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The Vermont Geological Society's
Spring Meeting

April 28, 2012, 8:15 AM
McCardell Bicentennial Hall, Room 220
Middlebury College, Middlebury, Vermont

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ABSTRACTS

MULTIFACETED ANALYSIS OF DRIFT B, LAKE CHAMPLAIN

Flora Weeks, Geology Department, Middlebury College, Middlebury, VT 05753

Two lacustrine sediment drifts were located in Lake Champlain. Oceanic sediment drifts contain a nearly continuous sediment record, therefore providing significant paleoclimate data, which has been utilized in marine environments for decades. With few documented lacustrine sediment drifts, these Lake Champlain datasets will contribute new paleoclimate data for this lacustrine environment and continental NE North America since ~14K BP. Seismic profiles show that both Drift A and Drift B are built atop the same sediment package, indicating that they are very similar in age. Drift B was studied in the summer of 2011 using a Compressed High Intensity Radar Pulse (CHIRP) survey of 28 seismic lines, four piston cores, and five subsurface moorings equipped with Acoustic Doppler Current Profilers (ADCPs), temperature sensors, sediment traps, and Laser Suspended Sediment Sensors (LISSTs). Drift B is located atop a structural high and classified as a detached elongate drift. The sedimentation rates range between 0.10-0.13 cm/yr utilizing sediment trap accumulations. Back calculating an accumulation rate from the maximum thickness of 12m on the drift and using the base age of Drift A (8,700 yrs), results in a similar rate of 0.14 cm/yr. The LISSTs recorded higher volumes of sediment and finer grains on the west side of the drift, as compared to the east. This sediment distribution is potentially due to high velocity currents recorded on the east side of the drift (maximum: 54.6 cm/s). The center of the drift had the lowest maximum velocity (35.8 cm/s), making it conducive to sedimentation. Velocity differences across the drift are explained by impingement due to bathymetric highs north of the drift region. In all cores taken from within Drift B, the sediment properties were relatively consistent, with fairly poorly sorted grains of with mean grain sizes in the fine silt range (10-25 microns), and olive grey in color. These properties echo the general characteristics of Lake Champlain sediments. The sedimentation within Drift B provides information on the past 8,700 years of Lake Champlain's climatic history and provides a baseline from which to examine current and future climate changes.

PHOSPHORUS MOVEMENT AND REDOX FRONT MIGRATION AT THE SEDIMENT WATER INTERFACE IN SEDIMENT CORES (MISSISQUOI BAY, LAKE CHAMPLAIN)

Nicole Shufelt, Geology Department, University of Vermont, Burlington, VT 05446, and
Greg Druschel, Indiana University-Purdue University, Indianapolis, IN

Eutrophication, due to internal and external loading of nutrients, is a serious problem for Lake Champlain as cyanobacteria blooms dominate the ecosystem. Cyanobacteria blooms are able to influence their environment by creating anoxia in the water column, which can lead to a migration of the redox front (the boundary between oxic and anoxic conditions) out of the sediment and into the water column. Under oxic conditions at the sediment water interface (SWI,) phosphorus is sorbed to the iron oxides at the sediment surface. When the redox front migrates out of the sediment and into the water column, the iron oxides are broken down into soluble Fe (II) and the previously sorbed phosphorus is released into the water column. This can allow for an uptake of the limiting nutrient phosphorus by the bloom and result in a growth of the bloom. In order to observe this internal nutrient loading, experiments were done on sediment cores collected from the bloom prone Missisquoi Bay. These cores were manipulated by controlling headspace gas levels to provoke movement of the redox front across the SWI. Microelectrodes were used to determine the location of the redox front and the concentration of several dissolved ion species (O_2, Mn and Fe (II).) The mesocosm experiments showed that while the water column is oxygenated lower SRP and TP values were found due to phosphorus sorbing to the iron oxides in the sediment. Anoxia in the water column resulted in higher SRP and TP values in the overlying water column as the phosphorus was released from the iron oxide particles at the sediment surface.

MILLER BROOK INCISION HISTORY, NORTHWESTERN VERMONT

Sandra Cronauer and Stephen Wright, Geology Department, University of Vermont, Burlington, VT 05405

The Miller Brook Valley in northwestern Vermont is an eastward trending valley containing ice-contact and lacustrine sediments deposited during and after the retreat of the Laurentide ice sheet. Previous research suggests ridges in this area are esker deposits and that lacustrine deposits are from Glacial Lake Winooski. This study focuses on understanding the complex incision history of Miller Brook following the retreat of the ice sheet and draining of Glacial Lake Winooski using a detailed geomorphic map of terraces in a 0.3 km^2 area and the use of ground penetrating radar (GPR). The map was created with latitude, longitude, and elevation data collected by a GPS unit of approximately 5 meter accuracy. GPR was used along accessible landforms in an attempt to image subsurface geometries and examine the utility, penetration depths and resolution of GPR in different types of glacial materials. GPR transects were taken across a number of landforms including esker ridges, fluvial terraces incised into ice-contact sediments, and two possible lacustrine terraces. Profiles were taken using GSSI 200 and 400 MHz antennas accessed through the University of Vermont Geology Department. A profile over a lacustrine terrace showed reflectors reminiscent of what may be deltaic deposits. One transect along a road built on an esker ridge showed signs of curved reflectors that may indicate a channel cutting across it or sediments draped over underlying structures. Parabola curves change throughout some profiles suggesting that there are transitions in material type along transect. As would be expected for poorly sorted materials, the fluvial terraces incised into the ice-contact

sediments did not show continuous, well defined reflectors. When comparing the antennas the 200 MHz equipment was able to penetrate deeper than the 400 MHz could. Mapped terraces suggest that during incision the esker played a part in determining where stream channels flowed over time. Miller Brook currently loops around the large esker on its south side and it may have been dammed before breaking through and eroding sediment to create gaps between the ridges.

A HYDROLOGIC, STRUCTURAL, AND CARTOGRAPHIC ANALYSIS OF GROUNDWATER IN THE VICINITY OF THE CHAMPLAIN AND HINESBURG THRUSTS, WEST-CENTRAL VERMONT

John Filoon, Geology Department, Middlebury College, Middlebury, VT 05753

Multiple studies have shown that bedrock-derived groundwater contamination is a concern in some areas of Vermont, mainly in fractured bedrock aquifers composed of metamorphic rocks that house radionuclides and trace metals. The bedrock aquifer system in the vicinity of Hinesburg, Vermont has recently undergone numerous geochemical evaluations that indicate locally elevated uranium and alpha radiation, but little is known about the physical hydrology, particularly recharge and productivity. This project investigates the relationship between the region's structural characteristics and its groundwater flow patterns via several techniques.

Lineament and fracture correlation, determination of the potentiometric surface, and recharge analyses were all carried out using ArcGIS and freely available data. These analyses confirmed recent findings that suggested the bedrock aquifers of the upper plate of the Hinesburg Thrust are much less productive than those of the lower plate. Areas of with a high concentration of lineaments and/or course stratified drift were found to be extremely important in terms of local recharge, though high yield areas were often found to be located down the potentiometric gradient from these sites.

Groundwater samples retrieved from around the Hinesburg Thrust underwent CFC testing to determine the recharge ages of various parts of the aquifer. Results from this testing has revealed that water drawn from wells on either side of the thrust infiltrated the aquifer ~29 years ago, while wells that pierce the thrust contain water that infiltrated the aquifer ~38 years ago. These results alone offer insignificant evidence to determine flow patterns around the thrust fault, so recent geochemical data was investigated as well.

INTEGRATION OF STRUCTURAL ANALYSIS, AN EMI SURVEY, AND HYDROGEOLOGY IN THE PLAINFIELD QUADRANGLE, CENTRAL VERMONT

Abigail Ruksznis, Geology Department, University of Vermont, Burlington, VT 05446, Jonathan Kim, Vermont Geological Survey, Waterbury, VT 05671, Keith Klepeis and Laura Webb, Geology Department, University of Vermont, Burlington, VT 05446

The Plainfield 7.5’ Quadrangle lies on the western side of the Connecticut Valley Trough (CVT)- a post-Taconian (Ordovician) extensional basin that was filled in with Silurian-Devonian sedimentary and volcanic rocks. The basin was deformed and metamorphosed during the Devonian Acadian Orogeny, and later intruded by post-orogenic granitoids of the New Hampshire Plutonic Series (NHPS). From oldest to youngest, the rocks in the field area consist of interlayered gray phyllites and impure marbles (Waits River Fm), interstratified gray phyllites and phyllitic quartzites (Gile Mt. Fm), and biotite granites (NHPS). The Waits River Fm is further divisible into members with thick (DSwt) and thin (DSwl1) marbles, respectively. The degree of metamorphism ranges from biotite- staurolite grade.

We observed three distinct sets of topographic lineaments: the first set follows the dominant bedding-parallel cleavage (S1) that is pervasive in all metasedimentary lithologies. The second set follows the less prominent NW/SE trending fracture set. The third set follows E-W fractures that are orthogonal to the dominant foliation (S1). Whereas all three lineament sets are clearly expressed in the Waits River Fm, lineaments in the Gile Mt. Fm are dominantly E-W.

Because previous Electromagnetic Induction (EMI) surveys in an adjacent quadrangle showed a strong connection between brittle and ductile structures and groundwater flow, we conducted detailed (1:4000) EMI in specific areas of the Waits River Fm. These surveys demonstrated a direct correlation between linear zones of high conductivity and ~E-W fracture sets suggesting the fractures may be groundwater pathways. Both M-folds and Z-folds were identified in the EMI plots and correlated to locations on a cross section of the area, further evidencing the asymmetric east verging F2 fold geometry. It is hypothesized that the folds are most distinguishable in the surveys taken on days when the ground was not saturated because subtle variations in conductivity are easier to recognize.

These studies were summarized in a 3D conceptual model representative of the bedrock hydrogeology of the DSwt formation. The three scenarios of maximum yield were identified as: 1) down plunge of an F2 fold, 2) into a fractured marble member, or 3) into any thick marble unit with high porosity.

AN ANALYSIS OF RADIONUCLIDES IN THE CLARENDON SPRINGS FORMATION: IMPLICATIONS FOR WATER QUALITY IN HIGHGATE, VT

Emily C. McDonald, Peter Ryan, Geology Department, Middlebury College, Middlebury, VT 05753, and Jon Kim, Vermont Geological Survey, Waterbury, VT 057671

Groundwater produced from fractured bedrock of the Clarendon Springs Formation is enriched in uranium and alpha radiation in some areas of northwestern Vermont, but this issue has not been examined in all areas where the Clarendon Springs Formation occurs. Previous research by the Vermont Geological Survey in Chittenden County has indicated that the radioactivity in the Clarendon Springs Formation is associated with 'black-chip' breccia horizons that are speculated to be rich in U-bearing phosphorite minerals. NURE surveys from the 1970s identified uranium anomalies associated with the Clarendon Springs Formation in Franklin Country of northwestern-most Vermont, but no systematic study of bedrock and well water chemistry has been performed in this area. Accordingly, the purpose of this study is to determine if the concentration and distribution of radioactivity in the Highgate area is confined to the Clarendon Springs breccia horizons and whether or not the radioactivity is being mobilized into drinking water, resulting in elevated uranium and/or gross alpha in private bedrock wells.

61 bedrock samples have been collected across the Highgate area of the Clarendon Springs Formation as well as other formations. Using both ICP-AES and ICP-MS, geochemical data indicates a correlation between uranium concentration and phosphorus content particularly in localized Clarendon Springs Formation black chip breccias near the Vermont-Quebec border.

For example, bedrock in this area contains up to 9.85 % P_2O_5 and 79.6 ppm uranium. XRD analysis shows that the U rich phosphorite mineral in the black chip breccia in this area is flouroapatite. 27 domestic water samples were collected and 25 % contain elevated gross alpha (between 5 to 19 pCi/L).

We speculate that syndepositional tectonics that produced the down-dropped Franklin Basin in late Cambrian time led to the deposition of U-rich phosphorite minerals through marine upwelling currents that occur in the black chip breccias. Current research is examining mineralogy, mineral textures and chemistry by a combination of XRD, SEM-WDS and ICP-AES/MS in order to better understand the speciation of U in these rocks.

RELATIONSHIP OF BEDROCK GEOCHEMISTRY AND GROUNDWATER CHEMISTRY IN THE FRACTURED BEDROCK AQUIFER SYSTEM OF THE PLAINFIELD QUADRANGLE, VERMONT

Nick Daly, Geology Department, Middlebury College, Middlebury, VT 05753

Several studies over the past 5-10 years have demonstrated elevated levels of naturally occurring radionuclides and other contaminants in groundwater wells that tap the deep fractured bedrock aquifer systems in Barre, Marshfield and Peacham, Vermont. Many of these wells are completed in the Knox Mountain pluton, a large igneous intrusion. These studies implicate this rock unit as the likely source of contamination. This study uses a multidisciplinary approach to assess: (1) the groundwater chemistry and bulk rock geochemistry in the adjacent Plainfield and Montpelier Quadrangles; and (2) the lithologic, hydrologic and hydrogeologic factors controlling water chemistry and groundwater flow in this fractured bedrock system.

The bedrock geology of the study area was mapped in detail over the last year, and wells in the study area tap into three main units: (1) thick bedded Waits River Fm. (predominately impure marbles with minor phyllitic members); (2) thinly bedded Waits River Fm. (same as previous); and (3) Gile Mountain Fm. (phyllites with minor carbonate beds).

Twenty private wells were sampled representing the three main rock units. Each water sample was tested for a suite of metals, non-metals, anions, gross alpha (GA; test for radioactivity), temperature, pH, conductivity and oxidative reduction potential. Of the private wells tested in the study area, two samples demonstrated GA at or above the Vermont Department of Health action level of 5 pCi/L; which recommends further testing for radionuclides. Neither of these wells contained Gross Alpha above the EPA maximum contaminant level (MCL) of 15 pCi/L. Three of the twenty wells exceeded the secondary standard of 50ppb for manganese levels.

Gross Alpha levels did not correlate to one unit. Manganese levels are not unique to one formation and do not necessarily correlate to increases in GA. High well yields, and low residence times likely contribute to the observed low contaminant levels in this fractured aquifer system.

EVIDENCE FOR THE RELATIONSHIP BETWEEN ARSENIC AND METAMORPHIC GRADE AND IMPLICATIONS FOR BEDROCK AQUIFER GEOCHEMISTRY

Diego Russell, Peter Ryan, Geology Department, Middlebury College, Middlebury, VT 05753, and Jon Kim, Vermont Geological Survey, Waterbury, VT 05671

In northern New England and southern Quebec, elevated naturally-occurring As levels have been reported in bedrock wells completed in slates of the Taconic Allochthons (VT) and Central Maine Belt (ME), ultramafic rocks of the Rowe-Hawley Belt (VT), contact zones for granitic intrusions (NH and ME), and low grade metasedimentary rocks of the Connecticut Valley Trough (CVT) in Quebec. The most common lithologic sources of arsenic in Vermont bedrock aquifers is 1) authigenic pyrite which initially formed in geochemically-reduced marine sediments that have been lithified into shales or chlorite grade slates and 2) serpentine-group minerals in ultramafics. Through the plate tectonic cycle, marine shales may either be subducted or thrust onto a continental margin during orogenesis; in either case, the As may initially be metasomatically liberated during metamorphism and then resequestered (i.e. in ultramafics). Through the detailed geochemical analysis of rocks of different metamorphic grades in the Taconic Allochthons and CVT, we will assess the role that metamorphism plays in As mobility.

For example, low-grade slates (chlorite-illite) of the Giddings Brook slice in the Taconic Allochthons contain an average of 44.44 mg/kg As and 33 % of bedrock wells contain > 10 ppb As; by contrast, higher grade slates and phyllites (paragonite-chlorite-muscovite) of the Bird Mountain slice contain an average of 3.59 mg/kg As and only 4 % of wells contain > 10 ppb As. In the Rowe Hawley belt, biotite grade metapelites contain low concentrations of As (7 mg/kg) whereas ultramafics within the same belt have elevated As levels (93 mg/kg), suggesting that As was transferred from metapelites to ultramafics during subduction zone metamorphism and serpentinization.

Thus, based on these results, we hypothesize that for two pelitic rocks of initially equal arsenic concentration, the rock exposed to the greater degree of metamorphism will have a lower arsenic concentration. We are currently evaluating the As content of metapelites and metapsammites of the CVT (Gile Mountain Fm and Waits River Fm of VT) as a function of metamorphic grade and proximity to granitic intrusions of the New Hampshire Plutonic series. Existing data from biotite grade rocks of the CVT in Vermont indicate average arsenic concentration of 7 mg/kg; chlorite zone rocks from the Taconics contain 44 ppm As, whereas garnet and staurolite zone lithologies contain no detectable As. These data are compelling evidence for the influence of of prograde metamorphism on As in metapelites.

GEOMETRIC VARIABILITY AND SPATIAL EXTENT OF AN ACADIAN DOME AND BASIN FOLD INTERFERENCE PATTERN IN NW VERMONT

Christine McNiff, Keith Klepeis, Laura Webb, Geology Department, University of Vermont, Burlington, VT 05446, and Jon Kim, Vermont Geological Survey, Waterbury, VT 05671

Two east-dipping thrust faults that formed during the Ordovician Taconian Orogeny divide the bedrock geology of Vermont's Champlain Valley into lithotectonic slices. On the west, the Champlain thrust (CT) placed M. Cambrian – M. Ordovician sedimentary rocks over L. Cambrian – M. Ordovician sedimentary rocks. Farther east, the Hinesburg Thrust (HT) placed L. Proterozoic – E. Cambrian chlorite-sericite grade metamorphic rocks over rocks above the

CT. Subsequent deformation during the Devonian Acadian Orogeny resulted in the folding of both faults and other Taconian structures. Previous work recognized two sets of open, upright folds— a N-S-trending, asymmetric, open-tight fold set (F_3) and an E-W-trending, open fold set (F_4)— that create a dome and basin fold interference pattern. We report on the spatial extent and variable geometry of this pattern between the towns of Milton and Williston with the goal of understanding how it formed and its significance.

The dome and basin pattern is best developed in chloritic schists in the upper plate of the HT. This trend may reflect the presence of mica-rich lithologies, which are relatively weak and easily deformed. At Colchester Pond and central Williston, F_3 and F_4 are equally displayed. The folds trend N-S and E-W, respectively, and are associated with two steeply dipping, orthogonal crenulation cleavages (S_3, S_4) and related crenulation lineations (L_3, L_4). Between these locations, however, the two folds sets are not orthogonal. In Essex Junction, near the leading edge of the HT, F_3 is dominant whereas F_4 is weakly developed. Orientations also are different: S_4 is weak and strikes ESE whereas S_3 is penetrative and strikes to the north. The L_3 and L_4 lineations also form an oblique angle, suggesting they were rotated as F_4 folds formed. These observations suggest that the two folds sets formed approximately at the same time. Geometric changes toward the leading edge of the HT also raise the possibility that the pattern formed by an Acadian reactivation of the HT.

Ongoing analysis seeks to further resolve the relative ages and three dimensional geometry of the fold sets along strike of the thrust belt and resolve whether they reflect an Acadian reactivation of the HT.

THE STRATIGRAPHY, LITHOFACIES, AND DEPOSITIONAL ENVIRONMENT OF THE MIDDLE ORDOVICIAN MIDDLEBURY FORMATION

Megan Scott, Geology Department, University of Vermont, Burlington, VT 05446

The Middlebury Formation is a Middle Ordovician limestone deposited on the margin of Laurentia during the collision of the Ammonoosuc Arc with Laurentia. The field area for this study includes the towns of Middlebury and Orwell, Vermont. Cross sections from both the northern and southern part of the field area are characterized by north trending tight asymmetric folds dissected by thrust faults. These geometries are part of a larger structure, the Middlebury Synclinorium. The thickness of the Middlebury Formation within the synclinorium can be up to 800 feet. The cross sections enable the placement of each outcrop in its relative stratigraphic position. The motivating questions for this project include: what depositional environment do the lithofacies of the Middlebury Formation represent and how does the stratigraphy of the Middlebury Formation reflect tectonic processes, if at all? Six lithofacies are present in the Middlebury Formation. The dominant lithology is a gray laminated mudstone. On the basis of field observations and petrography, well sorted quartz sand grains and recrystallized allochems are identified in the heavily bioturbated mudstones, which is interpreted to record deposition in a lagoonal setting on a restricted marine platform.

USE OF LITHIUM HETEROPOLYTUNGSTATE HEAVY LIQUID IN CONDONT MICROFOSSIL RECOVERY FOR BIOSTRATIGRAPHY FROM THE MIDDLEBURY FORMATION (MIDDLE ORDOVICIAN) OF WEST CENTRAL VERMONT

Amanda Northrop and Char Mehrtens, Geology Department, University of Vermont, Burlington, VT 05446

During the Middle Ordovician (~480-450 mya), what is now western New England was a tropical continental shelf. The shelf, subjected to tectonic forces originating to the east during the Taconic Orogeny (~460 mya), was fragmented and moved through a variety of bathymetries before finally being buried beneath ocean muds. The overall timing of the orogeny has been fairly well constrained; however, specific timing of its onset is less well constrained. The Middlebury Formation, a rock unit comprised of multiple limestone and dolostone layers in west-central Vermont, was deposited on the eastern portion of the shelf. The presence or absence of evidence of faulting in the Middlebury formation can give a more constrained age to the Taconic Orogeny if the absolute age of the formation is known. To date, studies have yielded only a relative age of the Middlebury Formation. In my study, I attempted to use fossil biostratigraphy in order to determine the absolute age of the Middlebury Formation by identifying conodont species within the Middlebury Formation and surrounding rock units and comparing those conodont species to species found in rock units of known age. I collected 30 two kilogram samples from the Middlebury, Glens Falls, Crown Point and Beekmantown Formations, crushed them to 1cm fragments, dissolved them in dilute acetic acid and used heavy liquid separation in order to extract and identify conodont fossils. I used lithium heteropolytungstates, a new and less toxic heavy liquid, and a major outcome of my study was refinement of the separation protocol. My samples yielded few, highly fragmented and unidentifiable conodonts and consequently, I was unable to assign an absolute age to the Middlebury Formation.

LOW-TEMPERATURE THERMOCHRONOLGY AND THE TOPOGRAPHIC EVOLUTION OF THE WHITE MOUNTAINS, NEW HAMPSHIRE

Alyssa J. Anderson, Geology Department, Middlebury College, Middlebury, VT 05753

Are the White Mountains we see today the eroded remnants of old Paleozoic orogenies, or are they the result of accelerated exhumation occurring during the Mid-Miocene or at the onset of Northern Hemisphere glaciation? The purpose of this project is to examine the topographic evolution of the White Mountains, NH using low-temperature thermochronometry. Samples from a ~3,000 ft drill core of Conway granite from Conway, NH were analyzed using apatite (U-Th)/He dating and $^{4}He/^{3}He$ thermochronometry. Lab results were compared to AHe ages computed from *t*-T paths produced by Pecube, a numerical model that simulates crustal heat transfer with changing topography. Modeled AHe ages indicate that the effect of grain size must be taken into account when interpreting results from the region. AHe ages ranged from ~126 Ma at 0.515 km elevation to ~52 Ma at the base of the core. The AHe ages of the core samples are the youngest ages reported in the region, yet the $^{4}He/^{3}He$ profiles show that samples did not pass through the apatite He PRZ recently enough to record Mid-Miocene or glacial exhumation. AHe ages and model results indicate that one possible exhumation history for Conway, NH involves slow erosion, 0.009 km/myr, from 180 to 75 Ma followed by a period of accelerated erosion, 0.045 km/myr, from 75 to 50 Ma and a return to slow erosion, 0.01 km/myr, from 50 Ma to the present day. Given these erosion rates, ~2.57-2.7 km of rock has been exhumed over the past 180 Ma. Passage over the Great Meteor Hotspot is interpreted to be the driving factor behind this Late Cretaceous-Early Paleocene accelerated exhumation at which time a close approximation of the modern topography likely developed.

MINERAL REACTION PATHWAYS AND RATES IN A TROPICAL SOIL CHRONOSEQUENCE, NICOYA PENINSULA, COSTA RICA

Franklin W.C. Hobbs, and Peter Ryan, Geology Department, Middlebury College, Middlebury, VT 05753

Chemical weathering and strong leaching in moist tropical environments tend to produce kaolinite-rich soils that are depleted in base cations characterized by low Si:Al ratios. These soils often reach steady state conditions within 100 – 200 ka; however, the rates and pathways to these steady state clay conditions can be varied and often consist of intermediate/metastable minerals such as smectite and/or interstratified kaolin-smectite (K-S) phases. Some studies have observed that, with increasing soil maturity, metastable smectite transitions to interstratified K-S phases which in turn give way to kaolinite or halloysite. The rates and pathways of such reactions are important for understanding nutrient cycling in tropical soils as well as to applying understanding of reaction rate to interpreting landscape evolution (e.g. uplift rates). The field area for this study, the southeastern tip of the Nicoya Peninsula in northwestern Costa Rica, provides an ideal environment for the study of soil chronosequences due to the terraced landscape produced by uplift associated with subduction at the Mid-America Trench.

Accordingly, the purpose of this study is to examine the mineralogy and geochemistry of parent materials (beach deposits) as well as soils on uplifted beach terraces with a particular focus on determining reaction rates and sequences of mineral reactions as well as details of clay mineral structures. Preliminary X-ray diffraction results indicate a full weathering sequence from parent materials rich in rock and fossil fragments to 10 ka soils rich in pedogenic smectite with relict primary minerals (including calcite) to a kaolin-dominated assemblage in 80 to 125 ka soils. Intermediate age soils show evidence of interstratified kaolinite-smectite, and Fourier-transform infrared analysis data demonstrate a decreasing Si:Al ratio consistent with the breakdown and leaching of tetrahedral layers in the transition of parent materials to smectite to K-S to kaolin. Quantification of %K using DTA-TG and XRD has revealed a delay in the smectite to kaolinite transitions followed by the rapid silica tetrahedral leaching to a steady state kaolinite-rich soil. The resulting stair-step weathering pathway hopes to be explained through leachate buffering by interlayer cations and amorphous aluminosilicates.

INTERPRETING THE GEOMORPHOLOGY AND HYDROLOGIC HISTORY OF DEVIL'S CORRAL, IDAHO

Brittany Barrett, Geology Department, Middlebury College, Middlebury, VT 05753

Much ambiguity surrounds the geomorphology and hydrology of the Snake River Plain (SRP) in southern Idaho. Many geomorphic features on the SRP are attributed to the Pleistocene Bonneville flood that drastically reconfigured the landscape. Several enigmatic canyons along the Snake River canyon wall are unique due to the absence of drainage systems or modern rivers flowing through them. Devil's Corral is an especially interesting canyon because it contains a huge number of angular boulders that cover the canyon floor. It is debated whether the canyon formed during the Bonneville megaflood at ~17.5 kyr, or during a pre-Bonneville flood event.

Through field mapping, boulder measurement, and cosmogenic ^{3}He analysis, this study shows that the current canyon geometry was formed during the Bonneville flood event. Boulder measurements compared with estimates of peak shear stresses during the flood show that much of the present canyon geometry can be attributed to plucking of boulders during flood recession.

PRESIDENT'S LETTER

By the time you read this, the new *Bedrock Geologic Map of Vermont* will have been unveiled at a Montpelier ceremony. It's the work of a couple of generations of dogged researchers and will certainly serve as a springboard for future research into the geology of our state. The term "map" used to be simple and easy to understand. A map was "a drawing or representation, usually on a flat surface, of part or all of the surface of the earth...indicating a specific group of features, as land masses, countries...." (Random House Dictionary of the English Language, unabridged edition, 1967). In most cases, it was printed on a piece of paper. That was it. It existed in one form at one scale. If you wanted a copy you traced the paper map, photographed it, or crammed it onto the bed of a copy machine.

The technology of map production has, of course, changed greatly over the years. The 1861 *Geologic Map of Vermont* was printed via the lithography process using a specially prepared slab of limestone (a process that is exquisitely appropriate for a geologic map!). The framed copy on my wall at home is colored, but those colors came via the painstaking hand-application of watercolors to the black-and-white lithographic print (I'd like to know what nameless person did this work and how much they got paid per map). The 1961 *Centennial Geologic Map of Vermont* was compiled and drafted by hand and then printed in full color by means of four-color printing from separates produced by wet photographic processes. The newest map was produced using the latest digital technology and it "exists" in both the hard copy form of the printed paper maps but also (and perhaps primarily) as digital files.

This introduction of the digital version is perhaps the greatest change of all. Many of us already make heavy use of such digital map files in our geographic information systems, and I would be the last one to say that they are not immensely versatile, but I do think something is lost if we give up on having complete, stand-alone maps which can be spread out on a table and pored over. With the big maps it's all there--you can't get away from the big picture, even as you peer in at the details of a small area. The big paper maps enable your eye to roam around and explore intriguing parts you didn't know you were looking for. I hope that the future will still hold some room for these great monuments to the geologist's and the printer's science and craft. At the very least, we will have this grand geologic and cartographic product to treasure for many years to come.

On a more mundane note, we have a Geological Society to run. In the last newsletter I stated that we would have an Executive Committee meeting prior to the upcoming Spring Meeting. It looks like that will have to be postponed until after the Spring meeting. We need nominations for officers and need to plan out spring and perhaps fall field trips. Above all, we truly need to get more of our members involved in running the society. If you can devote a little time to helping the organization, it will be much appreciated! I hope to see many of you at the Spring meeting.

Respectfully submitted, George Springston

ANNUAL MEETING MINUTES

The Executive Committee did not meet over the Winter.

TREASURER'S REPORT

The Society continues to find itself good financial health, thanks to the generous support from its members. Cash on hand as of April 15 is balance of $6,154.50. Dues for 2012 were solicited late, and to date we have received $1,270 with a number of prominent members still in arrears. (You know who you are, and that stamped envelope is on the refrigerator). We have also received $610 in contributions to the Research Grant Program. We have also spent $243.20 on mailing with a substantial inventory of "forever" stamped envelopes on hand.

Please join me in welcoming the following new members:

Will Amidon, Middlebury College
Cynthia Norman, Lake Champlain Basin Program
Paul Wagenhofer, New Zealand Oil and Gas
John Moore, George Mason University
Jeff Pelton, retired – (welcome back Jeff)
Dagan Murray, Lincoln Applied Geology, Inc.
Peter Valley, USGS

Respectfully submitted, David S. Westerman, Treasurer

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The committee received no research grant applications for the April 1st deadline.

Previous VGS research grant recipients Nick Daly, Emily McDonald, and Diego Russell (all from Middlebury College) will present their work at the 2012 VGS spring meeting on Saturday April 28th.

We are currently looking into the possibility of running a summer VGS field trip that will integrate bedrock and surficial geology and ecology/botany in the Plainfield Quadrangle (parts of the towns of Calais, East Montpelier, Marshfield, Plainfield). Details to follow in the summer GMG.

Respectfully Submitted, Jon Kim

VERMONT STATE GEOLOGIST'S REPORT

The Governor brought the presentation of the New State Bedrock Geologic Map into his Executive Office in the State House on April 11, 2012. Approximately 40 people from the geologic and interested community trooped in to hear the presentation with the State House Press Corps in attendance. He noted that "Every 50 years or so something big happens, this is one of them".

Please see various documents below that relate to this exciting day.

I wanted to make special commendation for Marjorie Gale's work on behalf of the Vermont Geological Survey and the citizens of Vermont. One cannot say enough about her commitment, her science, her ability to balance and illuminate the geologic ideas that are represented on the Map especially in Northern VT. She served as a conduit for the Vermont Survey and UVM authors and contributors bringing their submissions to the final map while working the compilation between USGS primarily in southern VT and the VGS and the University in northern VT. Peter Thompson, now at UNH, gave much of his time and effort over the years in field mapping and as an author. He like Marjorie is a link to the legacy of Rolfe Stanley. Jon Kim contributed his mapping from the many projects he has undertaken in Vermont since his arrival in 1996.

Our USGS partners put years of work into the product led by Nick Ratcliffe. As lead author he was ultimately responsible for the compiled and integrated product along with his co-authors. He has been involved since the beginning bringing his geologic ideas up from mapping in the Massachusetts Precambrian in the 1980's covering countless outcrops in the subsequent years to get us to the final map.

Charlotte Mehrtens as present day UVM faculty and contributor of geology maps from the Champlain Valley represented the University at the event with Barry Doolan in attendance. They are also the link to Rolfe Stanley a mentor to many and a posthumous author.

More below:

<u>Acknowledgements for Agency of Natural Resources Secretary Deborah Markowitz Introduction</u>

The Map before us is a cooperative project between the Agency of Natural Resources/ Vermont Geological Survey, the United State Geological Survey, the University of Vermont and other academic partners – published by the USGS in Cooperation with the Vermont Geological Survey in the Agency of Natural Resources.

The authors of the map are: Nicholas Ratcliffe USGS, Rolfe Stanley UVM (Posthumous), Marjorie Gale VGS, Peter Thompson VGS (now with the University of New Hampshire), and Gregory Walsh USGS.

Other contributors included Norman L. Hatch, Jr.*, USGS; Douglas W. Rankin, USGS; Barry L. Doolan, UVM; Jonathan Kim, VGS; Charlotte J. Mehrtens, UVM; John N. Aleinikoff, USGS;

and J. Gregory McHone, Wesleyan University. Linda M. Masonic, USGS, was responsible for the cartography.

The map has been in development during the tenure of three State Geologists: Charles Ratte', Diane Conrad, and Laurence Becker

I also want to acknowledge the role Greg Walsh of USGS and ANR's GIS group played in developing digital map data over the course of this project.

We want to acknowledge two geologists no longer with us that would have been thrilled with this celebration, Rolfe Stanley of UVM and Norman Hatch of the USGS. Through their work in Vermont and New England, both were instrumental in developing many of the geologic ideas that went into the initial start up and development of the new map.

Press Release

NEW GEOLOGIC MAP OF VERMONT UNVEILED

APRIL 11 - MONTPELIER – *A new bedrock geologic map of the state was unveiled in a ceremony at the Vermont State House today, bringing a critical tool to land managers involved in natural resource planning and environmental assessment.*

The event, hosted by Gov. Peter Shumlin, included the Secretary of the Agency of Natural Resources Deb Markowitz; Peter Lyttle of the U.S. Geological Survey; Laurence Becker, Vermont Agency of Natural Resources; and Char Mehrtens of the University of Vermont. These three organizations were the main collaborators to produce this updated, highly detailed map. The state's last map of this kind was produced in 1961, with the first geologic map of the state being produced 150 years ago.

"Through the balanced work of all the partners, Vermonters now have a comprehensive map that will help us better understand and plan for issues like groundwater, energy, hazards, infrastructure development, and environmental protection for years to come," Gov. Shumlin said. "Such up to date information is crucial to the State when addressing the economic and environmental concerns of citizens, lawmakers, government, business, and local communities."

Geologic maps enable resource managers and land management agencies to identify and protect aquifers, evaluate resources and land use, and prepare for natural hazards, such as earthquakes and land subsidence, for example. Geologic maps are also critical tools for choosing safe sites for solid and hazardous waste disposal and for protecting sensitive ecosystems.

Understanding where different rock types are located provides important clues about where groundwater and mineral resources exist. The map provides a template for future studies in a variety of disciplines -- not only geologic, tectonic and hydrologic studies, but also economic and environmental evaluations.

"It was an incredible tour de force to bring this level of detail to the new bedrock map on account of the many intense geologic events that have left their mark on the state of Vermont over the eons," said USGS Director Marcia McNutt from the bureau's headquarters in Reston,

Va. "Without the steadfast and enduring partnership of the USGS, the Vermont Geological Survey, and the University of Vermont, this achievement would not have been possible."

Vermont's new map shows an uncommon level of detail for state geologic maps. Mapped rock units are based on lithology, or rock type, rather than traditional rock formations that may include multiple rock types. This map identifies more than 486 different types of rock throughout the state of Vermont, a design feature intended to facilitate use by multiple disciplines. During the project, scientists also discovered many fault lines, advancing understanding about how and where water travels through the underground rock formations and providing clues about where underground aquifers -- an important source for potable fresh water -- may be located.

"The Vermont map is the visual presentation used to communicate data, ideas and interpretations. New map patterns developed through years of field and laboratory studies led to recognition of terranes from different geologic settings. Most importantly, understanding these settings gives us predictive capabilities for the sub-surface including areas where rocks are covered by glacial deposits," said Laurence Becker, the 13th Vermont State Geologist. "The bedrock geology, in conjunction with the overlying glacial deposits, form the geologic system crucial to understanding economic and environmental issues that face our state"

Vermont's new geologic map substantially builds upon the state's previous geologic map – created in 1961– by incorporating the theory of plate tectonics, which had not yet been developed 50 years ago. The Green Mountains form the backbone of Vermont. Their geologic history, spanning more than 1.4 billion years, attests to a complex series of plate tectonic events including the formation of corals reefs, ocean basins and volcanic arcs punctuated by periods of Appalachian mountain building.

"The new bedrock geologic map of Vermont changes the way we look at the geologic history of the state because we can now see relationships between rock types and structures that were obscured on the old map," said Char Mehrtens, contributing author of the map and professor of Geology at UVM. "The level of detail provided by the new map is also a huge help to geoscience educators because we can now design student projects to utilize the three dimensional information it contains. The significance of this map can't be understated; it places us in the national conversation about the origin and evolution of mountain belts, particularly because the National Science Foundation-funded Earth Scope project will be working in New England starting in 2013. The new bedrock map sets the stage for collaborative studies of University of Vermont geologists with their national and international colleagues."

The process for creating a geologic map for an entire state is very field intensive, and The Bedrock Geologic Map of Vermont has been in development since the 1980s.

VT House of Representatives passed the following Resolution on April 11, 2012. Representative David Deen following the reading and affirmative vote asked the State Geologist, and the authors and contributors in attendance (Nick Ratcliffe, Marjorie Gale, Peter Thompson, Greg Walsh, Barry Doolan, Jon Kim, Charlotte Mehrtens) to stand at the front of the House and be recognized

House concurrent resolution thanking the staff of the agency of natural resources, academic and scientific institutions, and community members who contributed to the development of the new Bedrock Geologic Map of Vermont

Offered by: Representatives Deen of Westminster and Klein of East Montpelier

Offered by: Senator Lyons

Whereas, the publication of the new Bedrock Geologic Map of Vermont incorporates 30 years of new approaches to the science of geologic mapping and the technologies that support it, and

Whereas, the 2011 publication of this invaluable map occurred on the sesquicentennial anniversary of the first Vermont geologic map's issuance in 1861 and 50 years after the 1961 Centennial Geologic Map of Vermont was released, and

Whereas, this new map is the first Vermont state map published to include interpretations of geologic history based on the emergence of plate tectonic theory in the 1960s, and

Whereas, through its incorporation of a fundamental data layer, the map is a showpiece of the present-day understanding of Vermont's geology, and

Whereas, the map provides a primary geological science base to be used for years to come that will help us address Vermont's environmental issues, and

Whereas, protection of our state's natural resources will be easier when working on matters related to groundwater protection, energy development and use, hazardous waste, infrastructure development, and environmental protection, and

Whereas, this map's development and publication is an excellent example of cooperation between the state of Vermont, the federal government, and the academic and scientific community represented by the Vermont Geological Survey, the agency of natural resources, the United States Geological Survey, and the primary academic partner, the University of Vermont, now therefore be it

Resolved by the Senate and House of Representatives:

That the General Assembly thanks the staff of the agency of natural resources, academic and scientific institutions, and community members who contributed to the development of the new Bedrock Geologic Map of Vermont, and be it further

Resolved: That the Secretary of State be directed to send a copy of this resolution to Secretary of Natural Resources Deborah Markowitz.

ANNOUNCEMENTS

Field trips: The Society is always looking for field trips, so please contact any Executive Officer if you have an idea.

33rd Annual Champlain Valley Gem and Mineral Show, July 28-29. See the full announcement below.

Middlebury College is hosting the Champlain Valley Clay Symposium, June 1st. See the full announcement below.

33RD ANNUAL CHAMPLAIN VALLEY GEM, MINERAL & FOSSIL SHOW

2012 Show Theme: The Minerals of Canada

July 28-29, 2012
Saturday and Sunday 10 AM - 5 PM

Sponsored by the Burlington Gem and Mineral Club

2012 Show Dealers
Canadian Minerals | Cardinal Minerals | Circle of Stones | Crystal Cache Minerals
Ewing's Lapidary | Fantasy in Gemstones | Global Pathways | Gold-N-Gems
Green Mountain Minerals | JNL Minerals | Lake Champlain Minerals and Jewelry
Mineral Connection | Phoebe Designs | Vermont Amber Designs

Citrine Geode—Image similar to Raffle prize

Raffle tickets are available at the Show
Tickets: $1 each or 6 for $5

We will have an exciting slate of speakers lined up for our lectures at the Show!
Lecture schedule and topics to be added later.

Quality dealers offering minerals, fossils, gems, jewelry, lapidary equipment and supplies. Lectures, exhibits, raffle, hourly door prizes, silent auction, demonstrations, and fish pond for kids (catch a cup of minerals for a quarter). Refreshments available.

Tuttle Middle School
500 Dorset Street (near Kennedy Drive)
South Burlington, Vermont
FREE PARKING

Admission: $3.00 for Adults
$2.00 for Students (6-16) and Seniors
Children under 6 FREE

Come visit us, have a fun day with the entire family

Champlain Valley Clay Symposium

Sponsored by ***Annelid Environmental Services PLLC***
Co-sponsored by ***Middlebury College Geology*** and ***Vermont USDA- NRCS***

Friday June 1, 2012
220 McCardell Bicentennial Hall Middlebury College, Middlebury, Vermont
9:00am- 4:00pm

Schedule of Events:

8:30-9:00	Check-in
9:00-9:10	Welcome
9:10-9:35	Geomorphic Natural History of the Lake Champlain Basin
9:35-10:00	Natural Communities of Clay Soils in the Lake Champlain Basin
10:00-10:25	Introduction to Clay Mineralogy
10:25-10:40	Break
10:40-11:05	Agri-environmental Issues in Clay Soils Focusing on Drainage
11:05-12:15	Panel- Working with Champlain Valley Clay Soils
12:15-1:15	Lunch
1:15- 1:45	Mapping Clay Soils
1:45 - 4:00	Field demonstrations, soil test pits analysis, redoximorphic features evaluation, percolation testing, and Amoozemeter demonstrations.

Confirmed Speakers Include:
Peter Ryan , Middlebury College Geology, Chair
Marc Lapin, Middlebury College, Environmental Studies
Caroline Alves, USDA-NRCS Soil Scientist, Vermont
Thomas Villars, USDA-NRCS Soil Scientist, Vermont
Donald Ross, UVM Plant and Soil Science, Crop and Soil Testing
William Amidon, Middlebury College Geology, Assistant Professor
Rebecca Bourgault, UVM Plant and Soil Science, Graduate Student
Eric Young, Agronomist/Soil Scientist, Miner Institute, NY
Craig Heindel, Hydrogeologist, Heindel &Noyes
Karen Dudley, NRCS Soil Scientist, New Hampshire
Ernest Christianson, DW&GWP Division, State of Vermont

The costs associated with attending this event are as follows:
Credit: $ 100.00
Non-credit: $ 50.00
Student: $ 20.00

Registration information can be found at :
http://www.middlebury.edu/academics/geol/clay_symposium

Parking is free and located at McCardell Bicentennial Hall

VERMONT GEOLOGICAL SOCIETY CALENDAR

April 28: Spring Meeting, VGS, Middlebury College. See announcements within this newsletter.

October 1: Student Research Grant Program applications due, to Jon Kim. Please see the website for format information. Jon can be reached at the phone and email listed below.

Vermont Geological Society
Department of Geology and Environmental Science
Norwich University
Northfield, VT 05663

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

Vermont Geological Society
Spring Meeting
April 28, 2012, 8:15 AM
McCardell Bicentennial Hall, Room 220
Middlebury College, Middlebury, Vermont