THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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

WINTER 2010	VOLUME 37	NUMBER 1

The Vermont Geological Society's
Winter Meeting

Geologic Controls on River Systems in the Northeastern U.S.

February 6, 2010, 9:30 AM
Cabot Science Building, Room 085
Norwich University, Northfield, Vermont

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ABSTRACTS

MANAGING RIVERS FOR EQUILIBRIUM *[Keynote Address]*

John Field, Field Geology Services, Farmington, ME; jfield@field-geology.com

Human land use in watersheds throughout New England has greatly altered runoff and sediment transport, particularly direct impacts to the channel caused by berming, channel straightening, and wood removal. Habitat degradation, increased bank erosion, and accelerated channel migration occurs in areas where stream power and sediment transport capacity rapidly change. Those reaches most susceptible to channel adjustment following human alteration of the stream tend to be near geological constraints such as bedrock constrictions, high banks of glacial sediments, and alluvial fans, because of the rapid decreases in stream power or increases in sediment delivery that result. Bringing back a balance, or equilibrium, to altered stream systems requires more evenly distributing sediment and stream power throughout the watershed. In the upper watersheds, adding wood to the channels by selectively felling trees in the riparian zone (i.e., chop and drop technique) can lead to greater channel complexity, narrower stream channels, and increased sediment storage. Encouraging sediment storage on the lower valley bottoms in

protected floodplain areas can create aquatic habitat and decrease downstream erosion hazards. Using restoration techniques that bring about equilibrium conditions is the best approach for sustainable watershed management throughout New England.

POST-GLACIAL EXHUMATION OF THE UPPER WINOOSKI RIVER VALLEY, CENTRAL VERMONT

George E. Springston, Department of Geology and Environmental Science, Norwich University, Northfield, VT; gsprings@norwich.edu

The landforms within an 18-mile section of the Upper Winooski River valley from East Montpelier village upstream to the Marshfield–Cabot town line preserve a record of the progressive incision of the river through a sequence of till, ice-contact deposits, lacustrine silt and clay, and lacustrine sands, which are capped in a few places by late glacial stream gravels. The lacustrine deposits formed in glacial Lake Winooski (GLW), which had a present-day shoreline elevation of about 965 feet ASL at Plainfield village. The waters of this proglacial lake were impounded by ice to the west of Montpelier and drained through Williamstown Gulf into the White River watershed. As the river cut through the deposits, it left terrace remnants along the valley walls. Many of the remnants are preserved due to bedrock outcrops in critical upstream locations that deflected the river away from the terraces and out onto softer unconsolidated deposits closer to the center of the valley. A set of these terraces is preserved in Plainfield village, with elevations of 775 feet, 740 feet, 725 feet, and 710 feet (active floodplain is about 705 feet). Total down-cutting since the drainage of GLW (as derived from four sites in study area) ranges from ~40 to 45 feet. At Plainfield village, the original lake bottom is interpreted to be the 775 foot terrace, giving a depth for GLW at this location of ~190 feet.

Two alluvial terraces within about 2 meters of present bankfull elevation contain archaeological sites with pre-settlement artifacts near the present land surface. This suggests that there was no significant post-settlement aggradation and that there has been limited streambed degradation, at least in the stream reaches upstream of Plainfield village. Downstream of Plainfield, present-day bankfull elevations are between 1 and 2 meters below the main floodplain in several locations, suggesting some recent incision. Some of this incision may be due to the breaching of a dam at East Montpelier in mid-20th century.

Analysis of maps, air photos, and orthophotos from 1873 to 2005 shows that downstream migration of bends, lateral migration of meanders, and meander cutoffs with resulting oxbows are characteristic of the high sinuosity reaches. Low sinuosity reaches commonly are those with bedrock control and/or human straightening and show little channel movement.

USING NRCS SOIL DATA TO BETTER UNDERSTAND VERMONT RIVERINE SYSTEMS

Caroline Alves, USDA Natural Resources Conservation Service, Williston, VT; Caroline.Alves@vt.usda.gov

At the macro-scale, soils maps from the Natural Resources Conservation Service (NRCS) show the extent of alluvial deposits. By combining information from various sources, such as river

corridor mapping, FEMA floodplain delineations and NRCS map-units prone to flooding, a more complete picture can be derived of the spatial distribution of fluvial systems. Standard soil survey maps, generally done at 1:20,000 scale, cannot fully depict the complex distribution of soils found within the floodplain environment. Nonetheless, soil series descriptions include generalized data on texture, percentage of rock fragments, rooting depth, drainage, etc., which have a major influence on the susceptibility of riverbanks to erosion. At the site-specific scale, University of Vermont researchers and NRCS are conducting characterization studies on alluvial soils along 5 river corridors. This will provide in-depth laboratory data on the chemical and physical characteristics of soil samples taken from the most widely distributed floodplain map-units within Vermont. The primary goal is to build a database of background or native phosphorus (P) levels in non-managed alluvial soils. Additionally, an assessment of how well the data gathered fits into the range of characteristics for a given soil series will be made. In a parallel data gathering effort, NRCS has collaborated with the VT DEC River Management Program and the Agricultural Research Service to take soil samples at riverbank locations where *in-situ* tests for shear stress and resistance to erosion have been run. It is important to develop a database of P levels in soils, derived from lab data, which covers a wide range of soil series and geographic locations. Without actual data, estimated values could lead to distorted results from sediment transport models when quantifying the contribution of P from bank erosion. Preliminary data results will be discussed along with the implications of this data gathering effort on future updates to floodplain soil maps.

USING THE AGRICULTURAL RESOURCE SERVICE NATIONAL SEDIMENTATION LAB'S BANK STABILITY AND TOE EROSION MODEL (BSTEM) TO PREDICT RATES OF STREAM BANK EROSION AND ASSOCIATED PHOSPHORUS CONTRIBUTIONS

Shayne Jaquith, Vermont DEC River Management Section, Waterbury, VT; shayne.jaquith@state.vt.us

The Missisquoi River contributes a significant amount of the phosphorus that is responsible for the nutrification of Lake Champlain. Identification of effective solutions for reducing the rate of phosphorus delivery to Lake Champlain requires an understanding of the source of the sediment-bound phosphorus found in the Missisquoi. The Vermont Department of Environmental Conservation has partnered with the USDA National Sedimentation Lab to conduct a study of bank stability along the Missisquoi and its tributaries.

The USDA Agricultural Resources Service, National Sedimentation Laboratory has developed and used in a number of studies in various regions of North America and other continents, a deterministic bank stability and toe erosion model (Simon et al., 2000) that incorporates geotechnical data from bank soils and hydrologic data to determine bank stability. During the fall of 2009, field teams comprised of staff from the National Sedimentation Lab, Vermont DEC, USDA Natural Resources Conservation Service and one post-graduate student from the University of Vermont Engineering Department collected geotechnical data from twenty sites along the banks of the Missisquoi River and four of its tributaries. These data will be used by the National Sedimentation Lab to model bank stability along the Missisquoi, predict annual sediment loading rates resulting from bank erosion and explore the use of various best management practices to mitigate erosion and facilitate long-term channel equilibrium.

FLUVIAL EROSION HAZARD ZONES FOR THE ISINGLASS RIVER, SOUTHEASTERN NEW HAMPSHIRE

Shane Csiki, New Hampshire Geological Survey, Concord, NH; Shane.Csiki@des.nh.gov

New Hampshire is undertaking the development of a fluvial geomorphology program, modeled on Vermont's approach. As part of these efforts, the New Hampshire Geological Survey recently completed a Phase 2 rapid geomorphic assessment of the Isinglass River, in southeastern New Hampshire. The results of the assessment are used to create fluvial erosion hazard (FEH) zones adjacent to river reaches, which are in part determined by the sensitivity of a reach to future erosion and channel migration. This presentation will evaluate how the final sensitivity ratings compare to known existing surficial and bedrock geology, and the processes operating on the Isinglass. A brief description of New Hampshire's efforts, including plans for future assessments, will also be presented.

POSTER ABSTRACTS

BEDROCK CONTROL ON THE COURSE OF THE OTTAUQUECHEE RIVER, WOODSTOCK, VERMONT

Peter J. Thompson, Department of Earth Sciences, University of New Hampshire, Durham, NH; pjt3@cisunix.unh.edu

The Ottauquechee River rises in Killington, Vermont, on the east slopes of the Green Mountains, and flows SSE parallel to rock layers east of the Green Mountain anticlinorium, until it reaches West Bridgewater, where it turns abruptly east. The river has cut a valley across the grain of the geology to the Bridgewater/Woodstock town line, where steep easterly dips in Ordovician bedrock give way to gentler dips in Silurian and Devonian rocks between Chester and Pomfret domes. Across the town of Woodstock, the Ottauquechee jogs alternately ESE and NE, parallel to the two dominant joint sets measured in rock outcrops within the town. Photolinears from DEM and DOQ images follow these same two directions. Two tributaries, Broad Brook and Kedron Brook, follow a NNW photolinear to meet the Ottauquechee at Woodstock village. Depth-to-bedrock data from the Vermont water well database show that a buried channel up to 120 feet deep more or less follows the same course as the modern river through Woodstock. Farther downstream the river proceeds east across the south end of the Pomfret dome to Quechee, then turns south parallel to foliation and a mafic dike through Quechee Gorge (165 feet deep), and then SE to join the Connecticut River in North Hartland.

SUNCOOK RIVER AVULSION, EPSOM, NH: ASSESSMENT OF THE PRESENT EQUILIBRIUM STATUS OF THE RIVER

Nicole Kuenzel, Department of Earth Sciences, University of New Hampshire, Durham, NH; nikki@ccom.unh.edu

A portion of the Suncook River, located in the town of Epsom in southeastern NH, underwent a major avulsion during a flood event in May of 2006. The initial avulsion event was facilitated by land-use alteration in the form of a gravel pit excavation, which allowed for floodwaters to

breach the southern end of the gravel pit and erode headward. This created a steeper gradient and the water that originally split and flowed in two channels was redirected into a single channel. Presently, the system is not in equilibrium but is adjusting toward new equilibrium conditions after having crossed a geomorphic threshold during the avulsion. The adjustments are evident as knickpoint migration upstream, continuous downcutting that is also progressing upstream, sediment accumulation downstream and subsequent channel adjustment downstream since 2007. It is uncertain how long it will take for the system to reach a state of quasi-equilibrium again, but stream stabilization is likely to eventually occur as the upstream gradients are decreased by erosion and thereby decreasing sediment supply downstream. The rate of downcutting has slowed considerably from ~5 ft/month in the summer of 2006 immediately following the avulsion to ~0.125 ft/month in the fall of 2009. In addition, there is potential for stabilization of the knickpoint due to the shallow depth to bedrock in the area, which ranges from 45 ft in alluvium south of Round Pond, 32 ft in glaciolacustrine deposits west of where the two old channels used to split and 25-35 ft in alluvium upstream from the avulsion area, as observed from wells and test-borings in the area.

USING A GENERALIZED REGRESSION NEURAL NETWORK TO CLASSIFY STREAM HABITAT CONDITION

Bree R. Mathon[1], Nikos Fytilis[1], Lori Stevens[2], Michael Kline[3], and Donna M. Rizzo[1], [1]School of Engineering, [2]Department of Biology, University of Vermont, Burlington, VT; [3]River Management Program, VT Agency of Natural Resources, Waterbury, VT

The ability to identify streams with high environmental risk is essential for a proactive adaptive watershed management approach. In efforts to describe the conditions of streams, environmental managers must gather and assess various forms of information—quantitative, qualitative and subjective. We research and develop a classification tool to identify stream habitat values based on several geomorphic and biological parameters. In the development of this work, we are using the rapid geomorphic assessment protocols (RGA), as well as the rapid habitat assessment protocols (RHA), from 1412 Vermont stream reaches assessed by the Vermont Agency of Natural Resources (VTANR).

Geomorphic and biological health information (e.g., fish density, macroinvertebrate density) is traditionally researched separately by different experts. We build upon previous work (Besaw et al., 2009) by including biological data to assess habitat conditions. We explore the relationships between the RGA and RHA. Our research focuses on the integration of fuzzy numbers to assess the uncertainty in geomorphic and biological parameters with artificial neural networks (ANNs) to classify the biological condition of the reach. GIS is used to visualize the results.

A generalized regression neural network (GRNN) (Specht, 1991) will be modified to incorporate uncertainty (assigned by experts) in RGA and biological parameter values. This GRNN architecture allows for (1) the incorporation of uncertainty that is often ignored in traditional analysis techniques, (2) is sufficiently flexible to allow for continual updates and refinements as understanding/condition of fluvial geomorphology evolves, (3) the combination of data often collected separately, and (4) the potential to save time and resources, while enabling a truly adaptive management approach using expert opinion.

QUANTIFYING SEDIMENT LOADING DUE TO STREAMBANK EROSION IN IMPAIRED AND ATTAINMENT WATERSHEDS IN CHITTENDEN COUNTY, VT

K. M. Garvey[1], L. A. Morrissey[1], D. Rizzo[2], and M. Kline[3], [1]Rubenstein School of Environment and Natural Resources, [2]School of Engineering, University of Vermont, Burlington, VT; [3]River Management Program, VT Agency of Natural Resources, Waterbury, VT

High spatial resolution digital orthophotography acquired over a 9-year period of study and detailed LiDAR elevation data were combined to quantify lateral stream channel migration over time and associated sediment loading due to streambank erosion in 15 watersheds within Chittenden County, VT. Even after conservatively accounting for differences in pixel size and registration errors, extensive channel migration was observed in all watersheds. Migration rates were compared for impaired and attainment (reference) watersheds. Erosion "hot spots" within each watershed were identified and linked to watershed and corridor stressors. Our results are preliminary but demonstrate the value of remote sensing to quantify spatial and temporal variability in fluvial geomorphic change at watershed scales and a potentially viable methodology to evaluate sediment loading to streams at subreach to watershed scales.

GEOLOGIC AND GEOMORPHIC CONTROLS ON WATER QUALITY: IMPLICATIONS FOR WATERSHED MANAGEMENT, ADDISON COUNTY, VT

Kristen Underwood, South Mountain Research & Consulting, Bristol, VT; southmountain@gmavt.net

The Addison County River Watch Collaborative and LaPlatte Watershed Partnership have collected over 12 years of water quality monitoring data in seven watersheds of the eastern Lake Champlain basin. Monitored watersheds range in size from 53 to 498 square miles and span the Champlain Valley and Northern Green Mountain geologic provinces in Addison County and southern Chittenden County, Vermont. Bedrock and surficial deposits of these watersheds both directly and indirectly influence river water quality, through their controls on precipitation patterns, hydrology, geomorphology, soil types, vegetation, and human land use. Median turbidity and total phosphorus concentrations measured during baseflow and summer storm conditions are positively correlated with percent glaciolacustrine parent materials and percent agricultural land use in the upstream watershed (and inversely correlated with percent forest cover). Observed trends highlight the importance of different watershed-management priorities for the Champlain Valley province versus the Northern Green Mountain province.

PRESIDENT'S LETTER

Rivers on my mind

In the last decade a tremendous effort has been undertaken to understand the fluvial geomorphology of Vermont and adjacent areas. This has largely been driven by the recognition by river managers that old-style engineering fixes were expensive and often not effective over the long-term. The current view among most river management specialists is that it is necessary

to understand and accommodate the dynamic stability of the river system: A "stable" stream is one that will be able to transport a given amount of water and sediment with a corresponding cross-sectional profile, planform, and longitudinal profile, without substantial aggradation or degradation of its bed. This doesn't mean the channel will stay fixed in position. Rather, migration of meander bends and shifting of channel position across a floodplain are normal events, which we interfere with at our peril. Instead, although the channel position of a stable stream may shift over a few years time, factors such as the stream gradient, width-depth ratio, and meander wavelength would tend to be relatively constant. Of course, if there are changes to the banks or riparian zone, the watershed characteristics, or the climate, the stream will tend to adjust to compensate for these changes. Much of the river management effort at present involves trying to give the stream a meander belt of sufficient width to allow for these processes to play out without undue interference with human structures and facilities—a big task!

In order to apply the new river management techniques, considerable fieldwork is required (and GIS analysis as well). According the Vermont River Management Section, there have been about 120 assessment projects in Vermont since 2003. For more information, see their website at http://www.vtwaterquality.org/rivers.htm.

The Winter Meeting of the Vermont Geological Society on February 6th will showcase some of the results of this recent renaissance in studies of our dynamic river systems. The emphasis will be on the geologic factors that influence river forms and processes. I hope that many of you will be able to come and listen to the talks, view the posters, and participate in the discussions. See you there!

Respectfully submitted,
George Springston

ANNUAL MEETING MINUTES & ELECTION RESULTS

The Vermont Geological Society did not hold an Annual Meeting during the fall of 2009, nor did the Executive Committee meet. Instead, the members of the Committee communicated with one another on several occasions by e-mail to discuss a number of issues and to plan the upcoming Winter 2010 Meeting. As mentioned in the Treasurer's report, there has been some discussion of the possibility of establishing a cap on the total amount of funds that can be awarded for research grants during each of the two semiannual rounds, while still maintaining a maximum award per grant of $700.00, based on the Society's annual income derived from membership dues, additional research grant contributions, and publications sales. The Committee expects to discuss this matter more formally following the Winter 2010 Meeting.

Since the Society would not be holding an Annual Meeting during the fall, Steve Howe suggested to the rest of the Executive Committee that the Society initiate the use of electronic ballots to supplement the traditional paper ballots included within the Fall *Green Mountain Geologist*, since members would not have an opportunity to cast their votes for the officers standing for election at a meeting. Kristen Underwood agreed to tabulate the votes cast on the electronic ballots. Kristen reported that a total of 28 valid electronic ballots were received by the

voting deadline, while Dave West reported that he received 3 valid paper ballots by the deadline. The following officers were elected for the 2009-2010 year, with the number of votes cast in favor indicated in parentheses after the candidate's name:

President	George Springston (31)
Vice-President	John Van Hoesen (30)
Secretary	Dave West (31)
Treasurer	Steve Howe (31)

Based on the success of the electronic ballot initiative, Steve will recommend that the Executive Committee vote to establish electronic balloting as the preferred method of balloting for future elections. Kristen has kindly volunteered to tabulate electronic ballots in the future.

Respectfully submitted,
Stephen S. Howe

TREASURER'S REPORT

The financial condition of the Society continues to be very strong. As of January 8, 2010, the Society's checking account balance was $5,112.35. As indicated in the Advancement of Science Committee report, three Research Grant proposals were submitted by the October 1, 2009 deadline, and these proposals were awarded a total of $1,721.00. The Executive Committee is considering the possibility of establishing a cap on the total amount of funds that can be awarded for research grants during each of the two semiannual rounds, while still maintaining a maximum award per grant of $700.00, based on the Society's annual income derived from membership dues, additional research grant contributions, and publications sales. To my knowledge, there are no outstanding bills.

The following members have been approved for membership in the Society since the last report: Lilly Corenthal, Middlebury, Vermont and Victor Guevara, Middlebury, Vermont.

The 2010 membership renewal and directory information form was mailed to all members before December 31, 2009. The deadline for renewal is January 31, 2010. Please help the Society keep expenses to a minimum by renewing your membership promptly. When renewing, please consider making an additional tax-deductible contribution to the Society's Research Grant Program.

I would like to express my appreciation to all of the members who have chosen to receive the *Green Mountain Geologist* electronically as a PDF file, to help keep the Society's publication and mailing costs low, which will, in turn, allow us to keep membership in the VGS the bargain that it already is.

Respectfully submitted,
Stephen S. Howe, Treasurer

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

Three research grant proposals were received and funded by the Vermont Geological Society (VGS) during the fall of 2009:

Kyle Thomas Ashley, a graduate student in the Master's Program at the University of Vermont, received an award of $461.00 for his proposal entitled "TitaniQ Thermobarometry of Fabric Development in the Strafford Dome, Vermont: Linking Microstructures to Orogenic Processes."

Lilly Corenthal, an undergraduate student at Middlebury College, received an award of $700.00 for her proposal entitled "Identifying the Source of Arsenic in Three Public Water Supplies in North-Central Vermont: Potential Contribution of Ultramafic-derived Arsenic."

Victor Guevara, an undergraduate student at Middlebury College, received an award of $560.00 for his proposal entitled "A Geochemical and Petrographic Study of the Echo Pluton, VT."

As a condition for receiving this grant money, the Vermont Geological Society expects that the results of these studies will be presented at a future VGS spring student meeting or a professional meeting. We also anticipate upcoming presentations by Lauren Chrapowitzky and Halen Earle, both from the University of Vermont, who received VGS research grants during the spring of 2009.

Respectfully submitted,
Jon Kim, Chair

VERMONT STATE GEOLOGIST'S REPORT

Joint Northeastern–Southeastern Section Mtg., Geological Society of America, March 14-16, 2010
If you can make the trip to Baltimore this year for the combined Northeastern and Southeastern Section Meeting of the Geological Society of America, please join us for an exciting symposium entitled *The New Bedrock Geologic Map of Vermont: New Answers, New Problems, and New Uses of Bedrock Geologic Data*, chaired by Nicholas M. Ratcliffe, U.S. Geological Survey; Marjorie Gale, Vermont Geological Survey; and Peter Thompson, University of New Hampshire.

The forthcoming bedrock geologic map of Vermont represents a 20-year effort by numerous geologists from federal, state, and academic institutions. This symposium will focus on new aspects and questions associated with the geology of Vermont. Following an introduction by State Geologist Laurence Becker and USGS Program Director Peter Lyttle, Nick Ratcliffe will present an overview of the new map. The Sunday morning session on March 14th begins 15 minutes early and the poster session will be held in the afternoon. The map will be on display at the entrance to the poster session.

List of talks:
Introduction to the New 1:100,000 Bedrock Geologic Map of Vermont, by Ratcliffe

U-Pb Geochronology Studies in Vermont, by Aleinikoff, Ratcliffe, and Walsh

New Bedrock Map and Cross-Sections of Vermont: Structural and Stratigraphic Constraints for Northern Vermont, by Gale and Thompson

Along-Strike Changes in Depositional Facies and Structural Style as Portrayed on the Bedrock Map of Vermont, by Thompson and Gale

The Connecticut Valley–Gaspe Trough in Vermont, by Walsh, McWilliams, Ratcliffe, Aleinikoff, Thompson, Gale, and Rankin

The Bronson Hill Arch, Upper Connecticut Valley, North of 43º 52.5', by Rankin and Tucker

Tectonic Evolution of The Rowe–Hawley Belt In Central And Northern Vermont, by Kim, Gale, Coish and Laird

The Origin of The Moretown Formation, Vermont—An Alternative Perspective From The Southern Québec Appalachians, by DeSouza and Tremblay

Conodonts—Useful But Underused Tools For Deciphering Geology In Vermont, by Repetski, Ratcliffe, Walsh, Thompson, Thompson, and Harris

Creation of The Bedrock Geologic Map Of Vermont—An Evolution From Analog To Digital Mapping Techniques by Walsh, Ratcliffe, Masonic, Gale, Thompson, and Becker

Vermont Applied Projects as a Guide for Use of the New State Bedrock Map, by Becker, Gale, Kim, Thompsons, Springston, Eliassen, and Walsh

List of posters:
Contrasting Origins of Mafic Rocks in the Rowe–Hawley Belt of Vermont: Evidence from Geochemistry, by Coish, Kim, Gale, and Laird

Variations in Slaty Cleavage and Stretching Lineation Orientation in the Taconic Allochthon, Vermont and New York, by Mirakian, Drennan, Thorne, Feder, and Crespi

C. H. Hitchcock's 1877-78 Geologic Maps of New Hampshire, Vermont and Western Maine: His First Relief Map Restored, by Bothner, Batchelder, Lecain, King, and Thompson

Comparison of Ductile Structures across the Hinesburg and Champlain Thrust Faults in NW Vermont by, Earle, Kim, and Klepeis

New Data Available as Geodatabases
New data available for download as geodatabase files are posted on our website. The data includes bedrock and/or surficial and groundwater resource data for the following areas: Burlington, Brandon, Charlotte, Colchester, Dorset, Hinesburg, Londonderry, Lowell Mtns., Manchester, Rutland, Wallingford, Williston, and Woodstock.

Respectfully submitted,
Laurence R. Becker, State Geologist

CALL FOR STUDENT ABSTRACTS

SPRING MEETING OF THE VERMONT GEOLOGICAL SOCIETY

The Vermont Geological Society has tentatively scheduled to hold its Spring 2010 Meeting on Saturday, April 24, 2010, in Bicentennial Hall at Middlebury College, Middlebury, Vermont, but the date and location are subject to change. The meeting is dedicated to students conducting research in the geological sciences. Undergraduate and graduate students are encouraged to submit abstracts outlining the results of their research. Abstracts covering all aspects of the geological sciences are welcome and will be published in the Spring issue of the *Green Mountain Geologist*. The Charles Doll Award for the outstanding undergraduate paper will be presented. Cash awards for the top three papers will also be presented based on quality of the research, the abstract, and the presentation of the paper. An example of last year's judging form will be placed on the Society's website shortly.

Abstracts should be prepared using the style employed for abstracts submitted to Geological Society of America meetings (maximum of 2,000 characters without spaces). We strongly encourage speakers to send their abstracts electronically as a Word file with a .doc extension attached to an e-mail message sent to Kathleen Howe at khowe@uvm.edu

If electronic submission is not possible, please mail your abstract well in advance of the deadline to:

Kathleen D. Howe
University of Vermont
Office of Health Promotion Research
1 South Prospect Street, Room 4428A
Burlington, VT 05401

Oral presentations will be limited to 12 minutes with 3 additional minutes for questions. A computer projection system is available for PowerPoint presentations.

Deadline for abstracts: Monday, April 5, 2010 at noon

ANNOUNCEMENTS

STUDENT RESEARCH GRANT APPLICATIONS DUE APRIL 1, 2010

Students and secondary school teachers are encouraged to apply to the VGS Research Grant Program by April 1, 2010. Downloadable Research Grant Program applications are available from the Society's website at http://www.uvm.org/vtgeologicalsociety/. For those without Internet access, forms may be obtained by writing to Jon Kim at the Vermont Geological Survey, 103 South Main Street, Logue Cottage, Waterbury, VT 05671, e-mail: jon.kim@state.vt.us, or by calling (802) 241-3469.

SUMMER FIELD TRIP

This is a preliminary announcement that Jon Kim and George Springston expect to lead a field trip for the Vermont Geological Society entitled "Bedrock Control on Surficial Deposits and Groundwater Issues in Part of the Knox Mountain Granite Pluton, Central Vermont" next summer. Details will be announced as summer approaches.

VERMONT GEOLOGICAL SOCIETY CALENDAR

February 6:	Winter Meeting, Cabot Science Building, Norwich University
March 14-16:	Joint Northeastern and Southeastern Section Meeting, Geological Society of America, Baltimore, Maryland
April 1:	Student Research Grant Program applications due
April 5:	Student abstracts for Spring Meeting due
April 5:	Executive Committee reports due
April 24:	Spring Meeting, Bicentennial Hall, Middlebury College

The **Vermont Geological Society** is a non-profit educational corporation.
The **Executive Committee** of the Society is comprised of the Officers, the Board of Directors, and the Chairs of the Permanent Committees.

Officers

President	George Springston	(802) 485-2734	gsprings@norwich.edu
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Chairs of the Permanent Committees

Advancement of Science	Jon Kim
Geological Education	Christine Massey
Membership	Stephen Howe
Public Issues	Laurence Becker
Publishing	Stephen Howe

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

Vermont Geological Society
Winter Meeting
February 6, 2010, 9:30 AM
Cabot Science Building, Room 085
Norwich University, Northfield, Vermont

Directions to Norwich University:

Norwich University is located on Vermont Route 12, one mile south of the center of Northfield. It can be reached from I-89 by taking Exit 5 and following Vermont Route 64 west to Route 12, and then north to the University. The Geology Department is located in Cabot Science Building, the southeastern most brick building on campus, just west of Route 12. The entrance is near the northeast corner of the very large white Kreitzburg Library, which can't be missed. The easiest parking for the meeting will be in the commuter lot opposite the Science/Engineering complex on the east side of Route 12.

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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

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The Vermont Geological Society

Spring Meeting

April 24, 2010, 8:30 AM
McCardell Bicentennial Hall, Room 417
Middlebury College, Middlebury, Vermont

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9:15AM	Robert Athan: SEISMIC EXPLORATION OF THE PORT HENRY WATER PLANE IN LAKE CHAMPLAIN
9:30AM	Lauren Chrapowitzky* and Charlotte Mehrtens: ECOLOGIC SUCCESSION IN THE VALCOUR FORMATION REEFS (MIDDLE ORDOVICIAN, CHAZY GROUP) OF VERMONT AND NEW YORK
9:45AM	Halen Earle*, Jonathan Kim, and Keith Klepeis: ANALYSIS OF THRUST RELATED STRUCTURES IN THE CHAMPLAIN VALLEY OF VERMONT
10:00AM	Lilly Corenthal: ARSENIC IN GROUNDWATER WELLS IN GLACIAL DRIFT, NORTH-CENTRAL VERMONT
10:15AM	Jonathan Moen: ANALYSIS OF ARSENIC SPECIATION IN ULTRAMAFIC ROCKS BY SEQUENTIAL CHEMICAL EXTRACTION
10:30AM	Alyssa Findlay* and Greg Druschel: MINERALOGY OF VERMONT ASBESTOS GROUP MINE WASTE, EDEN, VERMONT
10:45AM	BREAK
11:00AM	Jason Sanford: FOSSIL EARTHQUAKES IN SOUTH-CENTRAL MAINE: PSEUDOTACHYLYTES IN THE JONES CORNER FAULT ZONE
11:15AM	Matthew Bigl: A MULTI-PROXY STUDY OF A POST-GLACIAL SEDIMENTARY RECORD FROM OVERLAND LAKE, NEVADA
11:30AM	Catherine Klem: NEOGLACIAL EPISODES RECORDED IN A LAKE SEDIMENT CORE FROM THE UINTA MOUNTAINS, UTAH
11:45AM	Graham Hagen-Peter*, Laura E. Webb, and Merril Stypula: TIMING AND SIGNIFICANCE OF LARGE-SCALE FOLDING IN THE TAVAN HAR BASEMENT BLOCK IN SOUTHEASTERN MONGOLIA RELATIVE TO LATE TRIASSIC SINISTRAL SHEAR
12:00PM	Donald Hefferon: PETROGRAPHIC AND GEOCHEMICAL ANALYSIS OF BASEMENT ROCKS IN THE EAST GOBI FAULT ZONE, MONGOLIA
12:15PM	Janelle McAtamney*, Keith Klepeis, and Charlotte Mehrtens: SYNTHESIZING SOUTHERN ANDEAN OROGENESIS FROM THE EVOLUTION OF THE MAGALLANES FORELAND BASIN, SOUTHERN PATAGONIA, CHILE
12:30PM	Shane Snyder*, Janelle McAtamney, Charlotte Mehrtens, and Keith Klepeis: TECTONIC TRANSITION FROM BACKARC RIFT BASIN TO COMPRESSIONAL FORELAND BASIN IN THE SOUTHERNMOST ANDES: ITS GEOCHEMICAL EXPRESSION
	* Speaker
12:45PM	JUDGING and AWARDS PRESENTATIONS
1:15PM	EXECUTIVE COMMITTEE MEETING

ABSTRACTS

A GEOCHEMICAL AND PETROGRAPHIC ANALYSIS OF THE ECHO POND PLUTON, VERMONT

Victor Guevara, Geology Department, Middlebury College, Middlebury, VT 05753

A group of syn- to post-collisional Devonian plutons in the Northeast Kingdom of Vermont is representative of a significant period of magmatism that occurred after the main phase of the Acadian Orogeny between approximately 390 and 360 Ma. The dates of the Acadian Orogeny are poorly constrained and the tectonic history near the end of the Acadian Orogeny is poorly understood. The study of these plutons using modern techniques of geochemistry and age-dating is an important step toward gaining a better understanding of the tectonic processes occurring at the end of the Acadian Orogeny.

The focus of this study is the Echo Pond Pluton, a member of a group of plutons collectively known as the Northeast Kingdom Batholith. Our work has confirmed the presence of four distinct zones in the Echo Pond Pluton, based on rock type: mafic zones in the southern and northeastern areas of the pluton containing quartz-amphibole gabbro and diorite, a zone of granodiorite and granite that constitutes the central portion of the pluton, and a small zone of porphyritic granodiorite and granite containing rounded quartz grains in the east-central part of the pluton. The pluton intrudes the meta-sedimentary rocks of the Gile Mountain Formation. Quartz veins, granite dikes, and xenoliths are common at gradational contacts with the surrounding country rock. Previous workers used isotopic data to suggest that both mantle and crustal components played a role in the evolution of the Echo Pond Pluton. ICP-AES analysis of major, minor, and trace elements and ICP-MS analysis of rare earth elements will build upon this work, leading to more detailed conclusions about the magmatic evolution of the pluton.

Few studies have addressed the Echo Pond Pluton specifically, and little is known about its magmatic origin. Moreover, a precise age for the Echo Pond Pluton has not been obtained. The use of U-Pb dating of zircon, petrography, and modern methods of geochemical analysis will further constrain the dates of Acadian magmatism in Vermont and contribute to a more complete understanding of the magmatic origin and tectonic processes that led to the emplacement of the Echo Pond Pluton. This study hopes to accomplish this and provide a foundation for future study of the final stages of the Acadian Orogeny in Vermont.

SEISMIC EXPLORATION OF THE PORT HENRY WATER PLANE IN LAKE CHAMPLAIN

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The Port Henry water plane, located below the current water level of Lake Champlain, is examined through a series of seismic profiles gathered from 2003 to 2009. The increase in technology throughout the years has enabled the gathering of higher resolution profiles than those captured during previous studies in the 1930's. The water plane is identified through erosional terraces found within these high-resolution seismic profiles. Mapping of these terraces allows the creation of digital models of the Port Henry water plane using the program

EarthVisions. The terraces in these models have revealed that the Port Henry water plane is bowl shaped in nature as opposed to flat lying and is located at a depth within the range of 80 to 95 feet. These features are attributed to the effects of isostatic rebound since the retreat of the Laurentide ice sheet as well as the effects from rising lake level over time.

ECOLOGIC SUCCESSION IN THE VALCOUR FORMATION REEFS (MIDDLE ORDOVICIAN, CHAZY GROUP) OF VERMONT AND NEW YORK

Lauren Chrapowitzky and Charlotte Mehrtens, Department of Geology, University of Vermont, Burlington, VT 05405

The Chazy Group (Mid. Ord.) of the northern Appalachians has been the focus of numerous reef surveys since the early 20th century. It was deposited syn-tectonically on the eastward-dipping margin of Laurentia during the Taconic Orogeny, and comprises part of a major Ordovician carbonate sequence found throughout the Appalachians. The Chazy Group consists of 3 reef-bearing units. The uppermost Valcour Fm. contains reef horizons constructed by distinctly different framebuilders than the older Chazy Group units (Day Point and Crown Point Fms.), as well as strata elsewhere in the Appalachians. This study seeks to identify how and why the composition of the framebuilders changed over time.

The reefs are lensoid to circular in shape and can be up to 4m in cross-section. Lithofacies composition, size and shape of mounds, and subaerial exposure surfaces have allowed for identification of up- and downslope reefs. Stringline sampling was used to identify major framework organisms in the reefs in the field, followed by thin section point counting. In downslope reefs, the trepestome bryozoan *Batostoma* dominates the pioneer organisms (up to 40% of framebuilders), which passes vertically into tabulate algae dominated climax organisms (20-80%). Elsewhere, the *Batostoma* base transitions upwards through an intermediate stage of *Batostoma, Billingsaria,* and tabulate algae, and finally a tabulate algae dominated climax layer. Downslope reefs are commonly flanked by crinoid-dominated wackestones-packstones, but are capped by cross-bedded grainstones. In contrast, upslope reefs are a maximum of 2m thick in cross-section, and are pioneered by tabulate algae, and *Billingsaria*, diversify vertically in the composition of the framebuilders, and in the climax stage, tabulate algae is replaced by stromatolites and stromatoporoids.

These horizons contain evidence of firmgrounds. Upslope reefs are most commonly capped and flanked by cross-bedded crinoidal grainstones. Two primary lithofacies comprise the reefs and adjacent environments. The cores themselves are typically *Batostoma* (downslope) and tabulate algae (upslope) crusstones, Surrounding the cores are wacke-pack-rudstones of varying compositions, but generally contain bioclastic debris of bryozoa, coral, sponges, algae, brachiopods and crinoids. Upslope reefs are most commonly capped and flanked by cross-bedded crinoidal grainstones.

ANALYSIS OF THRUST RELATED STRUCTURES IN THE CHAMPLAIN VALLEY OF VERMONT

Halen Earle[1], Jonathan Kim[2], and Keith Klepeis[1], (1) Department of Geology, University of Vermont, Burlington, VT 05405; (2) Vermont Geological Survey, 103 South Main Street, Logue Cottage, Waterbury, VT 05671-2420

Our field area consists of the towns of Williston, Charlotte, and Hinesburg, Vermont, and contains portions of the Champlain and Hinesburg thrusts (CT and HT, respectively). We defined three structural domains within the field area: the lower plate of the CT, the upper plate of the CT (both consisting of Cambrian–Ordovician sedimentary rocks), and the upper plate of the HT, consisting of chlorite-sericite grade metamorphic rocks. These thrust slices were imbricated during the Ordovician Taconian Orogeny.

The oldest structures in the field area are related to thrusting along the HT and CT. Near the HT, these include mylonites and F1 isoclinal folds of bedding that are deformed by F2 folds with asymmetric shear bands. Above the CT, syn-thrusting responses in the Monkton Quartzite include extensive fracturing, open folding, and thrust duplexing. Directly below the CT, within Stony Point Fm. shales, structures include large open-tight reclined folds (F1), intraformational thrusts, and axial planar cleavage. Across the field area, deformation style appears to have been influenced by rock unit rheology.

All syn-thrust structures throughout the field area are deformed by N-S trending asymmetric folds (F3) and E-W trending open folds (F4). These fold sets create a dome and basin pattern across the region, which is visible at outcrop and map scale. Presence of the fold sets was confirmed by field mapping throughout the region. Above the HT domestic well logs and LIDAR slope maps were used as well.

Our analyses suggest that structural variations within each thrust slice are caused by rheological contrasts between rock units during top-to-the-northwest motion. The data also suggest that some structural variability is related to the magnitude of strain, which is controlled by proximity to major thrust faults. The dome-and-basin interference pattern created by Acadian (Devonian) F3 and F4 fold sets is kinematically compatible with either two discrete orthogonal fold sets or simultaneous development of both fold sets during constriction. We favor an interpretation involving constriction strains whereby the interference pattern was created during a reactivation of pre-Taconic E-W trending basement ramps.

ARSENIC IN GROUNDWATER WELLS IN GLACIAL DRIFT, NORTH-CENTRAL VERMONT

Lilly Corenthal, Geology Department, Middlebury College, Middlebury, VT 05753

Groundwater wells in glacial drift in north-central Vermont contain arsenic concentrations above the EPA maximum contaminant level (MCL) of 10 ppb. These wells are situated within or adjacent to the Rowe-Hawley Belt (RHB), a sequence of early Paleozoic metasedimentary and metaigneous rocks in the suture zone of the Ordovician Taconian Orogeny. Whole rock As concentrations of the dominant rock units in the RHB, in order of decreasing as concentration,

include (1) meta-ultramafic (UM) rocks (serpentinites and talc-magnesites) with As values as high as 1104 ppm in talc-magnesite and 449 ppm in serpentinite (mean As = 93 ppm, n = 41), (2) phyllites with a mean As concentration of 22 ppm (n = 34), including two isolated occurrences of 101 and 190 ppm As from below As-rich talc-magnesite, and (3) greenstones (n = 33) with a mean As concentration of 4.1 ppm. Elevated As in wells glacially down-gradient from UM in the RHB raises the possibility that the As is derived from UM components in the till and outwash, a hypothesis that has also been suggested for the original source of As in the Bengal fan (Guillot and Charlet, 2007). Accordingly, this study aims to evaluate the origins of As in glacial drift and groundwater through a combined geochemical, mineralogical and spatial analysis of glacial drift aquifer materials, well water chemistry and historic well records. While surficial wells in New England are generally thought to not be elevated in naturally-derived As, approximately 40% (7 out of 17) of the surficial wells tested in the RHB contain As exceeding 10 ppb. Analyses of drift and groundwater composition reveal possible variation in As sources. XRD and ICP-MS data suggest a partial ultramafic signature to As in down-gradient glacial drift, with phyllite from the Ottaquechee Fm. responsible for additional inputs. Weathering of talc-magnesite concentrates As in iron-hydroxide weathering products, confirming the hypothesis that UMs contribute As to down-gradient surficial deposits. Closer to ultramafics, a higher percentage of residential surficial wells contain elevated As, but the sample set is small and suggests the need for future work. The presence of chlorinated solvents and pesticides in one well permits the hypothesis that the elevated As levels in that well are either anthropogenically-derived or modified.

ANALYSIS OF ARSENIC SPECIATION IN ULTRAMAFIC ROCKS BY SEQUENTIAL CHEMICAL EXTRACTION

Jonathan Moen, Geology Department, Middlebury College, Middlebury, VT 05753

Arsenic-enriched ultramafic rocks from northern Vermont were studied using a sequential extraction process to determine arsenic speciation. Attention was brought to high arsenic levels in these rocks when groundwater with elevated arsenic (above the EPA MCL of 10 ppb) was discovered in bedrock wells in north-central Vermont. Previous work suggests that the arsenic source is metasomatized ultramafic rocks, specifically serpentinites and talc-carbonates found within Rowe-Hawley Belt, a tectonic assemblage of thrust slices in the suture zone of the Taconian Orogeny. Arsenic levels in these rocks are highly elevated, with concentrations up to 450 ppm in serpentinites and up to 1104 ppm in talc-carbonates. Arsenides, sulfides and other minerals frequently associated with arsenic were not detected in these samples, indicating that other minerals host the arsenic. It was predicted that arsenic would instead be hosted in tetrahedral sites of antigorite or talc as As(V) substituted for Si, in magnesite as arsenate anions substituted for carbonate anions, or adsorbed onto mineral surfaces. A 3-step sequential extraction is being applied to determine arsenic speciation, using 1 M ammonium nitrate (pH = 4.7) to extract exchangeable ions, 0.11 M acetic acid (pH = 2.6) to dissolve carbonates, and aqua regia to dissolve antigorite and talc. At each extraction step, ICP-MS, XRD and FTIR were used to determine geochemistry, mineral content, and bond configurations, respectively, in remaining pulps and extracted solutions. Sequential extraction results suggest that arsenic in the Vermont rocks is securely bound within crystal structures of antigorite, talc, and magnesite. Surface sorption was not found to play a significant role in arsenic content, except in one sample. FTIR

and XRD data indicate disorder in antigorite crystallographic structures; this may be the result of arsenic substitution in tetrahedral sites. Electron microprobe data from a collaborating lab (personal correspondence, Keiko Hattori, March 2010) indicate the presence of highly arsenic-enriched magnetite in one antigorite sample; this suggests that substitution of As(III) for Fe(III) in minute grains of magnetite may be another major As host site. Future work is needed to disambiguate the As contributions of magnetite and other stable mineral sites.

MINERALOGY OF VERMONT ASBESTOS GROUP MINE WASTE, EDEN, VERMONT

Alyssa Findlay and Greg Druschel, Department of Geology, University of Vermont, Burlington, VT 05405

The Vermont Asbestos Group (VAG) mine in Eden, Vermont was one of the largest national producers of chrysotile asbestos and was active from 1900 until 1993. As a result of the extent of the operation, there exist large piles of waste rock containing remnant asbestos fibers. The serpentinized ultramafic rock deposit from which the asbestos was mined also contains high concentrations of nickel and chromium. Elevated concentrations of these elements and the presence of asbestiform mineral fibers have been observed in sediments from rivers surrounding the area (ANR, 2008), suggesting contamination by the erosion of the mine waste pile. Metal concentrations are not reflected in the water column (Piatek, 2009). Chrysotile is often enriched in metals compared to the surrounding rock (Barbeau and Dupuis, 1985), however small quantities of heazelwoodite (Ni_3S_2), and chromite ($FeCr_2O_4$) are present within the waste piles (ANR, 2008).

Samples were collected by John Schmeltzer (VT Agency of Natural Resources) from the VAG site. Samples were obtained from the mine waste pile and from a settling pond within Hutchins Brook, downstream of the tailings pile. Additional samples include a piece of magnetite from within the mine, and examples of chrysotile fibers produced by the mine.

Preliminary analysis of samples by X-ray diffraction shows the dominant mineral species to be serpentine and spinel. Further XRD work is in progress in order to determine mineralogy more specifically. Bulk chemical composition obtained by X-ray fluorescence spectroscopy shows high concentrations of iron, nickel, and chromium within samples. SEM-EDS X-ray element mapping suggests that significant quantities of these metals may be present in concentrated amounts within specific mineral grains. Metal sulfide species appear to be the primary phase containing nickel, while chromium appears to be incorporated with iron into oxides. Work is in progress to further determine the extent to which nickel and chromium are present in the chrysotile fibers; however the data collected thus far suggest the presence of primary nickel and chromium mineral phases is a significant source of nickel and chromium in sediments working their way offsite. Metals contained in these phases will be transported and solubilized via very different paths than chrysotile asbestos fibers.

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Barbeau, C., Dupuis, M., et al. (1985). Metallic elements in crude and milled chrysotile asbestos from Quebec. Environmental Research 38(2): 275-282.
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Levitan, D. M., Hammarstrom, J. M., Gunter, M. E., Seal, R. R., II, Chou, I.-M., and Piatak, N. M. (2009). Mineralogy of mine waste at the Vermont Asbestos Group mine, Belvidere Mountain, Vermont: American Mineralogist, 94(7), 1063-1066.

FOSSIL EARTHQUAKES IN SOUTH-CENTRAL MAINE: PSEUDOTACHYLITES IN THE JONES CORNER FAULT ZONE

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Pseudotachylites are rare fault rocks formed only through extraterrestrial impacts (i.e., meteorites) or extremely high-velocity seismic events. They are typically dark, microcrystalline to glassy veins, of varying width, interpreted to have formed via frictional melt. While the processes of pseudotachylite generation are frequently disputed, it is agreed upon that seismogenic pseudotachylite is unique in being the only known rock that forms exclusively at seismic slip rates. As such, seismogenic pseudotachylite is able to preserve the many dynamic processes of paleoearthquakes and can itself be considered a fossil earthquake.

The Jones Corner fault zone is a previously unrecognized and unmapped zone of brittle and ductile deformation in south-central Maine containing a variety of fault-generated rocks, including mylonite, cataclasite, and multiple generations of seismogenic pseudotachylite. The zone is located roughly 3.5 kilometers southeast of the Sandhill Corner mylonite belt, a zone associated with the regional Norumbega fault system. The Jones Corner zone, as currently mapped, trends approximately N55ºE and is at least 3 kilometers long and up to 250 meters wide. Pseudotachylite in the zone occurs as fault and injection veins with thicknesses of up to 5 centimeters. These rocks exhibit a variety of structures, including flow banding and folding, microlitic textures, and cross-cutting veins. Bulk geochemistry of pseudotachylite suggests that they originated locally within the amphibolite facies quartzofeldspathic gneiss and biotite schist of the Ordovician Cape Elizabeth Formation.

Using field observations, thin section petrography, and whole-rock geochemical analysis, the Jones Corner pseudotachylite has been comprehensively characterized, and interpretations have been made concerning the conditions of faulting and seismicity responsible for the generation of the Jones Corner pseudotachylite.

A MULTI-PROXY STUDY OF A POST-GLACIAL SEDIMENTARY RECORD FROM OVERLAND LAKE, NEVADA

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Overland Lake is a tarn at 2880 m asl in the Ruby Mountains of northeastern Nevada. A core was retrieved from the lake in July, 2009 in order to develop a record of post-glacial environmental change. The core extended from the sediment-water interface to a depth of 4.7 m. A layer of tephra encountered at a depth of 328 cm is believed to be Mazama based on the presence of similar ash in nearby Angel Lake for which radiocarbon age control is available. Several proxies were considered including: water content, loss on ignition (LOI), magnetic susceptibility (MS), reflected light color spectrophotometry (CSP), grain size distribution (GS), dry bulk density (BD), biogenic silica content (bSi), and carbon to nitrogen ratios (C/N). LOI and water content both rise rapidly in the basal sediment, but then fall and rise again through a long oscillation that spans ~1.5 m. The ash is located at the low-point of this interval, but the falling LOI values begin ~50 cm deeper, indicating that the ash alone is not responsible for the LOI decrease. Analysis of bSi and C/N will shed light on whether this oscillation represents a

change in aquatic or productivity or in the inwashing of terrestrial organic matter. The luminosity component of the CSP (L*) is strongly correlated with LOI, indicating that organic matter is primarily responsible for the darkness of the sediment. Mean clastic grain size exhibits notable cyclic variability throughout the record, with values oscillating between 10 and 40 μm. Given the setting of the lake in a cirque surrounded by steep slopes with two major fluvial inputs, these variations likely indicate changes in the amount of precipitation resulting in fluctuations in clastic input. Values of MS are greatest in the tephra layer, but lower-amplitude variability exhibits a pattern similar to the trends in mean grain size, which is consistent with inwashing of iron-bearing minerals. Radiocarbon dating and geochemical fingerprinting of the tephra supported construction of a depth-age model allowing comparison of these time series with other dated paleoenvironmental records from the region.

NEOGLACIAL EPISODES RECORDED IN A LAKE SEDIMENT CORE FROM THE UINTA MOUNTAINS, UTAH

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Considerable paleoclimate research is focused on climatic variability during the Holocene, including the enigmatic period of renewed glaciations known as the Neoglaciation. Alpine lake sedimentary records are particularly useful in Neoglacial studies because they can provide uninterrupted, high-resolution records of environmental changes. This study focused on analysis of biogenic silica, phosphorus, and carbon/nitrogen from an alpine lake sediment record collected in northeastern Utah, adding to an extensive dataset that suggests several periods of Neoglacial activity in the Uinta Mountains. The sediment core, which spans the past 5300 years, was taken from EJOD Lake, a small lake with a maximum depth of 4.3 m, and a surface area of 2.7 ha, located above modern treeline at 3323m. The lake is situated in a large glacial cirque ~500 m downslope from a complex of Neoglacial end moraines. Dry meltwater channels run from these moraines directly into EJOD Lake establishing a clear connection between glacial activity and the lake sediment record. The biogenic silica, LOI, and clastic flux time series all exhibit an overall decreasing trend over the past 5000 years suggesting a gradual shift of the lake environment towards a colder, harsher climate. Superimposed on this downward trend are smaller-scale fluctuations characterized by intervals of notably low values in biogenic silica and LOI, and high values in C:N. These intervals suggest episodes of Neoglacial advance at 3600-3400, 2500-2300, and 2000-1600 BP. Subsequent increases in mineral P and clastic flux and decreases in median grain size at 3000-2900, 2300-2000, and 1400-1200 BP mark times when glacial retreat washed fine-grained rock flour stored in the moraines into the lake. Less pronounced variability at 809-560 and 395-182 BP show similar trends which may indicate two episodes of Neoglacial advance associated with the Little Ice Age. The dating of these episodes shows some synchronicity with periods of Neoglacial advance in western North America, but also indicates that such advances were extremely regionally variable. A dramatic shift in proxies indicates a change towards warmer climates and less soil development between 182 BP and AD 2005.

TIMING AND SIGNIFICANCE OF LARGE-SCALE FOLDING IN THE TAVAN HAR BASEMENT BLOCK IN SOUTHEASTERN MONGOLIA RELATIVE TO LATE TRIASSIC SINISTRAL SHEAR

Graham Hagen-Peter, Laura E. Webb, and Merril Stypula, Department of Geology, University of Vermont, Burlington, VT 05405

The East Gobi Fault Zone (EGFZ) in southeastern Mongolia is part of the Central Asian Orogenic Belt and has experienced a complex history of deformation subsequent to continental accretion during the Paleozoic. Several phases of deformation have been identified in the Tavan Har region including Late Triassic sinistral shear, Late Jurassic–Early Cretaceous rift basin development, mid Cretaceous basin inversion, and early Cenozoic sinistral strike-slip faulting. The lithologic units of northern Tavan Har consist of amphibolite–upper greenschist-facies metamorphic rocks with variable lower greenschist-facies overprints, a granitic gneiss body, and higher-grade migmatites. An ENE-striking, near-vertical S1 foliation, associated with the Triassic shear zone, is well developed across the region, with some outcrops displaying a strong mylonitic fabric. In northern Tavan Har the S1 foliations define large scale (~200 m wavelength), shallow-plunging, isoclinal folds that are observable in satellite imagery. Axial planar S2 is not seen at outcrop scale within the folded unit observable in satellite imagery, but is observed in nearby outcrops in Tavan Har. Smaller-scale folding was also observed in southern Tavan Har with an axial planar S2 cleavage. Measured parasitic fold axes, as well as π-axes calculated for the large-scale folds, are near parallel to mineral lineations associated with the Late Triassic shear zone fabric. Preliminary interpretations of the available data suggest that the large-scale folding is kinematically related to shear zone development. This presentation will integrate the results of microstructural analyses with field and petrological observations to test this hypothesis. The results of this project have implications for unraveling the history of polyphase deformation in the EGFZ and for the dynamics of large-scale intracontinental deformation.

PETROGRAPHIC AND GEOCHEMICAL ANALYSIS OF BASEMENT ROCKS IN THE EAST GOBI FAULT ZONE, MONGOLIA

Donald Hefferon, Department of Geology, University of Vermont, Burlington, VT 05405

The East Gobi Fault Zone (EGFZ) is NE-striking structural corridor in southeastern Mongolia. Rocks in region record the history of the amalgamation of Asia via collision and accretion in which microcontinental blocks are proposed to have played a significant role as a site of nucleation. Metamorphic tectonites of basement blocks in the EGFZ have been traditionally mapped as Precambrian based on their relatively high metamorphic grade and high strain, however, these associations are largely speculative with few isotopic age constraints from the region. Field, petrographic, and new geochronological data support the interpretation that the high strain/high grade rocks have Paleozoic protoliths rather than Precambrian. This study will test this hypothesis through geochemical correlations of the metamorphic tectonites and rocks of known Paleozoic or Mesozoic age.

Correlations investigated as part of this study include: 1) a sill within an Upper Permian–Lower Triassic clastic sedimentary sequence and a boudinaged dike/sill in paragneiss. Both samples are

mafic intrusions in (meta)sedimentary rocks and, based on field and geochronological constraints, possibly represent different structural levels in the lower plate beneath a carbonate nappe in the Bulgan Uul region. 2) an Early Permian volcanic unit and mylonitized metavolcanic rocks from different structural levels of a Late Triassic ductile shear zone in the Tavan Har region. Data presented from geochemical analyses will include trace and REE analyses conducted via ICP-OES. In addition to petrographic analyses, spider diagrams and discrimination diagrams will be compared with each other, published data from the region, and standard values for igneous rocks of various tectonic settings to assess correlations between the metamorphic tectonites and rocks of known Paleozoic age. Geochemical and petrographic assessments will be linked to sample position within the structural corridor to compare sample deformation histories on a larger scale. The results of this study bear on the role that Precambrian crust plays in continental growth and the tectonic evolution of the region.

SYNTHESIZING SOUTHERN ANDEAN OROGENESIS FROM THE EVOLUTION OF THE MAGALLANES FORELAND BASIN, SOUTHERN PATAGONIA, CHILE

Janelle McAtamney, Keith Klepeis, and Charlotte Mehrtens, Department of Geology, University of Vermont, Burlington, VT 05405

South of 51ºS latitude, in the southernmost Andes, the Cretaceous inversion of the Late Jurassic Rocas Verdes rift basin created the Cretaceous-Neogene Magallanes foreland basin between an active volcanic arc and the South American craton. I studied the Lower and Upper Cretaceous sedimentary units, known as the Zapata Formation and Punta Barrosa Formation, that record this tectonic transition to test previous models of rift basin inversion and foreland sedimentation patterns. I describe sandstone petrography, detrital modes, and detrital zircon ages from pre- and post-inversion sediments within both units in two previously unstudied parts of the foreland basin. My results constrain the timing of uplift and denudation of source terrane in the internal part of the orogen and characterize the depositional setting and provenance during the transition from back-arc to foreland basin sedimentation in the southernmost Andes.

Three kilometers of measured section record the stratigraphic transition from the Zapata Formation to the Punta Barrosa Formation. Thinly bedded shallow marine mud and incomplete Bouma sequences characterize the Zapata Formation. Fining-upward packages of thickly bedded coarse-grained sand mark the onset of deposition of the Punta Barrosa Formation. Complex paleocurrent patterns from both units support a sedimentation model of multiple back-arc submarine fans during the initiation of the foreland basin. Modal analysis and petrography of sandstone from both units shows sediments are compositionally immature, highly feldspathic, and derived from a volcanic arc. Detrital modes record the transition from dominantly volcanic lithic fragments in the Zapata Formation to dominantly metamorphic lithic fragments in the Punta Barrosa Formation. Detrital zircon age spectra yielded maximum depositional ages between ~88 Ma and ~82 Ma through the stratigraphic transition interval which is younger than previously interpreted depositional ages for these units.

Andean orogenesis began as a submarine thrust wedge behind an active Late Cretaceous volcanic arc. Foreland basin infill was sourced from uplifted horst-and-graben style blocks

proximal to an active volcanic arc. Uplift and erosion of pre-rift basement schists and Upper Jurassic volcanic rocks occurred after about ~82 Ma.

TECTONIC TRANSITION FROM BACKARC RIFT BASIN TO COMPRESSIONAL FORELAND BASIN IN THE SOUTHERNMOST ANDES: ITS GEOCHEMICAL EXPRESSION

Shane Snyder, Janelle McAtamney, Charlotte Mehrtens, and Keith Klepeis, Department of Geology, University of Vermont, Burlington, VT 05405

The southernmost Andes record the formation of a Jurassic oceanic rift called the Rocas Verdes basin. By the late Cretaceous this rift inverted under compression, forming the Magallanes foreland basin. In this study I examined the REE characteristics of mudstones from stratigraphic sections exposed in two localities to determine temporal changes in sediment composition during this tectonic transition and to evaluate possible differences in sediment provenance along the strike of the belt. Rocks of the Lower Cretaceous Zapata Formation fill the Rocas Verdes basin; rocks of the Upper Cretaceous Punta Barrosa Formation mark the initiation of the Magallanes foreland basin. Distinguishing between these two units has been difficult to interpret in most localities. To solve this problem, we investigated REE data from a sequence of 12 mudstones from the central part of the Rocas Verdes and Magallanes basins and compared them to two other sequences located 300 km along the strike of the orogen to the southeast and the northwest, respectively. Our results indicate that rocks of the Punta Barrosa Formation are more enriched in the light REE and more fractionated than rocks of the Zapata Formation. The latter are more enriched in the heavy REE, most likely reflecting a mafic source. In addition, the base of the Zapata Formation is characterized by a strong negative Eu anomaly that gradually becomes less pronounced at the top of this unit and into the Punta Barrosa sequences. We interpret these patterns to reflect an increase in the contribution of eroded upper crustal continental arc material during the compressional inversion of the Rocas Verdes basin. In addition, a comparison between the geochemical signature of these two units along the strike of the basin suggest that, in the south, basaltic crust and rift mudstones preferentially were recycled into the first foreland basin sediments whereas in the north they were not. This heterogeneous pattern can be explained if the southern part of the Rocas Verdes basin was wider than that in the north and accumulated a much thicker mudstone section prior to inversion. The patterns suggest that the REE composition of Magallanes foreland basin sediments that mark the initiation of Andean orogenesis was strongly influenced by the preexisting architecture of the Rocas Verdes rift basin.

PRESIDENT'S LETTER

The Big Picture

Most geologists spend their working days immersed in the details of their specialty. Although this is necessary in order to advance our knowledge, this focus on the details makes it easy to lose track of the broader context that our specialties are part of. It seems to take a rare sort of author to combine a knowledge of earth science with a knowledge of how to tell a story. Many of us are familiar with the writings of Stephen Jay Gould and John McPhee. After reading

Earth: An Intimate History, by Richard Fortey (Alfred A. Knopf, New York, 429 p., 2005), I would argue that Fortey should be added to this select few.

Earth is a travelogue to some of the geologic high-points of the planet, a history of the development of geological thought, and an exploration of how science gets accomplished in the real world. It is a story of visionary thinkers, plodding realists, grand ideas, and the testing of those ideas in the harsh light of accumulating facts.

Besides helping us to understand the contributions of Hutton, Lyell, Harry Hess, and J. Tuzo Wilson (a story that many of us know tolerably well already), he introduces us to some of the now lesser-known names, such as Léonce Elie de Beaumont, Eduard Suess, and G. Steinman.

Plate tectonics is the glue that holds his story together. I think what is particularly fine about the book is that he doesn't just tell us the current plate-tectonic explanation for the features of the Earth, he describes quite a bit of the story of how, over the last century, geologists and geophysicists figured it out. In the last chapters of the book he tries to make the case that just about everything about the world around us can, in some more or less fundamental way, be related to plate tectonics. On first encountering some of these statements, I wanted to find fault with them, but then, as I thought about them, I had to largely give in to his argument; it really is all about the plates!

Although plate tectonics is used as an organizing principle in the book, Fortey does a particularly fine job of reminding us that the great geologic theories of today may sound extremely dated and quaint in only 25 or 50 or 100 years. We need to remember that the geologist of a couple generations back were at least as good at observing as we are today—they were just working from different paradigms.

Fortey is not quite as skilled a writer as Gould or McPhee. Indeed, in the early chapters I found several spots where I thought he lacked the perfect phrase. However, as I read deeper into the book, I was caught up in the story he was telling and no longer noticed the occasional clumsy sentence (if they were even there). I highly recommend this book to any amateurs or professionals who are interested in how the planet works.

Sincerely,
George Springston, President

WINTER MEETING MINUTES

The meeting of the Executive Committee followed the Society's Winter Meeting held on February 6, 2010 at Norwich University. Present at the meeting were George Springston, John Van Hoesen, Rick Dunn, Les Kanat, Jon Kim, Larry Becker, and Kristen Underwood. Steve Howe and Dave West were unable to attend the meeting. Steve sent a report by e-mail to the members of the Executive Committee prior to the meeting detailing the financial condition of the Society and the status of membership renewals and the Spring Meeting. He also introduced three

proposals concerning research grant funding levels, electronic balloting, and the establishment of an Election/Nominating Committee. George Springston took the minutes for Dave West.

Research Grant funding: The Executive Committee voted to table a proposal to establish a cap of $1,100.00 on the total amount of funds that can be awarded for research grants during each of the two semiannual rounds, while still maintaining a maximum award per grant of $700.00, for the calendar year 2010. Committee members would like to get more information from the Treasurer regarding the need for this cap. The Committee would like to discuss this issue at the next meeting, with a balance sheet in hand, to help it understand how this impacts the Society's finances.

Electronic balloting: The Executive Committee discussed the idea of electronic balloting as the preferred method of balloting for future elections. John Van Hoesen will research the idea of using SurveyMonkey to accomplish this.

Election/Nominating Committee: The Executive Committee felt that an Election/Nominating Committee might not be needed presently.

VGS Lecturer: Stephen Wright was not present at the meeting, so Committee members did not discuss with him the idea of continuing as Lecturer for 2010. George Springston will contact Stephen to discuss this with him.

Vermont Geological Survey: The Executive Committee discussed the proposal in the Governor's budget to shift the Vermont Geological Survey to an educational institution such as the University of Vermont extensively. It was deemed appropriate to prepare a letter of support. The members not directly involved with the Survey will work with John Van Hoesen to draft a letter of support for the work of the Vermont Geological Survey. This will be sent to members of the Administration and the Legislature.

Outreach to other geological societies: In order to promote wider participation in Society activities, Committee members voted to have the *Green Mountain Geologist* sent electronically to the secretaries of other geological societies in the region, including New Hampshire, Maine, and New York.

Analysis of the Winter Meeting: The Executive Committee expressed satisfaction at the attendance and the range of discussions that resulted from this very successful Winter Meeting. It extended its appreciation to John Field for his excellent keynote presentation, to Kristen Underwood for her help organizing the meeting, and to John Van Hoesen for his help publicizing the event. A tentative topic for the Winter 2011 Meeting, "Geology and Public Health," was proposed.

Summer Field Trip: Jon Kim and George Springston will lead a field trip to the Knox Mountains area of Marshfield and Groton. Date still to be decided.

Respectfully submitted,
George Springston, President

TREASURER'S REPORT

The financial condition of the Society continues to be very strong. As of April 3, 2010, the Society's checking account balance was $6,767.41. One Research Grant proposal was submitted by the April 1, 2010 deadline and is currently under review by the Advancement of Science Committee. The amount of the funding awarded during this round will be reported in the Treasurer's Report in the Summer 2010 *Green Mountain Geologist*. To my knowledge, there are no outstanding bills.

The following members have joined the Society since the last report: Don Hill, Swanton, Vermont, and Daniel Ruddell, Tunbridge, Vermont.

The Treasurer gratefully acknowledges the contributions to the Society's Research Grant Program by the following members:

Laurence R. Becker
Ray Coish
Jeanne C. Detenbeck
Barry Doolan
Albert W. Gilbert, Jr.
Timothy W. Grover
Craig Heindel
Barbara L. Hennig
Jefferson P. Hoffer
Stephen S. Howe
Jon Kim
Ronald B. and Anita H. Krauth
Frederick D. Larsen
J. Gregory and Nancy W. McHone
Alexis P. Nason
George Springston
Sharon Strassner
Peter J. and Thelma B. Thompson
Roger and Terry Thompson
David West
Stephen F. Wright

Respectfully submitted,
Stephen S. Howe, Treasurer

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The Advancement of Science Committee received one application for research grant support prior to the April 1, 2010 deadline and will evaluate this proposal in the near future. We are hoping to hear talks by recent VGS Research Grant awardees at the student meeting on Saturday, April 24th, at Middlebury College: Lauren Chrapowitzky (UVM), Hal Earle (UVM), Lilly Corenthal (Middlebury College), Victor Guevara (Middlebury College), and Kyle Ashley (UVM).

Respectfully submitted,
Jon Kim, Chair

VERMONT STATE GEOLOGIST'S REPORT

Governor Proposes Moving the Vermont Geological Survey to the University of Vermont

On January 19, 2010, Governor Douglas released his fiscal year '11 budget that will begin on July 1, 2010. Under key Department of Environmental Conservation (DEC) budget issues the narrative states:

"In FY'11 the Division of Geology (Vermont Geological Survey) is proposed to be transferred to the University of Vermont along with its three positions. This will allow the Program to better leverage research funds while continuing to provide geological mapping services to Vermonters."

The Commissioner of DEC and the State Geologist have met with the UVM Vice President for State and Federal Relations, the UVM Chief Financial Officer, both the Deans of Arts and Sciences and Extension, and the Chair of the Geology Department. Chair [Char] Mehrtens has been most helpful in moving this issue forward to the UVM administration.

These discussions are on-going. As members of the geological community in Vermont, if you would like to learn more about this issue, please contact me at (802) 241-3496 in my role as the Chair of the Society's Public Issues Committee.

Respectfully submitted,
Laurence R. Becker, State Geologist
Chair, Public Issues Committee

ANNOUNCEMENTS

FRIENDS OF THE PLEISTOCENE MEETING

The Northeastern Friends of the Pleistocene will hold its 2010 meeting, entitled "Deglaciation of the Connecticut River Valley—Hanover, Lyme, Lebanon, and Claremont, New Hampshire," on June 4-6, 2010 in Hanover, New Hampshire.

Field trip leaders include Carol Hildreth, CTH Enterprizes; Meredith Kelley, Dartmouth College; Jack Ridge, Tufts University; and Erich Osterberg, Dartmouth College.

Some of the sites we will visit include:

A sub-till varve site in the Sugar River valley just east of Claremont, with paleomag results
Landslide scars along the Mascoma River Gorge
A long (10-m) core from Occum Pond on the Dartmouth College campus [the lowest radiocarbon age is ~13.1 14C ka, from within varved sediment, and the core apparently has a continuous record since then]
Exposures in the large esker in the Hanover area
Varve deposits of glacial Lake Hitchcock in West Lebanon
Stream-terrace levels and associated deposits in Connecticut River tributary valleys

For further information, contact: Carol Hildreth at hildrethcr@comcast.net

Registration information, the trip schedule, and other details will be posted on the Friends of the Pleistocene website at http://www.geology.um.maine.edu/friends/

STUDENT RESEARCH GRANT APPLICATIONS

Students and secondary school teachers are encouraged to apply to the VGS Research Grant Program by **October 1, 2010**. Downloadable Research Grant Program applications are available from the Society's website at http://www.uvm.org/vtgeologicalsociety/. For those without Internet access, forms may be obtained by writing to Jon Kim at the Vermont Geological Survey, 103 South Main Street, Logue Cottage, Waterbury, VT 05671, e-mail: jon.kim@state.vt.us, or by calling (802) 241-3469.

VERMONT GEOLOGICAL SOCIETY CALENDAR

April 24:	VGS Spring Meeting, Bicentennial Hall, Middlebury College
June 4-6:	Friends of the Pleistocene Meeting, Hanover, New Hampshire
June 7-8:	Lake Champlain 2010 Conference, Burlington, Vermont
Sept. 24-26:	NYSGA Meeting, Staten Island, New York
Oct. 1:	VGS Research Grant Program applications due
Oct. 1-3:	NEIGC Conference, Orono, Maine
Oct. 31-Nov. 3:	Geological Society of America Annual Meeting, Portland, Oregon

The **Vermont Geological Society** is a non-profit educational corporation.
The **Executive Committee** of the Society is comprised of the Officers, the Board of Directors, and the Chairs of the Permanent Committees.

Officers

President	George Springston	(802) 485-2734	gsprings@norwich.edu
Vice President	John Van Hoesen	(802) 287-8387	vanhoesenj@greenmtn.edu
Secretary	David West	(802) 443-3476	dwest@middlebury.edu
Treasurer	Stephen Howe	(518) 442-5053	showe@albany.edu

Board of Directors

Richard Dunn	(802) 485-2304	rdunn@norwich.edu
Les Kanat	(802) 635-1327	les.kanat@jsc.edu
Jon Kim	(802) 241-3469	jon.kim@state.vt.us

Chairs of the Permanent Committees

Advancement of Science	Jon Kim
Geological Education	Christine Massey
Membership	Stephen Howe
Public Issues	Laurence Becker
Publishing	Stephen Howe

Vermont Geological Society
P.O. Box 1224
Saint Albans, VT 05478-1224

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

Vermont Geological Society
Spring Meeting
April 24, 2010, 8:30 AM
McCardell Bicentennial Hall, Room 417
Middlebury College, Middlebury, Vermont

Directions to Middlebury College:

From the town green in Middlebury, take Route 125 west, past the Catholic Church, and up the hill through the College. Go over the crest to the bottom of the hill as it flattens to a valley. Turn right onto Bicentennial Drive and follow the winding driveway to the large parking lot on the west side of McCardell Bicentennial Hall. The meeting will be held in Room 417.

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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

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The Vermont Geological Society's
Summer Field Trip

Bedrock Control of Surficial Deposits and Groundwater Issues in Part of the Knox Mountain Granite Pluton, Northeastern Vermont

July 31, 2010

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SUMMER FIELD TRIP DESCRIPTION

Saturday, July 31, 2010

TITLE: Bedrock Control of Surficial Deposits and Groundwater Issues in Part of the Knox Mountain Granite Pluton, Northeastern Vermont

LEADERS: Jon Kim and George Springston

TIME AND MEETING PLACE: 9:30 AM, Marshfield Public Offices, 122 School Street, Marshfield, Vermont

DIRECTIONS: From US Route 2 East, make a right onto School Street before Rainbow Sweets bakery, cross over the Winooski River on a small bridge, and make a right into the Marshfield Town Offices parking lot (AKA the Old Schoolhouse Commons). Lunch supplies can be obtained prior to the start of the trip in Plainfield village or here in Marshfield village. We will not be near any stores at noon.

NOTE ABOUT CARS: Please make every effort to carpool once you reach the assembly point as parking is tight at a couple of the sites. If you're driving, be aware that we'll be travelling for several miles on an old rail bed that has some ruts and jutting rocks. Although you do not need a big truck to get through, do not try to drive a really low-clearance car on this route.

ITINERARY: See the 2009 NEGSA abstract that follows this itinerary for an overview of this trip.

Stop 1. Marshfield public water supply well at southeast end of Folsom Road. Discussion of uranium in groundwater issue.

Stop 2. Marshfield Inn & Motel, Route 2.

> *Part A*. Surficial geology overview. From the parking lot we can overlook the Upper Winooski River valley. We'll point out the shoreline elevation of glacial Lake Winooski, fan-terrace deposits marking the former lake bottom elevation, and the meandering course of the parking lot.
>
> *Part B*. Bedrock geology overview and outcrops of biotite–garnet–staurolite phyllites and quartzites of the Gile Mountain Formation. At outcrops in the fields above the Inn.

Stop 3. View of Marshfield Mountain from Bailey Pond Road. Discussion of bedrock structures and their effect on the geometry of surficial deposits. The topography of the Marshfield Pond basin is the result of extensive glacial scour, followed by the deposition of a complex of ribbed moraines composed of sandy till.

Stop 4. Owl's Head Overlook (lunch stop). Discussion of orientations and cross-cutting relationships of aplites and pegmatites, relationship of NW-trending pegmatites to trend of Lake Groton basin. We'll hike about 0.2 miles to the top of the mountain (bring your lunch).

Stop 5. Kettle Pond parking area on west side of Vermont Route 232. This will be a somewhat rugged 0.5-mile hike over rough terrain.

Part A. Ribbed moraine near parking area, on west and east sides of Route 232. This is the most accessible of the complex of moraines in the Stillwater Brook valley. The boulder-studded moraine is composed of sandy till (exposed in an overgrown sand pit on the east side). The overall pattern of moraines and outwash channels in the vicinity suggests that active glacial ice occupied the Kettle Pond basin and the Marshfield Pond basin to the north and that meltwater flowed southeastward down the Stillwater Brook valley toward the Lake Groton basin.

Part B. Lag deposit of granite boulders in a meltwater channel in the bottom of the Stillwater Brook valley. The modern Stillwater Brook flows among moss-covered boulders spread out on a broad, flat-bottomed valley floor. The boulders are interpreted to be a lag deposit left behind after glacial meltwaters winnowed away finer material. The present-day brook is incapable of shaping the terrain it flows through, and thus is left to pick its way around and under the boulders.

Part C. "Leggo" blocks of granite bedrock along Stillwater Brook. The pattern is formed by the intersection of shallowly dipping exfoliation fractures with two vertical fracture sets (commonly NW- and NE-trending). We'll discuss the implications of these outcrop-scale "Leggo" blocks for the origin of map-scale topographic patterns.

Stop 6. Naismith Brook swimming hole along Naismith Brook Road.

Part A. Beginning of contact zone for Knox Mountain granite pluton. Granite dikes that intruded phyllites and quartzites of the Gile Mountain Formation.

Part B. Thick surficial deposits along the granite contact zone. Water well records indicate thick surficial deposits in the Naismith Brook valley, with several exceeding 80 meters. Some of the well records report stratified sand and gravel deposits under thick, sandy till. We may be able to take a look at the till at a stream bank that is a couple hundred feet downstream from Part A.

2009 NEGSA Abstract, Portland, Maine

Kim, J., Springston, G., and Charnock, R., 2009, Bedrock control on surficial deposits and groundwater issues in part of the Knox Mountain Granite Pluton: NE Vermont: Geological Society of America Abstracts with Programs, vol. 41, no. 3.

During the 2008 field season, bedrock and surficial geologic maps were constructed of parts of the towns of Marshfield and Peacham to serve as a basic framework for understanding elevated U levels in groundwater from bedrock wells in this area. The SE 75% of this region is underlain by the M. Devonian Knox Mt. granite pluton that intruded the Late Silurian-Early Devonian metasedimentary rocks of the Gile Mt and Waits River fms. in the NW 25%. The dominant surficial deposits are tills, ranging from dense, fine-sandy silt matrix till in the NW to a variety of looser, sand-matrix tills in the granite portions. During the course of this project, it was apparent

that bedrock structures exerted strong control on the thickness and distribution of surficial deposits. These thick surficial deposits may form localized areas of higher well yields.

We focused on the following associations between bedrock structure and surficial deposit distribution and/or thickness: 1) The paleochannel of Naismith Brook, currently buried by >80 meters of sediments (sandy till at surface with stratified sand and gravel at depth), follows the western intrusive contact of the Knox Mt. granite. 2) Thick (>30m) surficial deposits in the Winooski River valley bottom from Plainfield to Marshfield villages roughly follow the granite contact. 3) Complexes of moraine ridges are found in glacially scoured rock basins down ice (south of) granite hills whose shapes are controlled by major fracture sets. 4) Major E-W trending valleys in the granite parallel to an E-W fracture set. 5) The granite hills deflected ice-flow from about 165° in the metasediments in the NW of the field area to 170-200° in the bottom of the Winooski valley and in the granite.

The bedrock-surficial associations have implications for groundwater quantity and quality issues. The thick surficial deposits in the granite contact zone near Naismith Brook are potential zones of higher well yields due to buried stratified sand and gravel aquifers. With respect to groundwater quality, there are numerous public and domestic bedrock wells with elevated abundances of U in the Knox Mt granite. A collaborative study by Gleason (2007) with the Vt Geological Survey tested 19 additional bedrock wells in the field area and found that 2 of 19 wells had elevated gross alpha (>15 pci/l) and that 3 of 19 had elevated U (>20 ppb).

PRESIDENT'S LETTER

[Unavailable at publication time]

SPRING MEETING MINUTES

The meeting of the Executive Committee followed fourteen student presentations during the Spring Meeting held in Middlebury, Vermont, on April 24, 2010. President George Springston called the meeting to order and a total of six people were in attendance. Before addressing a number of agenda items, long-time VGS Treasurer and Membership Committee Chair Steve Howe announced that he would be stepping down from these posts at the end of the year. The Executive Committee acknowledged and thanked Steve for his long service to the Society (12 years on the Executive Committee). The Committee also discussed the significant workload Steve has assumed for the VGS over the years and the importance of finding a committed person(s) to fill the roles of Treasurer and Membership Committee Chair. The identification of suitable candidates for these positions before the Fall Meeting was agreed to be a top priority.

Treasurer Steve Howe indicated that the financial condition of the Society is sound (see the Treasurer's Report below for details). In his capacity as Membership Committee Chair, Steve indicated we currently have 104 members in the Society (98 individuals and 6 institutions). Steve also indicated that publishing the *Green Mountain Geologist* continues to go well and that printing and postage costs have been greatly reduced by the electronic delivery option adopted by most members.

The major topic of discussion at the meeting centered on whether to impose an annual maximum limit on the amount of funds that are allocated to Student Research Grants. It was emphasized that while the financial condition of the Society is sound, it is not sustainable to allocate more money to Student Research Grants than is taken in through dues and contributions – the Society's primary income sources. The importance of allocating as much money as possible to student research was emphasized and discussions shifted to ways to increase revenue. The Committee discussed and eventually approved an increase in the annual dues to $20/year for individuals and institutions (up from $15), and $25/year for families (up from $20). It was agreed that dues for students would remain the same ($8/year). Additional ideas aimed at increasing revenue (e.g., soliciting corporate/industry donations, producing and selling calendars, etc.) were discussed and several Committee members agreed to explore these various options before the Summer Meeting.

It was noted that the electronic balloting option employed during last year's election was highly successful (over 30 votes were cast, as opposed to the typical fewer than five votes cast in previous "all paper elections"). The Committee agreed to continue with this form of balloting. It was announced that Stephen Wright agreed to continue is his role as the VGS Lecturer for 2010. It was confirmed that Jon Kim and George Springston will be leading this year's Summer Field Trip to the Knox Mountain pluton on one of the last two weekends in July (see the details of this field trip elsewhere in this issue). There was a brief discussion of running a combined Fall Field Trip with the New Hampshire Geological Society and this is currently being explored. Finally, the Committee briefly discussed the possibility of establishing an award for "Outstanding Lifetime Contributions to Vermont Geology." It was agreed that if such an award were established, the award would come in the form of a plaque produced from some prominent "Vermont stone" (e.g., Barre Granite). The meeting was adjourned.

Respectfully submitted,
Dave West, Secretary

TREASURER'S REPORT

The financial condition of the Society continues to be very strong. As of July 11, 2010, the Society's checking account balance was $6,158.60. To my knowledge, there are no outstanding bills, but one student from Middlebury College who received a cash award of $75.00 at the VGS Spring Meeting in April still has not cashed or deposited his check. The Treasurer will continue to attempt to contact this student.

The following members have been approved for membership in the Society since the last report: Kerry Bowen, Brandon, Vermont; Kerrie Garvey, Burlington, Vermont; Leslie Morrissey, Burlington, Vermont; and Chris Stone, Montpelier, Vermont.

The Treasurer gratefully acknowledges the contributions to the Society's Research Grant Program by the following members: Peter Adams, Rick and Gretchen Dunn, David Gross, Peter Ryan, and John Van Hoesen.

Respectfully submitted,
Stephen S. Howe, Treasurer

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The Vermont Geological Society funded one research grant proposal during the spring of 2010.

Rebecca Derr, an M.S. candidate in the Department of Geology at the University of Vermont, received an award of $622.50 for her proposal entitled "Measuring the Isostatically Tilted Surface of Glacial Lake Winooski, North-Central Vermont."

Respectfully submitted,
Stephen S. Howe *for* Jon Kim, Chair

VERMONT STATE GEOLOGIST'S REPORT

National Science Foundation (NSF) supported Vermont cooperative project presented to the AASG

As Chair of the Association of American State Geologists (AASG) education committee, the Vermont State Geologist led a planning session at the annual AASG meeting in New Brunswick, New Jersey, on June 28, 2010. The AASG plans to rekindle a previously supported NSF intern/mentor program. Several new concepts for an intern program were presented to stimulate the discussion. A University of Vermont–Norwich University–Vermont Geological Survey cooperation formed the core of one of the concepts. UVM and Norwich were successful in obtaining a NSF geophysical equipment grant for classroom instruction and senior projects. Helping the success of the application was the involvement of the Vermont Survey. Class and senior projects will focus on applied problems connected to Vermont Survey projects. The intern option was presented as "Geophysics Support for Survey Projects – a Survey/University Collaboration." The focus for students is work on real-world geology and environmental problems that are inquiry-based while including experiment design, deployment, data collection, and software analysis. The metrics to assess success include: field project reports, pre- and post-project knowledge surveys, and presentations before professionals.

Respectfully submitted,
Laurence R. Becker, State Geologist

ANNOUNCEMENTS

VERMONT GEOLOGICAL SOCIETY LECTURER PROGRAM

The goal of the Vermont Geological Society Lecturer Program is to offer local colleges, universities, and high schools the opportunity to invite a member of the VGS to speak at their institution on timely topics within the broad realm of earth and environmental sciences. The program is primarily intended to reach those departments which either do not hold a regularly scheduled seminar series or whose finances do not permit them to invite external speakers to present talks on a regular basis. Any costs associated with the Lecturer's travel, lodging, and meals are borne entirely by the Vermont Geological Society.

Stephen Wright, Ph.D., Department of Geology, University of Vermont, is our 2010 Lecturer. Stephen is offering the following lecture topic: "Glacial Geology of Northern Vermont: Ice Flow, Water Flow, and Glacial Lake History." For scheduling information, see the Society's website at http://www.uvm.org/vtgeologicalsociety/lecturer_program.html

STUDENT RESEARCH GRANT APPLICATIONS

Students and secondary school teachers are encouraged to apply to the VGS Research Grant Program by October 1, 2010. Downloadable Research Grant Program applications are available from the Society's website at http://www.uvm.org/vtgeologicalsociety/. For those without Internet access, forms may be obtained by writing to Jon Kim at the Vermont Geological Survey, 103 South Main Street, Logue Cottage, Waterbury, VT 05671 or by calling (802) 241-3469.

VERMONT GEOLOGICAL SOCIETY CALENDAR

7/31/10	VGS Summer Field Trip, Knox Mountain Pluton area, Vermont
8/1-6/10	National Speleological Society 2010 Annual Convention, Essex Junction, Vermont
9/24-26/10	NYSGA 82nd Annual Meeting, New Paltz, New York
10/1/10	Student Research Grant Program applications due
10/1-3/10	NEIGC 102nd Annual Meeting, Orono, Maine
10/10-16/10	Earth Science Week, various locations in Vermont
10/31-11/3/10	GSA Annual Meeting and Exposition, Denver, Colorado

Vermont Geological Society
P.O. Box 1224
Saint Albans, VT 05478-1224

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

Vermont Geological Society
Summer Field Trip
July 31, 2010, 9:30 AM

Bedrock Control of Surficial Deposits and Groundwater Issues in Part of the Knox Mountain Granite Pluton, Northeastern Vermont

Meet at the Marshfield Public Offices, 122 School Street, Marshfield, Vermont. From US Route 2 East, make a right onto School Street before Rainbow Sweets bakery, cross over the Winooski River on a small bridge, and make a right into the Marshfield Town Offices parking lot (AKA the Old Schoolhouse Commons).

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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

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ANNUAL MEETING AND ELECTION

No Annual Meeting will be held this year. Four Officers, three Directors, and two Chairs of two Permanent Committees will be elected by a combination of electronic and paper ballots. The ballot is included at the end of this issue. Members are encouraged to vote electronically by clicking on the link http://www.surveymonkey.com/s/RH7NGC9. Members without access to e-mail should send their voted paper ballots to David West, Dept. of Geology, Middlebury College, Middlebury, VT 05753. The deadline for the receipt of both electronic and paper ballots is December 4, 2010 at 5:00 PM.

PRESIDENT'S LETTER

[Unavailable at publication time]

SUMMER MEETING MINUTES

No Executive Committee Meeting was held following the Society's Summer Field Trip to the Knox Mountain Granite Pluton, Northeastern Vermont area on July 31, 2010.

TREASURER'S REPORT

The financial condition of the Society continues to be very strong. As of September 30, 2010, the checking account balance was $6,194.80. To my knowledge, there are no outstanding bills. A financial statement for the period 10/1/09-9/30/10 is indicated below.

The Society has seven student members, four of whom received free membership for one year as an additional benefit of having been awarded Research Grants. Expenses exceeded income during this 12-month period, primarily due to significantly increased Research Grant awards that more than offset moderately higher income from membership dues and voluntary Research Grant contributions. The *Green Mountain Geologist* was printed this year at no cost to the Society due to the generosity of the Department of Geology at Middlebury College. In addition, the Society did not incur any VGS Lecturer expenses this fiscal year. Although Winter Meeting expenses increased significantly, the Society incurred no Spring Meeting expenses, again due to the generosity of the Department of Geology at Middlebury College. The Treasurer has previously cautioned the Officers and Board of Directors that the current level of Research Grant awards cannot be sustained unless additional sources of income are developed.

The following members have been approved for membership in the Society since the last report: Dennis S. Albaugh, Meredith, New Hampshire, and Alex G. Czuhanich, Schuylerville, New York.

The 2011 membership renewal and directory information form will be mailed to all members by December 31, 2010. The deadline for renewal will be January 31, 2011.

As noted in the Minutes published in the Summer 2010 *Green Mountain Geologist*, this will be my last report to you as Treasurer of the Vermont Geological Society. I have been Treasurer for the past eight years, after an earlier stint from 1992 to 1995, and although it has been a privilege to have served the Society in this capacity, the time has come for me to turn over the reins to someone else. I do so with the knowledge that the Society is in sound financial shape.

Respectfully submitted,
Stephen S. Howe, Treasurer

Income and Expenses
10/1/09-9/30/10

INCOME		
Total Dues (2010 membership)		$1,584.00
Member	$1,155.00	
Family	$300.00	
Student	$24.00	
Institution	$105.00	
Student Research Grant Contributions		$790.00
TOTAL INCOME		$2,374.00
EXPENSES		
Green Mountain Geologist Printing		$0.00
Postage		$94.67
Office Supplies		$15.88
Post Office Box Rental (to 2/1/11)		$30.00
VGS Lecturer Reimbursement		$0.00
Winter Meeting Speaker Reimbursement		$274.50
Winter Meeting Refreshments		$121.48
Spring Meeting Refreshments		$0.00
Awards		$2,568.50
Research Grants	$2,343.50	
Spring Meeting Student Talks	$225.00	
TOTAL EXPENSES		$3,105.03
TOTAL INCOME – TOTAL EXPENSES		($731.03)

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The Advancement of Science Committee received four Research Grant applications before the Fall 2010 submission deadline. We have not yet begun to review these applications. The grant titles and awards will be listed in the next issue of the *Green Mountain Geologist*. We are currently looking into potential ways to increase the funds available for research grants; one idea is a Vermont geology calendar where part of the proceeds would benefit the Research Grant fund.

Respectfully submitted,
Jon Kim, Chair

STATE GEOLOGIST'S REPORT

Vermont Geological Survey Status
I last reported that the Vermont Geological Survey (VGS) was under consideration for a transfer to the University of Vermont. The University finds that the VGS program is valuable and important, but the transfer will not go forward as budget issues cannot be resolved without general fund (State) dollars to match other sources. The VGS is now funded through June 30, 2011 but faces an uncertain future during the next Vermont fiscal year that starts July 1, 2011. Following this decision, the University has been helpful. We have quantified the time Professors Keith Klepeis and Laura Webb spend as partners on Statemap geologic mapping projects. We have worked with their students and developed cooperation on mapping details and geophysical testing, and the time they spend on these projects can now be used as match. *However, this does not solve the overall general fund shortfall*.

Kristen Underwood, as the new Chair of the Statemap Geologic Map Advisory Committee, plans to be an *outside voice for the VGS* as we go through the transition to a new administration and during budget deliberations in the Legislature from January through May. I encourage you to contact her as a fellow Society member to lend support. State geological surveys are an integral part of the geologic community in any state. Vermont is no exception. Our work serves the citizens of the State, as well as those who know the value of geologic information and use it in support of their professional endeavors. I am excited that Kristen has agreed to chair the Statemap Committee. The Statemap grant program asked us to establish a chair from outside of the State Geological Survey. However, the impetus to make such a change is very welcome. Those using geologic maps can best speak for such maps and for the importance of geoscience research and information to our state. Kristen is keenly aware of the use of geologic maps to set the framework for the applied studies she undertakes. Please see Kristen's bio at the end of this report.

Statemap Projects Delivered – September 30, 2010
See http://www.anr.state.vt.us/dec/geo/mapsonlineinx.htm for more details.

Bedrock Geologic Map of the Town of Craftsbury, Vermont
Authors: Jonathan Kim, Marjorie Gale, Maggie McMillon, Scott Zolkos, and George Springston

Surficial Geologic Map of the Town of Craftsbury
Authors: George Springston and Donald Maynard

In addition, Marjorie Gale pulled together the following groundwater resource map delivered to the Town of Charlotte on May 31, 2010 [also at the website above]:
Hydrogeology of Charlotte, Vermont, VG10-1 by Springston, G., Gale, M., Kim, J., Wright, S., Earle, H., Clark, A., Smith, T., and Petersen, K., 2010, 7 plates, scale 1:24,000.

Groundwater
Professor Peter Ryan of Middlebury College is working with students in his environmental studies class to develop information on Vermont's groundwater quality. A class session was held with the Department of Health, State Senator Virginia Lyons, and the Vermont Geological Survey to present different aspects of groundwater quality issues and data collection. We have worked with Middlebury on radionuclide and arsenic data collection and analysis but a larger

goal of the class effort is to show how a range of groundwater quality data can be integrated through GIS. Rutland County is a test area.

Professor Ryan and the State Geologist appeared on VPR's Vermont Edition on October 20, 2010 to discuss the "Science of Groundwater." See http://www.vpr.net/episode/49708/

Geothermal
The State Geologist has obtained a three-year $160,000 grant to place Vermont geologic and geothermal information into the U.S. Department of Energy's National Geothermal Data System. The grant will begin with document management of archived geologic reports, data, and maps. The State Geologist, with Marjorie Gale, developed preliminary maps to integrate geologic information with "Existing Transmission Line Constraints and Projected Areas of Generation Need" to better understand the geology under such corridors.

Hazards
As the result of the earthquake event of June 23, 2010 [Editor's note: The epicenter of this magnitude 5.0 earthquake was in Val-des-Bois, Quebec, 55 km north of Ottawa. See http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/us2010xwa7.php - summary], Vermont Emergency Management included the State Geologist as a contact in a press release. The State Geologist was interviewed by Vermont Public Radio, WCAX, WPTZ, and Fox44 News. He was invited back to the WCAX 6:00 PM news on June 24th to answer questions about why some people feel such events and others do not. (This, in part, relates to the amplification of earthquake waves and building heights as they react to a variety of wave periods emanating from the epicenter). On August 25, 2010, the Vermont State Geologist received a certificate of appreciation from FEMA "in recognition of his dedication to improving the identification of Seismic and other Natural Hazards Risks in the State of Vermont."

Professor Charlotte Mehrtens of the University of Vermont and the State Geologist appeared on the VPR's Vermont Edition on May 17, 2010 to discuss "Landslides and Regional Geology." See http://www.vpr.net/episode/48603/

Kristen L. Underwood, PG, is President/Founder and Principal Hydrogeologist of South Mountain Research & Consulting Services, a Vermont company based in Bristol. She holds a M.S. in Geosciences from Pennsylvania State University and a B.S. in Environmental Science: Aquatic Environments with a Geology Minor from Allegheny College, Meadville, Pennsylvania. Ms. Underwood has 22 years of experience in the environmental field, serving early in her career as quality assurance manager for RCRA facility investigations in the Mid-Atlantic States. Later, she was Supervisor of Environmental Programs for a Williston-based environmental firm conducting contaminated site investigations and remediation in New England and New York, including geologic mapping and fracture trace analysis to define hydrogeologic setting and contaminant migration. Since founding SMRC in 2000, Ms. Underwood has completed geomorphic assessments along more than 250 river miles in Addison, Bennington, Chittenden, Franklin, Lamoille, Rutland, and Windsor Counties of Vermont. Kristen served on the Board of Directors of the Vermont Geological Society from 1998-2002, also serving as Treasurer from 2000-2002.

Respectively submitted,
Laurence R. Becker, State Geologist

ANNOUNCEMENTS

VERMONT GEOLOGICAL SOCIETY LECTURER PROGRAM

The goal of the Vermont Geological Society Lecturer Program is to offer local colleges, universities, and high schools the opportunity to invite a member of the VGS to speak at their institution on timely topics within the broad realm of earth and environmental sciences. The program is primarily intended to reach those departments which either do not hold a regularly scheduled seminar series or whose finances do not permit them to invite external speakers to present talks on a regular basis. Any costs associated with the Lecturer's travel, lodging, and meals are borne entirely by the Vermont Geological Society.

Stephen Wright, Ph.D., Department of Geology, University of Vermont, is our 2010 Lecturer. Stephen is offering the following lecture topic: "Glacial Geology of Northern Vermont: Ice Flow, Water Flow, and Glacial Lake History." For scheduling information, see the Society's website at http://www.uvm.org/vtgeologicalsociety/lecturer_program.html

VERMONT GEOLOGICAL SOCIETY CALENDAR

3/20-22/11 Geological Society of America Northeastern/North-Central Combined Meeting, Pittsburgh, Pennsylvania

The **Vermont Geological Society** is a non-profit educational corporation comprised of academic, industry, and state government members interested in promoting the study of geology in the State of Vermont.

The **Executive Committee** of the Society is comprised of the Officers, the Board of Directors, and the Chairs of the Permanent Committees.

Officers

President	George Springston	(802) 485-2734	gsprings@norwich.edu
Vice President	John Van Hoesen	(802) 287-8387	vanhoesenj@greenmtn.edu
Secretary	David West	(802) 443-3476	dwest@middlebury.edu
Treasurer	Stephen Howe	(518) 442-5053	showe@albany.edu

Board of Directors

Richard Dunn	(802) 485-2304	rdunn@norwich.edu
Les Kanat	(802) 635-1327	les.kanat@jsc.edu
Jon Kim	(802) 241-3469	jon.kim@state.vt.us

Chairs of the Permanent Committees

Advancement of Science	Jon Kim
Geological Education	Christine Massey
Membership	Stephen Howe
Public Issues	Laurence Becker
Publishing	Stephen Howe

VERMONT GEOLOGICAL SOCIETY BALLOT

This year, Members will be voting for four Officers, three Directors, and two Chairs of two Permanent Committees. Associate Members, Student Members, and Honorary Members are not eligible to vote per Society Bylaws.

Returning Permanent Committee Chairs are:

Advancement of Science Committee: Jon Kim
Geological Education: Christine Massey
Public Issues: Laurence Becker

Please enter your name and address here:

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Officers

President	George Springston	_____
Vice-President	Keith Klepeis	_____
Secretary	David West	_____
Treasurer	David Westerman	_____

Board of Directors

Richard Dunn	_____
Les Kanat	_____
Jon Kim	_____

Chair, Membership Committee

David Westerman	_____

Chair, Publishing Committee

Richard Dunn	_____

Members voting electronically should click on the link http://www.surveymonkey.com/s/RH7NGC9 to record their vote. Members without access to e-mail should send their voted paper ballots to David West, Dept. of Geology, Middlebury College, Middlebury, VT 05753**. The deadline for the receipt of both electronic and paper ballots is December 4, 2010 at 5:00 PM.**

Vermont Geological Society
P.O. Box 1224
Saint Albans, VT 05478-1224

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

Don’t forget to vote!