QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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THE VERMONT GEOLOGICAL SOCIETY ANNUAL SPRING STUDENT PRESENTATION MEETING

April 27, 2019, 8:30 am
University of Vermont Department of Geology
Delehanty Hall, 180 Colchester Avenue Burlington, VT

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PRESIDENT'S LETTER

Since, 2017, the Vermont Geological Survey has collaborated with partners at the University of Vermont and Green Mountain College to conduct unmanned aerial vehicle (UAV= "drone") surveys of fractured bedrock sites in the Champlain Valley of west-central Vermont. The purpose of these studies is to develop a detailed understanding of the fracture and brittle fault systems that may influence groundwater flow and contaminant transport. In addition, these studies help us to decipher the structural and tectonic history of the Champlain Valley from the Ordovician to Neogene.

The "birds-eye view" from a UAV strongly complements the line of sight- and outcrop-scales that are normal vantage points. The UAV has an on-board camera and GPS and is directed telemetrically from the operator on the ground. For our studies, the UAV was flown in parallel lines at altitudes ranging from 35-80' until the outcrop of interest was covered. The georeferenced photos acquired during the survey were then downloaded and assembled in GIS to make an outcrop mosaic, and all fractures and faults were digitized on the mosaic.

Intensive field surveys always accompany UAV surveys and involve the measurement of structural features (bedding, fractures, and faults) and noting their relationship(s) to one another throughout the drone survey area. For areas where structural relationships are especially clear, scanlines (all structures intersecting a measuring tape are measured) and scangrids (all structures within a 3' square defined by steel rulers) are used. The drone mosaic and field data are ultimately integrated in GIS. For examples of two recent studies, see the poster citations (and links) below on the Vermont Geological Survey website. These posters were presented at recent Geological Society of America-Northeastern Section meetings.

VGTR2019-1: Portnoy, S., Kim, J.J., Klepeis, K., and Van Hoesen, J., 2019, Using Unmanned Aerial Vehicle (UAV) Photogrammetry to Revisit a Classic Outcrop: Shelburne Boat Access (SBA), West-Central Vermont 2: Vermont Geological Survey Technical Report VGTR2019-1, 1 plate.
https://dec.vermont.gov/sites/dec/files/geo/TechReports/Portnoy%2C%20Kim%2C%20Klepeis%2C%20Van%20Hoesen%2C%202019%2C%20Using%20UAV%20Photogrammetry.....%2CVGSTR2019-1.pdf
VGTR2017-1: Remington, C., Kim, J.J., Klepeis, K., and Van Hoesen, J., 2017, Using Drone Surveys to Interpret the Geometry and Kinematics of a Mesozoic Fault Zone in Dolostones of the Champlain Valley Belt of West-Central Vermont II: Vermont Geological Survey Technical Report VGTR2017-1.
https://anrweb.vt.gov/PubDocs/DEC/GEO/TechReports/VGTR2017-1_Remington%20et%20al,%20Using%20Drone%20Surveys%20to%20Interpret%20Champlain%20Valley%20Fault%20Zone.pdf

UAV "Quadcopter" taking off to conduct a survey of a Monkton Quartzite outcrop (Shelburne boat access area)

John Van Hoesen guiding a UAV survey at the Shelburne boat access

Fracture intensification domain in the Winooski spillway in Williston.

Students measuring every fracture along a scanline in the Winooski spillway.

TREASURER'S REPORT

Finances: The Society is in sound financial health, maintaining a relatively steady-state as regards income and expenses.

Membership Renewal: Please accept my sincerest apologies for the late renewal noticed for 2019 membership dues and research grant program. Keep an eye out for your renewal notice in the coming weeks!

Expenses:	$333.29	winter meeting expenses
	$106.00	Post Office Box – Annual Renewal

Income: $0.00

Balance: Our current balance as of March 29, 2019 is $9,901.77. No new members joined the society since our last newsletter.

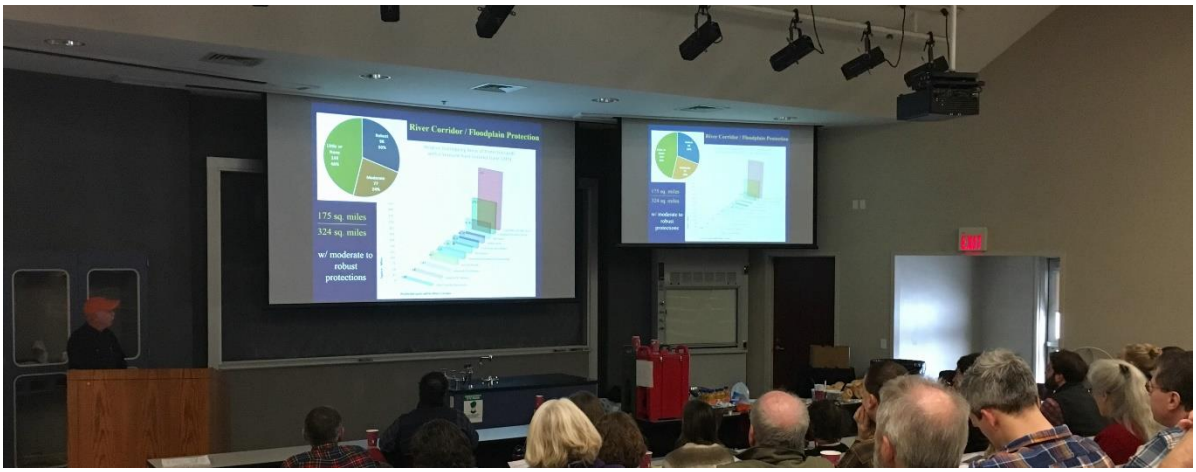
Respectfully submitted,
Carey Hengstenberg, Treasurer

SECRETARY'S REPORT

Winter Meeting Summary - *Focus on Water Quality and Quantity Challenges in the Mad River Valley*
The Vermont Geological Society winter meeting was held at Norwich University in Northfield on Saturday, February 2, and was co-sponsored by the Friends of the Mad River, the Norwich University Department of Earth and Environmental Sciences, and the University of Vermont Departments of Geography and Civil & Environmental Engineering.

With a focus on the Mad River valley geographic region, the event showcased cross-disciplinary research, from academics and consultants, on the effects of extreme events, as well as various modeling and restoration approaches to enhance flood resiliency, improve water quality, and restore aquatic habitats.

Invited speaker, Mike Kline (VT Rivers Program Manager) set the stage with an overview of Vermont's Functioning Floodplains Initiative, aimed at restoring and protecting the physical integrity (i.e., connectivity) of rivers, riparian areas, and floodplains.



Tropical Storm Irene in August of 2011 was the subject of the first three talks. George Springston of Norwich University summarized volunteer efforts in the days and weeks following this extreme event to catalogue high-water marks and estimate peak stream flows in tributaries of the Mad River. Don Ross (UVM Plant and Soil Science) detailed his recent publication estimating sediment and phosphorus loading to the Mad River from eroding streambanks during TS Irene. Scott Hamshaw (VT EPSCoR) reviewed his work using Unmanned Aerial Systems to make remote-sensing based estimates of streambank erosion along the Mad River in the years following TS Irene.

Various modeling approaches offered in the next three talks underscored the significance of road networks as a source of sediment to the Mad River. Jody Stryker (Stone Environmental, Inc.) presented results of a rainfall-runoff model coupled with a geotechnical model to simulate streambank erosion along the Mad River. Beverley Wemple, UVM Geography Department Chair, reviewed an empirical modeling approach to estimate sediment contributions from gravel road networks and quantify the effectiveness of various Best Management Practices. Kristen Underwood (UVM Civil & Environmental Engineering) presented a Bayesian statistical approach to estimate relative proportions of surface soils and subsurface soils (road ditches, gullies) in the suspended sediment load of the Mad River.
The final three talks addressed ongoing restoration and research efforts to enhance lateral and longitudinal connectivity along rivers as a strategy for improving flood resiliency, water quality and aquatic habitats. Rebecca Diehl (UVM Dept. of Geography) introduced a newly-funded research project to map floodplains across the Lake Champlain Basin and quantitatively evaluate the retention of sediment and nutrients. Jessica Louisos (Milone & MacBroom, Inc.) presented a successful floodplain reconnection project along the Dog River, which was implemented following FEMA buyouts after TS Irene, and is now serving to attenuate flood peaks in the community of Northfield. Roy Schiff (Milone & MacBroom, Inc.) wrapped up the morning with an overview of a project to restore fish passage along the Bradley Brook tributary of the Mad River.

The event was well attended including citizens from the Mad River valley and regional watershed groups, as well as VGS members and students. A lively discussion ensued, fueled by pizza.

Respectfully submitted,
Kristen Underwood – Executive Committee

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

Judges are still needed for the Vermont Geological Society Spring Meeting on Student Research that will be held Saturday April 27th at the UVM Dept. of Geology (Delehanty Hall).
One proposal was submitted to the Vermont Geological Society Research Grant Program for the spring deadline (now May 1st) and will soon be evaluated.
Name: Kristen Schnalzer, M.S. student, Geology Dept., University of Vermont
Title: Investigating the timing of deformation in the Chester and Athens Domes with $^{40}Ar/^{39}Ar$ geochronology
Amount: $1000.00

Will Amidon of Middlebury College volunteered to lead the Vermont Geological Society summer field trip on the structural and tectonic implications of U/Pb dates on calcite veins in the Champlain Valley of west-central Vermont. Dave Westerman of Norwich University volunteered to lead the Vermont Geological Society fall field trip on Silurian trondhjemitic intrusions in the Moretown Formation of central Vermont.
Dates, times, and meeting places for both field trips to be announced.

STATE GEOLOGIST'S REPORT

Spring is upon us and we are in the midst of the annual dash to complete and deliver maps to the USGS STATEMAP program and to prepare for the next round of mapping. Maps and GIS data for the Proctor, Richmond and Huntington quadrangles will be delivered in May and uploaded to the web site and the open geodata portal in early June. Maps were completed by John Van Hoesen, Stephen Wright and George Springston. We are also making good progress on the 1:100,000 scale compilation of the Montpelier one-degree sheet. This coming field season we will be mapping in the Groton and Stowe quadrangles, completing the landslide hazard inventory for Orange County, and continuing the compilation of the surficial geology of the Montpelier one-degree sheet.

The Association of American State Geologists (AASG) held their spring liaison in Washington DC in February. I met with staffers from the offices of Senators Leahy (D-VT), Shaheen (D-NH), Capito (R-WV) and Durbin (D-IL) to discuss the National Cooperative Geologic Mapping Program (NGCMP) and its applications to groundwater, hazards, ecosystems, mining reclamation, and infrastructure. I also had an opportunity to discuss issues of importance to these senators and to provide the New England perspective (sometimes different than that of surveys in the mid-continent and west). Most states expressed concern about groundwater quality issues such as PFAS and nitrates contamination. The state geologists, in teams of 3-4, visited 31 congressional offices and met with 25 of our federal partners including USGS, the National Park Service, NASA, and EPA. The Spring Liaison and AASG meetings are important venues for Vermont and other New England state surveys to voice our issues to external partners and to the AASG organization. The New England state geologists are working to define shared priorities and strengthen our collaboration and communications.

Recent projects

The Geology Division worked with the Health Department (VDH) since 2009 to develop maps of the distribution of radon in air as it relates to bedrock and surficial materials. We released an Open File Report by Jon Kim, Peter Young and Nicholas Peterson (Health Dept.) with maps of over 14,000 radon test locations and statistics for the percentage of elevated radon tests by generalized bedrock zones. We also posted a radon web page: https://dec.vermont.gov/geological-survey/health/radon with links to our maps and to the new interactive web site developed by the Vermont Department of Health.

The Geology Division and key DEC personnel (Colin Dowey, Eric Engstrom, Scott Stewart, Tim Phillips, Heather Campbell, Jeff Crocker and Rodney Pingree) made substantial upgrades to water data with support from the USGS Water Use Data and Research grant program. Colin and company upgraded locations in the Well Completion Report database and assigned well type to over 80,000 records, completed and populated a database for Snowmaking Water Use data, and linked monthly-reported data from public water supplies with source location information. In addition, the multi-division group created a scheduled task to run a python script that will update the well driller report GIS layer on the ANR Atlas on a nightly basis. Only three counties remain for review of data and locations: Addison, Orleans and Rutland.

Presentations at the Northeast Section Geological Society of America meeting

Jon Kim (Geology), Patti Casey (VAA) and Jeff Comstock (VAA, retired) presented on nitrates. The Vermont Geological Survey (VGS) and Agency of Agriculture (VAA) have collaborated for 17 years to understand the fate and transport of nitrates at large dairy farms in Vermont, where groundwater from farm and domestic wells (and springs) exceeds the maximum contaminant level (MCL) of 10 ppm. Aquifer characterization studies were completed at farms in Sheldon and East Montpelier, are ongoing in Hardwick and Sutton, and are planned in Bristol and Irasburg. The goal of these studies is to build a geologic framework that can be used to guide nutrient management practices.

Jon Kim, Peter Ryan (Middlebury College), Timothy Schroeder (Bennington College), Edwin Romanowicz (SUNY Plattsburgh), David Boutt (UMASS) and Marcel Belaveau (EPA) presented on their use of groundwater tracers to assess the fate and transport of PFOA in groundwater in Bennington.

The multi-disciplinary methodology was effective in characterizing this heterogeneous and anisotropic aquifer system, where thrust faults and fracture zones strongly influence groundwater flow.

Colin Dowey (Geology) presented a poster to document the improved subsurface geologic information obtained through updated water well logs and database improvements. Samantha Portnoy, a summer intern, presented results of her work on a detailed statistical analysis of structures in fractured rock in Shelburne. Ryan Van Horn, Timothy Quesnell, Sam Knapp and Frank Piaseki, summer interns working with Stephen Wright of UVM, presented a poster on the results of their geologic mapping in the Richmond area.

Charles A. "Chuck" Ratte' remembrance

Charles A. "Chuck" Ratte', Vermont State Geologist from 1976-1991, passed away on February 20, 2019 at the age of 91. Chuck was the 11th State Geologist and successfully transferred the responsibilities of the Survey from the University of Vermont to the Agency of Natural Resources, performed a survey of radioactivity in Vermont rocks and grappled with the issues of radioactive waste siting in Vermont. In 1989, he spirited legislation through the State House that redefined the mission of the State Geologist and set us on our current course. Chuck was a mentor and friend to many in our geologic community and we'll miss him.

The Isle LaMotte Preservation Trust is hosting a Gathering of Remembrance in honor of Chuck at 2 pm on June 15, 2019 at Fisk Farm, 3849 West Shore Rd., Isle La Motte. Chuck was instrumental in preserving the Fisk Quarry Preserve, an internationally known geological site, now designated as a National Natural Landmark by the US Department of the Interior. If you plan to attend, please reply to Linda Fitch at 802-238-7040 or linda@ilmpt.org.

Respectfully Submitted,
Marjorie Gale
Vermont State Geologist

2019 SPRING MEETING PROGRAM

(Order of presentations is subject to change)

LOCATION: University of Vermont Department of Geology Delehanty Hall, 180 Colchester Avenue Burlington, VT

8:30 AM - COFFEE & REFRESHMENTS

9:00 AM -- INVESTIGATION OF CRYOGENIC CAVE CARBONATES FROM WINTER WONDERLAND CAVE, UINTA MOUNTAINS, UTAH, USA
KIMBLE, Kristin, MUNROE, Jeff, WALCOTT, Caleb, Department of Geology, Middlebury College, Middlebury, VT 05753, USA; and HERRON, David, USDA Forest Service, Ashley National Forest, Duchesne, UT 84021, USA

9:15 AM -- CORRELATION OF VOLCANIC DEPOSITS BY MINERALOGY, GEOCHEMISTRY, AND RADIOCARBON DATING: IMPLICATIONS FOR ASSESSING VOLCANIC ACTIVITY AND RISK IN COSTA RICA
BARCA, Malia, RYAN, Peter, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

9:30 AM -- CHANGES IN FLUORESCENCE CHARACTERISTICS AS A FUNCTION OF SUBSTRATE QUALITY AND MICROBIAL ACTIVITY: TESTING A CONCEPTUAL MODEL
LANDSMAN-GERJOI, M., LANCELOTTI, B, SEYBOLD, E., PERDRIAL J, ADAIR, C. SCHROTH, A., University of Vermont, Burlington, Vermont

9:45 AM -- MODELING CLIMATE CONSTRAINTS ON THE FORMATION OF PLUVIAL LAKE BONNEVILLE IN THE GREAT BASIN, USA
BELANGER, Bryce, AMIDON, William, Department of Geology, Middlebury College, Middlebury VT 05753, USA LAABS, Benjamin, Department of Geosciences, North Dakota State University, Fargo, North Dakota 68102, USA MUNROE, Jeffry, Department of Geology, Middlebury College, Middlebury VT 05753, USA

10:00 AM - APATITE DISSOLUTION: MICRO AND NANOSCALE INSIGHTS
CONDE, Adele University of Vermont, Burlington, Vermont

10:15 AM - LOW-TEMPERATURE THERMOCHRONOLOGY ACROSS A PORTION OF THE NORUMBEGA FAULT SYSTEM, CASCO BAY, MAINE
DE BEER, Miranda-Max, WEST, David P., AMIDON, William H., Department of Geology, Middlebury College, Middlebury, VT 05753, USA

10:30 AM - BREAK, COFFEE & REFRESHMENTS

10:45 AM - EXPLOSIVITY AND ERUPTION DYNAMICS OF A PLEISTOCENE CINDER CONE IN THE LASSEN REGION: INSIGHTS FROM TEXTURAL AND GEOCHEMICAL ANALYSES
KAELIN, Samuel, WALOWSKI, Kristina, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

11:00 AM - PETROGENESIS OF A PARTIALLY SERPENTINIZED DUNITE IN SOUTHERN VERMONT BRIGHAM, John Mark and BALDWIN, Suzanne, Department of Earth Sciences, Syracuse University, Syracuse, New York

11:15 AM - TESTING THE CAPABILITIES OF MACHINE LEARNING AND REMOTE SENSING TO QUANTIFY THE CARBON STORAGE OF VERMONT FORESTS
LEPINARD, Octave, AMIDON, Will, Geology Department, Middlebury College, Middlebury, VT 05753, USA

11:30 AM – CLINOPYROXENE BAROMETRY OF THE RED LAKE MOUNTAIN CINDER CONE MAGMA, LASSEN NATIONAL PARK, CA: IMPLICATIONS FOR MAGMA STORAGE DEPTHS
MOFFAT, Kye, WALOWSKI, Kristina, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

12:00 AM - A LATE-PLEISTOCENE – MID-HOLOCENE LUMINESCENCE-BASED CHRONOLOGY OF PLUVIAL LAKE CLOVER, NEVADA, USA
WALCOTT, Caleb, MUNROE, Jeff[1], AMIDON, Will[1], BELANGER, Bryce[1], LAABS, Ben[2]
[1]Geology Department, Middlebury College, Middlebury, VT 05753, USA
[2] Department of Geosciences, North Dakota State University, Fargo, ND 58102, USA

12:15 PM - SOIL AGGREGATE STABILITY AND DOC RELEASE AS A FUNCTION OF CHEMICAL CHANGES IN SOIL SOLUTION CHEMISTRY.
ADLER, Thomas, PERDRIAL, Julia N, UNDERWOOD, Kristen L, RIZZO, Donna M, HANG WEN, Li Li, HARPOLD, Adrian, STERLE, Gary, SHANLEY, James RYAN, Kevin, University of Vermont, Burlington, Vermont

12:30 PM – BREAK, PIZZA & REFRESHMENTS and JUDGING

1:15 PM—AWARDS CEREMONY

1:30 PM - ADJOURN

STUDENT ABSTRACTS

INVESTIGATION OF CRYOGENIC CAVE CARBONATES FROM WINTER WONDERLAND CAVE, UINTA MOUNTAINS, UTAH, USA

KIMBLE, Kristin, MUNROE, Jeff, WALCOTT, Caleb, Department of Geology, Middlebury College, Middlebury, VT 05753, USA; and HERRON, David, USDA Forest Service, Ashley National Forest, Duchesne, UT 84021, USA

Cryogenic cave carbonates (CCC) are a unique type of speleothem associated with ice in caves. One particular type of CCC, known as CCC_{coarse}, is thought to form under transient climatic conditions when permafrost is degrading above a frozen subsurface. CCCs are the target of increasing research interest in Eurasia, but have not been widely studied elsewhere. Most CCCs reported from Eurasia are found in presently ice-free caves and date from the Last Glacial Maximum.

Here we report on what we believe to be the first examples of CCC_{coarse} in North America, from the recently discovered Winter Wonderland ice cave in the Uinta Mountains, Utah. The cave, which is located at an elevation of 3140 m in Mississippian-age Madison Limestone, has a surveyed length of 245 m, about half of which is floored by perennial ice locally at least 2 m thick. Dataloggers deployed in the cave from August, 2016 through August, 2018 reveal consistent subzero temperatures. CCCs occur as a layer of crystal aggregates 5-10 mm thick on the surface of the ice flooring the cave and on the tops of breakdown blocks emerging as the ice surface lowers through sublimation. The CCCs range in color from dirty white to orange/brown and visually resemble CCCs presented in the literature. Under SEM magnification, CCCs are resolved as globular aggregates of spheroidal bodies with a mean grain size of 20 microns. X-ray diffraction reveals that the CCCs are predominantly calcite, which is corroborated by XRF analysis confirming CaO as the most abundant oxide. Stable isotope values in the most calcite-dominated CCCs range from 1‰ to 6‰ VPDB for $\delta^{13}C$ and -14‰ to -21‰ VPDB for $\delta^{18}O$, confirming that these samples are CCC_{coarse}. U-Th dates suggest that the CCCs are forming in the present day. These samples were collected in late August, 2018. At that time, shallow pools of water that had entered the cave during the summer were observed freezing on the ice surface. Although the sampled CCC_{coarse} were noted on the ice surface before the arrival of this newest water, Winter Wonderland Cave may present the possibility of observing CCC_{coarse} formation *in situ*. Future efforts should be focused on monitoring the fate of inflowing water and the possible formation of new CCCs.

CORRELATION OF VOLCANIC DEPOSITS BY MINERALOGY, GEOCHEMISTRY, AND RADIOCARBON DATING: IMPLICATIONS FOR ASSESSING VOLCANIC ACTIVITY AND RISK IN COSTA RICA

BARCA, Malia, RYAN, Peter, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

An important component to evaluating present day risks in volcanically active landscapes is the capacity to date and correlate deposits left behind by past destructive events. This type of analysis can potentially facilitate the determination of recurrence intervals, providing insight into the probability of volcanic events occurring in the future. The destruction and loss of lives caused by a lahar in 2016 provides the impetus for such analysis on two inactive volcanoes in Costa Rica: Barva and Miravalles. Barva looms over the Valle Central (home to 2.5 million people), while Miravalles is in the rural north of Costa Rica and is host to a large geothermal field that may be at risk of damage from volcaniclastic activity.

The aim of this study is to ascertain the latest Pleistocene through Holocene eruptive histories of the Barva and Miravalles volcanoes through the mineralogical, geochemical, and geochronological analysis of their deposits. A total of 58 samples from 9 different sites were collected and analyzed using X-ray diffraction (XRD), X-ray fluorescence (XRF), and inductively coupled plasma mass spectrometry (ICP-MS). Five the samples were collected from two sites at Barva, including weathered and fresh lava, volcanic ash, and cinders, while 53 samples of lahars, pyroclastic flows, ash, cinders, and lava were collected from 7 sites at Miravalles. Among the locations of the 58 samples obtained, an additional 22 samples were collected for radiocarbon dating and 16 samples were collected to undergo IRSL analysis by Sebastien Huot (Illinois State Geology Survey).

Luminescence dating of plagioclase indicates that the most recent activity on the flanks of Barva – a cinder cone eruptive phase – occurred 16.8 ka +/- 1.1 ka. On the flanks of Miravalles, carbon dating indicates the occurrence of at least 11 lahars, 12 ash, lapilli or pumice events, a pyroclastic flow, and an extensive lava flow in the past 5,700 years. Lahars seem to pose the greatest risk, with seven major events in recent times (2016 A.D., 1540 A.D., 1410 A.D., 1155 A.D., 675 A.D., 460 A.D. and 170 A.D. – C.E., cal), as well as a pulse of four extensive lahar events between 470 B.C. to 1110 B.C. (2.4 and 3.1 ka, cal). XRF and ICPMS analysis indicate that deposits mainly carry a basaltic-andesitic composition and thus far indicate that unweathered lahar, ash, and lapilli deposits along the flanks of Miravalles do not demonstrate a significant geochemical fingerprint that allows for deposit correlation across the landscape. However, XRD analysis of the <2 micron fraction shows distinctive differences in the extent of chemical weathering in paleosols formed throughout the stratigraphy at Miravalles, including one very well-developed 4.2 ka paleosol below a lahar that may serve as a marker bed. Paleosols also serve as a proxy for length of exposure to the weathering environment of a given deposit before burial by the subsequent event. Current analysis includes assessment of recurrence intervals and risk, as well as continued correlation of deposits across the landscape. An additional 10 radiocarbon dates (soon to be determined) will ultimately be incorporated into the data set.

CHANGES IN FLUORESCENCE CHARACTERISTICS AS A FUNCTION OF SUBSTRATE QUALITY AND MICROBIAL ACTIVITY: TESTING A CONCEPTUAL MODEL

LANDSMAN-GERJOI, M., LANCELOTTI, B, SEYBOLD, E., PERDRIAL J, ADAIR, C. SCHROTH, A., University of Vermont, Burlington, Vermont

Dissolved organic matter (DOM) is a complex mixture of labile and bioavailable carbon (C) that is readily processed by microorganisms and can potentially impact global atmospheric pCO_2. Fluorescence spectroscopy is a simple way of assessing bioavailability and a fast and reliable method to determine DOM characteristics. However, recent studies indicate that no single fluorescence-derived parameter reliably predicts bioavailability across the broad spectrum of C sources in natural environments. For example, a study by Wymore et al. (2015) showed that as the fluorescence index (FI) decreased, bioavailability increased, while a study by Johnson et al. (2011) showed decreased FI usually correlated with decreased bioavailability. To address this discrepancy, we developed a conceptual model where change in DOM fluorescence was modeled as a function of substrate quality and microbial activity. We tested variations in substrate and microbial activity over four seasons and landscape positions using water extractable DOM from soils (e.g. microbial biomass, % respired C) and measured fluorescence metrics including FI, humification index (HIX), and relative abundance of parallel factor (PARAFAC) analysis components. Samples were taken from a broad spectrum of C sources (streams, soils, and ground water), and landscape position (proximity to a stream and elevation) from well-studied sites in Northern Vermont. Our results suggest that gradual shifts in substrate quality and microbial

activity by season and landscape position are reflected by shifts in fluorescence metrics, especially FI, which increases from hilltop through hillslope. Additionally, PARAFAC components change in relative abundance depending on site, season, and position within the transect.

Johnson, M., Couto, E., Abdo, M., Lehmann, J., 2011. Fluorescence index as an indicator of dissolved organic carbon quality in hydrologic flowpaths of forested tropical watersheds, 105, 149-157 pp.
Wymore, A. et al., 2015. Leaf-litter leachate is distinct in optical properties and bioavailability to stream heterotrophs, 34.

MODELING CLIMATE CONSTRAINTS ON THE FORMATION OF PLUVIAL LAKE BONNEVILLE IN THE GREAT BASIN, USA

BELANGER, Bryce, AMIDON, William, Department of Geology, Middlebury College, Middlebury VT 05753, USA LAABS, Benjamin, Department of Geosciences, North Dakota State University, Fargo, North Dakota 68102, USA MUNROE, Jeffry, Department of Geology, Middlebury College, Middlebury VT 05753, USA

Understanding how precipitation patterns will change in terrestrial areas in the future is one of the most important unanswered questions in climate change modeling. Reliable data on terrestrial paleo-precipitation is fundamental when making these predictions, as climate modelers must be able to accurately calibrate their models before applying them to future climate scenarios. This study will use the water-balance model developed by Condom et al. (2004) to determine the factor by which temperature decreased and precipitation increased during the late Last Glacial Maximum (LGM) in the Great Basin USA, enabling the persistence of Lake Bonneville during this period. In addition, this study will seek to investigate various theories interpreting the driving factors of pluvial lake formation in the Great Basin during the late LGM.

Lake Bonneville was the largest of the Great Basin pluvial lakes, with a maximum surface area exceeding 50,000 km^2, more than 10 times the size of modern Great Salt Lake and roughly the same size as modern Lake Michigan (McGee et al., 2012). The evaporation equation developed by Condom et al. (2004) has been determined to be the most effective equation for modeling evaporation in the Lake Bonneville basin from March-November, as the average SSR between observed and modeled evaporation at five sites throughout the Bonneville basin was calculated at 0.76. This selected evaporation model was used in conjunction with the Condom et al. (2004) water-balance model to reconstruct paleoclimate conditions in the Bonneville basin at various relative highstands of Lake Bonneville during the late LGM. For the late Pleistocene, the highstand of Lake Bonneville is well predicted by linear combinations of 6°C to 9°C decreases in temperature and corresponding changes in precipitation from 1.1 to 0.9 times modern values.

APATITE DISSOLUTION: MICRO AND NANOSCALE INSIGHTS

CONDE, Adele University of Vermont, Burlington, Vermont

The weathering of apatite is the foundation of the phosphorus cycle and essential to life, yet little is known about the nanoscale mechanisms driving apatite weathering. Deciphering nanoscale dissolution in apatite is a major step to understand phosphate behaviour in planetary systems, a key to the origins of life. Determining what controls apatite weathering can impact many areas of environmental and medical mineralogy such as dentistry, contaminant scavenging, geochronology or paleoenvironment studies. Recent research on the weathering of silicate minerals at the nanoscale has provided telling evidence of

a relatively new chemical weathering model referred to as coupled interfacial dissolution-precipitation (CIDR) mechanism. We hypothesize that this mechanism could be broadened to phosphate minerals.

To test our hypothesis, we acid-reacted crystals of fluorapatite (FAP) and hydroxylapatite (HAP) in flow-through devices with pH 3 HNO_3 solutions. Determination of the mechanisms of dissolution was carried at multiple scales using chemical analyzes (macroscale), SEM (microscale) and STEM-HAADF-EELS on FIB liftouts (nanoscale).

At the macroscale, we observed that the anionic composition of the apatite controls its weathering rate with, unsurprizingly, faster dissolution rates for HAp compared to FAp. SEM characterization of the crystal surface pre- and post-dissolution revealed the development of etch pits during dissolution, however more pronouced for FAp than HAp. Observation of the mineral/solution interface at the nanoscale using STEM-HAADF revealed the development of a nanometric amorphous layer depleted in Ca compared to P.

The observation of a sharp crystalline/amorphous transition a few nanometers thick, associated with sharp depletion in Ca suggests that, similar to silicate, apatite is subjected to a coupled interfacial dissolution-reprecipitation mechanism. This discovery has the potential to transform our understanding of phosphate behavior in medical and environmental mineralogy fields.

LOW-TEMPERATURE THERMOCHRONOLOGY ACROSS A PORTION OF THE NORUMBEGA FAULT SYSTEM, CASCO BAY, MAINE

DE BEER, Miranda-Max, WEST, David P., AMIDON, William H., Department of Geology, Middlebury College, Middlebury, VT 05753, USA

The ancient Norumbega fault system in Maine is one of the largest in eastern North America and, when active, was likely comparable in scale to the present-day San Andreas fault system in California. However, determining when portions of the Norumbega fault system were active has proven to be a challenge to geologists. The goal of this research is to constrain the timing of latest movement along this fault system in the Casco Bay region of Maine using (U-Th)/He apatite thermochronology. The methods in this study involve collecting rocks from either side of the fault system, separating apatite crystals from these rocks, determining their isotopic compositions, and modeling the results. This process results in a detailed time-temperature history of the rocks exposed on either side of the fault system and reveals when these rocks were at specific depths in the Earth's crust. Assessing the role of fault re-activation in facilitating post-tectonic uplift in older mountainous regions is important in understanding the complete evolution of mountain belts. In-depth study of a presumably inactive fault system thus allows not only for local, pinpointed knowledge of late displacement along a single fault system, but also general information on the role of these types of faults in facilitating post-tectonic uplift.

Finding similar time-temperature histories on either side of the fault system would imply no significant vertical motion during the time interval revealed by the modeling (in this case between about 130 and 90 million years ago). However, (U-Th)/He dates from the western side of the most prominent fault in the system (Flying Point fault) range from 130 – 72 Ma while those from the eastern side range from 177 – 82 Ma. Modeling of the data is still in progress, but preliminary results indicate some vertical displacement within the last 100 million years. Additionally, modeling from all samples reveals a period of accelerated cooling in the Late Cretaceous, consistent with findings in other parts of New England.

EXPLOSIVITY AND ERUPTION DYNAMICS OF A PLEISTOCENE CINDER CONE IN THE LASSEN REGION: INSIGHTS FROM TEXTURAL AND GEOCHEMICAL ANALYSES

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Cinder cones are one of the most common expressions of volcanism in the Lassen region of the Cascade Arc, yet their explosivity and hazard potential remain poorly constrained. Here, we use textural, compositional, and geochemical analyses to characterize the proximal scoria deposit of the Late Pleistocene eruption of Poison Butte, a cinder cone ~13 km NE of Lassen Peak, in Lassen Volcanic National Park, California. Poison Butte is a unit of the Poison Lake Chain, a sequence of basaltic cinder cones following a NW-SE lineament. Scoria samples were collected from an exposed 1m section of cone and analyzed for texture and componentry. We find that variations in vesicle and component distributions indicate a dynamically explosive eruptive episode with shifting phases. Through a comparison of observation-linked studies of Parícutin, Mexico (Pioli et al., 2008) and Mt. Etna, Italy (Polacci et al., 2006), we hypothesize the eruptive phases proceeded in moderate Strombolian style interposed with paroxysms of near Violent Strombolian activity. Through integration our data with previous melt inclusion geochemical work done by Walowski et al. (2016), we present a model for magmatic ascent and degassing process in which we propose shallow (<1km) crustal stalling as an important control for the variability of eruptive style exhibited in cinder cones. By extending this comparison to basaltic composite cones we aim to gain broader insight into cinder cone mechanisms and better inform future hazard models.

PETROGENESIS OF A PARTIALLY SERPENTINIZED DUNITE IN SOUTHERN VERMONT

BRIGHAM, John Mark and BALDWIN, Suzanne, Department of Earth Sciences, Syracuse University, Syracuse, New York

Ultramafic rocks exposed on the Earth's surface offer a rare opportunity to directly study the petrology of the upper mantle. The Appalachian Mountains of Vermont contain variably serpentinized ultramafic rocks that mark the suture zone for the Ordovician Taconic Orogeny. In southern Vermont, the ultramafic rocks were subsequently metamorphosed to amphibolite facies during the Devonian Acadian Orogeny. Key localities in the East Dover ultramafic body (meta-dunite) were sampled along with representative surrounding lithologies to further constrain the tectonic evolution of the region. This study aims to determine the petrogenesis of the East Dover meta-dunite by analyzing both primary and metamorphic minerals, identifying previously undocumented minerals, and analyzing surrounding lithologies to constrain the pressure-temperature evolution the region. Petrographic analysis reveals three generations of olivine based on textures preserved. Type 1 is interpreted to be primary olivine and occurs as inclusions in chrome spinel. Type 2 is serpentinized olivine. Type 3 olivine is fresh olivine that cross cuts highly serpentinized olivine. Electron microprobe analyses of the East Dover meta-dunite reveals an increase in forsterite component as a function of olivine textures between type 1 (Fo_{86}-Fo_{89}), type 2 (Fo_{88}- Fo_{91}), and type 3 (Fo_{90}-Fo_{95}). The increase in the forsterite component of olivine is hypothesized to result from the dehydration of antigorite serpentine (during the Acadian Orogeny) to form talc, tremolite, and forsterite (Fo_{90}-Fo_{95}). Additional electron microprobe analyses reveal previously undocumented minerals, including geversite ($PtSb_2$), nickeline (NiAs), and hydrous nickel silicate minerals (garnierite). Although arsenic bearing minerals have not been documented Vermont,

whole rock geochemical analysis (XRF) shows that the East Dover meta-dunite has similar arsenic concentrations (7-100 ppm) compared to other ultramafic rocks in Vermont.

TESTING THE CAPABILITIES OF MACHINE LEARNING AND REMOTE SENSING TO QUANTIFY THE CARBON STORAGE OF VERMONT FORESTS

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In a world plagued by global warming, accurately measuring the amount of carbon stored in forests is vital for proper resource management. Measurement of carbon storage is traditionally done by field surveying, measuring the diameter at breast height (DBH) of trees and using regression algorithms previously determined by species to calculate the above ground biomass. This method, although resulting in high accuracy, is too resource intensive to scale without a large degree of extrapolation and too expensive for extremely remote areas. Thus, we seek to develop new methods for quantification of above ground biomass by combining remote sensing with machine learning. With the growing availability of high spatial and temporal resolution satellite imagery, changes in forest lands can be observed daily and with high precision. Similarly, recent advancements in machine learning have led to a great diversification of its use.

In this study we use Landsat (30m, 8 Band) and Planet (3m, 4 Band) imagery combined with Light Detection and Ranging (LiDAR) data, slope, aspect, NDVI, band ratios as inputs to a ‘random forest’ machine learning algorithm. Imagery was selected from all season in order to test for the success of the algorithm given various leaf color/cover. The algorithm uses 1500 US Forest Service plots in Vermont as ground truthing data to train and validate our machine learning algorithm. The Forest Service dataset is split into subgroups, with 70% of sites used to train the model and 30% used to validate the Random Forest machine learning algorithm. Once the algorithm is trained and validated, inputs can consist of only satellite imagery and output carbon values creating new informative output datasets.

When tested on the US forest service plots the model demonstrated its ability to differentiate various forests type, which it did significantly more accurately when given canopy height then with only satellite imagery. Other remotely sensed data such as aspect and slope seemed to have no significance on the success of the model. Preliminary results demonstrate that the number of bands in the dataset benefits the model more than higher resolution.

CLINOPYROXENE BAROMETRY OF THE RED LAKE MOUNTAIN CINDER CONE MAGMA, LASSEN NATIONAL PARK, CA: IMPLICATIONS FOR MAGMA STORAGE DEPTHS

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Cinder cones are the most common surficial volcanic landforms on Earth and in the Lassen Region of the northern California. Due to their abundance, the potential to erupt in a violent Strombolian manor, and ability to disrupt infrastructure, it important to have a better understanding of their pre-eruptive magmatic development. In this thesis, the geochemical evolution and pre-eruptive storage depths are constrained for magmas erupted from the Red Lake Mountain Lava Cone, Lassen Region, CA, through bulk geochemical analyses and in situ mineral analysis of clinopyroxene (CPX) phenocrysts. The CPX compositions were determined by Electron Probe Microanalysis (EPMA) and compared to analyses of the same crystal using an Energy-dispersive X-ray Spectroscopy (EDS) detector on a Scanning Electron

Microscope (SEM). Because <20% of mafic magmas erupted from cinder cones in the Lassen Region contain CPX as a major phenocryst phase, the underlying reasons for the presence of CPX are also explored. Backscatter Electron imagery and EPMA results indicate that ~75% of the interrogated CPX phenocrysts display complex and sharp zones, which may indicate distinct and abrupt changes in the P/T conditions or melt compositions. Thus, a CPX-liquid barometer is used to constrain the depths of magma storage prior to eruption. The results may help to inform hazard models of the Lassen Region. Lastly, information on the ability of the SEM with an EDS detector to analyze mineral compositions through a statistical comparison with the more widely used EPMA method will be useful to further student research at Middlebury College.

A LATE-PLEISTOCENE – MID-HOLOCENE LUMINESCENCE-BASED CHRONOLOGY OF PLUVIAL LAKE CLOVER, NEVADA, USA

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Pluvial lakes occupied many topographically closed basins in the southwestern US during wetter times of the Quaternary. Ridges of coarse sand and gravel constructed by storm waves on these lakes are unequivocal testimony to the former presence of large bodies of water. Given the aridity of the modern climate in this region, and the corresponding lack of widespread surface water, pluvial lakes are important indications of prehistoric changes in effective precipitation (precipitation - evaporation). Chronologies of lake level change are therefore useful in interpreting past climatic variability. We are using optically-stimulated luminescence (OSL) dating to create a lake level chronology for Lake Clover (northeastern Nevada, USA), which had a surface area of ~800 km^2 at its maximum extent. Samples (n=12) were obtained from a series of well-developed beach ridges in the north-central part of the area inundated by Lake Clover. Samples were collected at depths of ~80 cm below the surface in hand-dug pits on the crest of each beach ridge. Ten samples represent individual beach ridges spanning ~15 m of elevation, and two additional samples were collected from the highest and lowest shorelines as replicates. Samples were processed in the Middlebury College Luminescence Laboratory using standard procedures to isolate quartz in the 80-250 µm fraction. Results obtained using the SAR protocol and a Daybreak 2200 OSL reader suggest that Lake Clover was present in the early Holocene. This result is unexpected, because gastropod shells from two different sites along the highstand ridge of Lake Clover yielded late Pleistocene ages in a previous study. However, previous attempts to apply OSL dating to Lake Clover shorelines, with analyses made in a different laboratory, also yielded relatively young ages spanning the Pleistocene-Holocene transition. Reworking of older shells in newer storm deposits may account for the discrepancy between OSL and ^{14}C ages if the shorelines are truly of early Holocene age. These ages group into two distinct clusters, suggesting two separate transgressive and regressive events. One dates to just prior to the onset to just after the end of the Younger Dryas, and the other dates to the Mid-Holocene. These ages give useful insight into the climate history of the Clover Valley and the Great Basin.

SOIL AGGREGATE STABILITY AND DOC RELEASE AS A FUNCTION OF CHEMICAL CHANGES IN SOIL SOLUTION CHEMISTRY.

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Long-term watershed monitoring indicates that in the past few decades dissolved organic carbon (DOC) flux has been increasing in forested headwater streams throughout the northeastern United States, as well as central and northern Europe. This has raised concerns due to the pronounced role DOC has in aquatic/terrestrial ecosystem functions, the global carbon cycle and water quality treatment. An array of hydrologic, biotic and geochemical variables have been recognized as potential drivers for these observed trends, however their order of influence has yet to be well defined. We hypothesize that the destabilization of soil aggregates as a function of soil solution chemistry is one of the essential drivers that contribute to rising DOC levels. Furthermore, we hypothesize that the aggregate stabilizing mechanism varies with soil composition. To test these hypotheses, we characterize aggregate composition and use soil column experiments to assess the effect of soil water pH and composition on DOC mobilization. We use samples from two locations: i) the Susquehanna Shale Hills Critical Zone Observatory (SSHCZO) in Pennsylvania and ii) the Sleepers River Research Watershed (SRRW) in Vermont. Both sites are well studied and long-term hydrological and soil chemical data are available and vary in bedrock and soil composition.

ANNOUNCEMENTS

Please send announcements that are pertinent to our membership to the VGS publications manager as listed below.

CALENDAR

University of Vermont Geology Seminar Series
Date: April 29, 2019
Location: Delehanty Hall, Burlington, VT
Information: Dr. Chris Marone from Penn State University will present “The Mechanics of Slow Earthquakes and the Spectrum of Fault Slip Behaviors”.

AAPG Annual Convention
Date: May 19-22, 2019
Location: San Antonio, TX

New England Intercollegiate Geologic Conference (NEIGC)
Date: Fall, 2019 TBA
Location: TBA

AIPG Annual Meeting
Date: September 14 - 17, 2019
Location: Burlington, VT

Earth Science Week 2019
Date: October 13-19, 2019

Great ShakeOut Earthquake Drills
Date: October 17, 2019
Time: 10:17 am
Location: USA and International
Information: Register your local school, business, organization or family to be counted in the ShakeOut. Planning tools, pamphlets, talking points, earthquake information and more are available on-line.

Geological Society of America Annual Meeting
Date: September 22-25, 2019
Location: Phoenix, AZ

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