite schist with fewer metawacke layers. The older pinstripe cleavage is not as prevalent due to the intense overprinting of the penetrative $S_3$ cleavage. In comparison to the eastern domain, the deformation processes are predominantly mechanical. Unlike the eastern domain, the thrust zones are parallel to $S_3$ and have a down dip quartz-chlorite +/- pyrite mineral lineation on the $S_3$ planes.

Outcrop and microstructural observations suggest the two different thrust styles result from the variability in lithology and location of a large-scale $F_3$ fold. The eastern type formed by faulting along the long limbs of asymmetric $F_3$ folds of $S_2$ while the western type formed by faulting parallel to the $S_3$ cleavage planes. This model is applicable to the southeastern portion of the Essex Junction Quadrangle where the Acadian deformation intensifies.

## VERMONT STATE GEOLOGIST'S REPORT

**Northeastern Geological Society of America Meeting**- March 18-20: Vermont Geological Survey (VGS) personnel were co-conveners of two successful topical sessions:

> *Getting the Work Done: State Geological Surveys; Partnering and Progress:* Abstracts highlighted the needs of the citizens of the Northeast. State Geological Surveys assemble resources for projects to provide framework and applied information on a range of geo-science topics. Presentations focused on collaborative research between state surveys and academic geology or contractors on topics such as hydrogeology, groundwater geochemistry, natural hazards, geomorphology, and geothermal issues. Conveners: Robert Marvinney, Maine Geological Survey; Laurence Becker, VGS; Jonathan Kim, VGS; Rick Chormann, New Hampshire Geological Survey.
>
> *The New England- Canadian Bedrock and Tectonic Connections*: Presentations highlighted research that helps to resolve the similarities and differences in the tectonic evolution of the New England and Canadian segments of the northern Appalachians. The session focused on resolving tectonic problems using various approaches, including elements of structural geology, petrology, geochronology. Conveners: Keith Klepeis, Univ. of Vermont; Jon Kim, VGS.

Abstracts, presentations and posters from VGS and our partners are listed below and abstracts are available at https://gsa.confex.com/gsa/2013NE/webprogram/start.html:

Improving Seismic Hazard Assessment In New England Through The Use Of Surficial Geologic Maps And Expert Analysis: Becker, Laurence R.[1], Patriarco, Steven P.[2], Marvinney, Robert G.[3], Thomas, Margaret A.[4], Mabee, Stephen B.[5], and Fratto, Edward S.[2], (1) Vermont Geological

Survey 2) Northeast States Emergency Consortium, (3) Maine Geological Survey (4) Connecticut Geological Survey (5) Massachusetts Geological Survey

Use of Lidar in a Landslide Inventory Protocol in Vermont: Clift, Anne E., Jericho, Springston, George E., Norwich University, and Becker, Laurence, VGS

Magmas Without Borders: Coish, Raymond, Middlebury College, Kim, Jonathan, VGS

Pre- and Post- Tropical Storm Irene Comparative Assessment of Channel Geomorphology Along the Dog River, Central Vermont: Hay, Jeffrey K.[1], Conley, Matthew J.[1], Waters, Kevin[1], Koteas, G. Christopher[1], Dunn, Richard K.[1], Springston, George E.[1], and Grigg, Laurie D.[1], (1) Norwich University

Analysis of Groundwater Resources in the Town of East Montpelier, Central Vermont: Kim, Jonathan J.[1], Springston, George E.[2], and Becker, Laurence R.[1], (1) VGS (2) Norwich University

Comprehensive Logging of Deep Bedrock Wells in Vermont for Geothermal Purposes: Kim, Jonathan J.[1], VGS, Romanowicz, Ed [2], (1) VGS (2) SUNY at Plattsburgh

Distribution and Geometry of Acadian Deformation in the Taconian Foreland of West-Central Vermont: Kim, Jonathan J.[1], Klepeis, Keith[2], and Gale, Marjorie H.[1] , (1) VGS (2) University of Vermont

Seismic Hazard Assessment of The Burlington and Colchester Quadrangles, Northwestern Vermont: Lens, John E.[1], Dewoolkar, Mandar M.[1], Springston, George E.[2], and Becker, Laurence[3], (1) Norwich University (2) University of Vermont (3) VGS

Compilation of Geochemical Data of Meta-Volcanics from the Rowe-Hawley Zone of Western New England are Consistent with Backarc, Arc, and Forearc Regions of One Composite Arc: Pierce, Natashia[1] , Dietsch, Craig[1], Kim, Jonathan[2], and Coish, Raymond[3], (1) University of Cincinnati (2) VGS (3) Middlebury College

Examining the Potential Effect of Metamorphism on Arsenic Concentration in Metapelite Bedrock Aquifers: A Case Study of the Taconic Sequence: Studwell, Sarah[1], Ryan, Peter[1], West, David P. Jr[1], and Kim, Jon[2], (1) Middlebury College (2) Vermont Geological Survey

Source of Arsenic-Bearing Pyrite in Southwestern Vermont: Sulfur Isotope Evidence Mango, Helen[1], and Ryan, Peter[2], (1) Castleton State College (2) Middlebury College

Variation in Two Styles of Acadian Thrust Faulting in the Pinnacle Formation, Richmond, Vt: Ruksznis, Abigail[1,2], Klepeis, Keith[1], and Gale, Marjorie H.[1], (1) University of VT (2) VGS

Rainfall, Flood Magnitude, and Geomorphic Impacts of Tropical Storm Irene on the White River Watershed, East-Central Vermont:Springston, George E.[1], Underwood, Kristen L.[2], Robinson, Keith[3], and Swanberg, Ned[4], (1) Norwich U. (2) South Mountain Research & Consulting,

Bristol, VT (3) USGS (4) VT Dept. of Environmental Conservation, Watershed Management Division

Leveraging a GIS and the Emerging Geoweb Towards Improving The Communication Of Geologic Mapping Endeavors To Community Stakeholders: Van Hoesen, John, and O'Keefe, Megan, Green Mountain College

Field-Based Undergraduate Curriculum and Research Exploring Geophysical Methods, With Applications to the State of Vermont: Webb, Laura E.[1], Westerman, David S.[2], Springston, George E.[2], Kim, Jonathan[3], Klepeis, Keith[1], Koteas, G. Christopher[2], Ruksznis, Abigail[1,2], Mehrtens, Charlotte[1], Becker, Laurence R.[3], and Gale, Marjorie[3], (1) University of Vermont (2) Norwich University (3) VGS

Surficial Geology and Land Use in Vermont: Wright, Stephen F., University of Vermont

**Hazards :** State Hazard Mitigation Plan (SHMP) – Landslides and Earthquakes
The VGS submitted the "Protocol for the Identification of Areas Sensitive to Landslide Hazards in Vermont" developed by Anne Clift and George Springston to Vermont Emergency Management and Homeland Security. There are landslide and earthquake narratives in the Vulnerability and Assessment section. The Executive Summary of the Protocol will be referenced and appear in the appendix. A URL link to the VGS web site gains access to the full report and protocol: http://www.anr.state.vt.us/dec/geo/hazinx.htm

**Geologist/Hydrogeologist – Discussion of Formal Designation**
(Please see public policy request to the VG Society membership in this issue)

**Move to National Life Building, Montpelier:** The VGS moved to permanent quarters at National Life, February 25, 2013. The Davis 2 space accommodates our light tables, map cabinets and places for temporaries and student interns. We appreciate our new location with thanks to the Agency of Natural Resources administration and staff that worked to accommodate our needs for the future. (address/phones)

Respectfully submitted,
Laurence R. Becker, State Geologist

## PUBLIC ISSUE: RESPONSES SOUGHT ON GEOLOGIST LICENSURE OR REGISTRATION

With recent proposed changes to the engineer's licensing statute, the geology and hydrogeology community is again discussing the question of licensing or registration for geologists.

A group in the Department of Environmental Conservation met to begin to consider the pros and cons of licensure/registration. Some states have licensing programs, others registration, so please consider the licensing/registration term as a catch all for considering a more formal designation for geologists.

Three questions are posed:

1. Is licensure/registration appropriate for geologists/hydrogeologists?

2. Is it necessary?

3. Would you support a bill in the Legislature if proposed?

Please respond by emailing Larry Becker, Vermont State Geologist and Chair of the VG Society Public Issues Committee. Email: laurence.becker@state.vt.us; If you prefer a phone conversation: 802-522-5165.

Looking forward to hearing from you.

## TREASURER'S REPORT

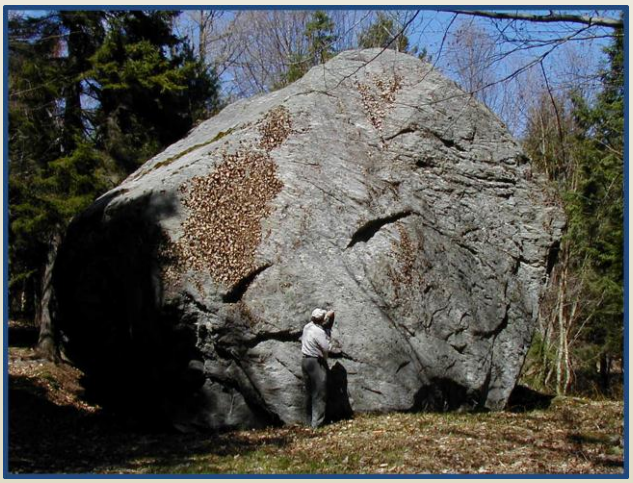
**Finances:** The Society is in excellent financial condition, thanks to all of its members. We are at our annual peak, with deposits in, and prizes and scholarships not yet distributed. Cash on hand as of April 1, 2013 is $6,741. Recorded dues payments for 2013 stand at $1,380, down about 6 members from last year; contributions to the Society's Research Grant Program equal $775 to date, down almost 50% from the year before. We have had no expenses since the last Treasurer's report.

**New Members:** Please join me in welcoming the following new and returning Members:
Alice Blount (M), Omya, Inc., Proctor, VT
Shannon Foster (M), Omya, Inc., Proctor, VT
James Nizamoff (M), Omya, Inc., Proctor, VT
Michelle Nucci, P.G. (M), Wilcox & Barton, Moretown, VT

**Sanborn "Sandy" Partridge (1915-2013):** I would like to take this opportunity to acknowledge that one of our longest-term members, Sanborn "Sandy" Partridge, passed away peacefully in January. I am lucky to have known him these past few decades. He led a rich and productive life, filled with service, always delivered with a smile. He never let me forget that he was related to the founder of Norwich University, Capt. Alden Partridge. Several news articles can be found with minimal searching, but here's one from the Rutland Hearald.
http://www.legacy.com/obituaries/rutlandherald/obituary.aspx?pid=162378465#fbLoggedOut

**Mystery Check:** Following separation of an envelope and an unidentified renewal form, and after making deposits before entering all the renewal data, I have no idea who wrote us check #4234 for $20 dues plus $10 donation. Step up and claim your prize!

Respectfully submitted,
David S. Westerman, Treasurer



**Where's It, What's It?** Send me an e-mail (marjorie.gale@state.vt.us) with the Vermont town name and a brief description of what is in the picture below. All correct entries will be entered in a drawing for a copy of the 2011 Bedrock Geologic Map of Vermont. Look for the answers in the GMG Summer Issue along with another puzzler. Feel free to contribute your own Vermont puzzlers too.

*Tom Eliassen is the winner of the last issue's contest. See the correct answer below*

## ANNOUNCEMENTS

**MAP EXHIBIT COMING SOON TO PERKINS MUSEUM -** The 2011 Bedrock Geologic Map of Vermont will be on permanent display in the Perkins Museum later this spring. More details TBA.

**SUMMER FIELD TRIP -** Tom and Pat Manley (Middlebury College) expect to take us in small groups for 2 hour excursions on board their research vessel on Lake Champlain on August 24. Details will be announced as summer approaches.

**ERIE PROGRAM -** The University at Buffalo's Ecosystem Restoration through Interdisciplinary Exchange (ERIE) Program offers 2013 Summer Stream Ecosystem Restoration Workshops and Professional Certificate Program. Registration is now open. Visit their website for more information: http://www.erie.buffalo.edu/trainingSummerCoursemainpage.php

## ANSWER TO WHERE'S IT, WHAT'S IT?



The picture is of the Yandow exploratory oil/gas well which was drilled to a depth of 4,500 feet in 1957. The well was drilled by the Henderson Company using a cable tool rig (center picture). Wooden blocks at the base of the derrick rotted and the derrick "settled" onto the well head, thus tipping it about 30 degrees (far right picture). The picture was taken from County Line Rd., St. Albans.

# CALENDAR

| | |
|---|---|
| April 27: | Spring Student Research Meeting, University of Vermont |
| August 24: | Summer Field Trip on Lake Champlain |
| Sept. 9-12: | 2013 Highway Geology Symposium, North Conway Grand Hotel, North Conway, NH: http://www.highwaygeologysymposium.org/default.asp |
| Sept. 23-24: | National Ground Water Association Conference on Groundwater in Fractured Rock and Sediment, Hilton Burlington, Burlington, VT |
| October 11-13: | New England Intercollegiate Geologic Conference, Millinocket Lake, ME |
| October 27-30: | Geological Society of America Annual Meeting, Denver, CO |

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***ADDRESS CHANGE?***
*Please send it to the Treasurer at the above address*