THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

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PRESIDENT'S LETTER

I want to begin this letter by quickly introducing myself as the new president of the Society. For those of you who don't know me, my name is Stephen Wright and I am a senior lecturer in the UVM Geology Department. I was formally trained as a structural geologist and used hundreds of small faults within a Laramide monocline in Colorado to understand its folding history for my MS thesis and later did my Ph.D. work in northern Sweden trying to better understand the deformation history of a group of early Proterozoic rocks that host the type locality of the Kiruna iron-oxide-apatite magnetite deposits. For the last 20 years the focus of my work has been the glacial geology of northern New England. While outwardly a big change from my earlier studies, a background in structural geology (and some glaciology) has actually been very applicable to understanding the behavior of the Laurentide Ice Sheet as it flowed across and later retreated across Vermont.

On behalf of the entire Society I want to extend a big thank you to Jon and Keith, our out-going president and vice-president, for all their work over the past 7+ years organizing the many meetings and field trips the Society has sponsored during that time. Laurie and I, both new to our leadership roles, look forward to following their lead and working with the on-going officers of the Society in the future. I also want to take this opportunity to thank Marjie Gale for all her work managing the many activities of the Vermont Geological Survey during her tenure as Vermont State Geologist. In addition to Marjie's many personal contributions to our understanding of the geology of Vermont, she's enabled and facilitated the work of many of the rest of us, both professionals and students. As most of you know too, Marjie's many detailed contributions to this newsletter have kept us all informed of the highly varied activities of the Survey. We all wish you the very best with your retirement!

I'm writing this letter in a very strange time, a time vaguely similar to stories many of us have heard from parents/grandparents of life during World War 2. With activities across the world sharply curtailed because of the Corona virus pandemic, the Society's spring meeting is among the casualties. Despite the cancellation of the combined Northeast/Southeast GSA meeting in March and our meeting in April, many students are in the process of completing their research projects and all of us benefit from learning about that research. Consequently, we have decided to still publish student abstracts in this issue of the GMG. Furthermore, we will encourage students to upload their talk slides or poster presentations and we will post links to those presentations on the Society's web page. While not the same experience as attending a "normal" meeting, we hope this still provides a venue for the broad range of high-quality research students are conducting in the course of their undergraduate and graduate careers.

While it's impossible to know now how normal or not things will be this coming summer, I'd still like to invite suggestions for a summer field trip. During December there was some discussion about a combined field trip and indoor presentation focused on landslides, a topic particularly relevant after last summer's large Cotton Brook landslide. Please send any ideas you have to me or one of the other executive committee members.

With another field season fast approaching, we're perhaps lucky that much of the field work many of us is a model of social distancing. Wishing all of you the best managing through this stressful period of time.

Respectfully submitted, Stephen Wright, VGS President

TREASURER'S REPORT

The treasurer's report is not available at this time

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The advancement of science committee report is not available at this time.

STATE GEOLOGIST'S REPORT

Spring tidings to each of you. My thoughts go out to all our members of the geologic community as we each adapt to the changes in our work and family lives. These are stressful days indeed as many of our usual routines are on pause. Personally, I have discovered all sorts of on-line services, although we definitely do not find Facetime to be a good substitute for visiting our children and grandchildren. We are looking forward to better days. As for the Geological Survey, Jon Kim, Julia Boyles and I are working from home and it is amazing that all the remote systems are functioning so well. Kudos to Vermont for that. We're getting used to Skype, Zoom and Teams so there is little interruption in the day to day work of the Geology Division.

As many of you noticed, in March we published the glacial lakes map, posted GIS data and even posted an animation of the lakes and the Champlain Sea. George Springston, Stephen Wright and John Van Hoesen were the main authors of the map and data, although the map incorporates the work of many other geologists. There's still more to be done but it is rewarding to have this data accessible to the public. We've received thank you notes and enthusiastic e-mails about the data, maps and their uses.

Other projects are also moving forward. Jon Kim is forging ahead on his work with PFAS contamination in Bennington and Rutland, nitrates on farms, and surface water-groundwater interaction at Lake Carmi. Jon's contributions to understanding PFAS in Bennington and developing the aquifer characterization process are recognized throughout our department and state agencies. Julia Boyles is working on the water use data sets and leading that project; she's also helping Jon on multiple projects and handling our social media posts. Yes, our Geology Division now contributes to the DEC Facebook page.

George Springston and Julia Boyles are hard at work on the compilation of the digital data for the surficial geology of Montpelier one-degree sheet. Stephen Wright's mapping in the Stowe quadrangle will feed directly into the compilation, as will George's mapping in the Groton quadrangle. Julia is on track to be our expert in the new geologic mapping standard, GeMS, which is required for USGS - funded projects.

George and I wrapped up most of the monitoring at the landslide in Waterbury; two game cameras continue to record activity. The landslide inventory maps have found their way into the Act 250 and other development processes and are proving useful for avoidance of serious slope instability issues.

Lastly, I never thought that my retirement would coincide with a pandemic, but such is the case. Retirement on April 24 was put in place two months ago yet I was waiting to make a broad announcement in hopes that I would also be announcing either my replacement or the posting of the job announcement. Those were all humming along on schedule until the corona virus struck, so now all are in flux as the State figures out financial impacts from the pandemic. Life is sometimes a roll of the dice and unfortunately, I now have no information to share about my replacement. I'm optimistic that decisions will be made soon and I will share whatever information I have before I leave. As a Society, we should remain vigilant in our efforts to advocate for geoscience.

In closing, I want to thank the Vermont Geological Society and all the members for their support of the Survey and of me personally over the years. I am so grateful for our geologic community, fun times shared at meetings and especially those truly wonderful days spent in the field. Best wishes to all our members.

Respectfully submitted,

Marjorie Gale, State Geologist

New (2019-2020) publications of the Vermont Geological Survey.
The following publications are available on our web site and GIS data is posted on the Vermont Open Geodata Portal:

Kim, J., Young, P., and Peterson, N., 2019, Bedrock Zones in Vermont and Radon in Air Test Points and Statistics: Vermont Geological Survey Open File Report VG2019-2, Readme file, Plate 1 and Plate 2.

Springston, G., Landslide Inventory of Orange County, Vermont: Vermont Geological Survey Open File Report VG2019-5, Report and Map.

Springston, G., 2019, Surficial geology and hydrogeology of the Huntington 7.5 Minute Quadrangle, Vermont: Vermont Geological Survey Open File Report VG2019-3, scale 1:24,000, Report, Plate 1 - Surficial Map. GIS data.

Springston, G., Wright, S., and Van Hoesen, J., 2020, Major glacial lakes and the Champlain Sea, Vermont: Vermont Geological Survey Miscellaneous Publication VGSM2020-1, scale 1:250,000. GIS data.

Van Hoesen, J., 2019, Surficial geology and hydrogeology of the northern half of the Proctor 7.5 Minute Quadrangle, Vermont: Vermont Geological Survey Open File Report VG2019-4, scale 1:24,000, Report plus 9 plates.

Van Hoesen, J., 2019, Surficial geologic map of the Proctor 7.5 Minute Quadrangle, Vermont: Vermont Geological Survey Open File Report VG2019-4A, scale 1:24,000. GIS data.

Wright, S., 2019, Surficial geology and groundwater hydrology of the Richmond quadrangle, Vermont: Vermont Geological Survey Open File Report VG2019-1, scale 1:24,000, Report plus 5 plates. GIS Data.

2020 STUDENT ABSTRACTS

A SEMI-AUTOMATED APPROACH TO LIDAR-DERIVED MAPPING OF SURFICIAL GEOLOGY: AN EXAMPLE FROM SOUTH-CENTRAL MAINE

AINSWORTH, Spencer, and WEST, David, Geology Department, Middlebury College, Middlebury, VT 05753

Traditional surficial geologic mapping relies extensively on field work which is time consuming, expensive, and prone to inaccuracies. Incorporating remote sensing and GIS into the mapping process can mitigate these limitations of traditional mapping by creating transferable and unbiased classification models. This thesis research uses Object-Based Image Analysis (OBIA) as a framework for semi-autonomously classifying LiDAR Digital Elevation Models (DEMs) to produce a surficial geologic map in south-central Maine. In doing so, this research also furthers the study of OBIA and its application to geology by applying the technique to more complex objectives than has been attempted in previous studies.

Classification is accomplished through a process of segmentation and fuzzy classification. The process begins by segmenting the DEM into objects from which topographic and geometric properties are extracted. These properties represent statistical signatures which are represented as histograms of each statistic for all surficial classes being mapped. By overlaying multiple statistical layers, each object's relative similarity to training data-derived characteristic distributions for each surficial class can be assessed. Each object is then classified to whichever class it is most similar.

This research demonstrates that remote sensing and semi-automated GIS processes can be used effectively to generate surficial geologic maps. Though the methodology of this research does not yield high enough classification accuracies to produce reference-level maps, it demonstrates the potential of such an approach and underscores the benefits for traditional field geologists to incorporate remote sensing and GIS into the mapping process.

USING INSAR TO ASSES ROCK GLACIER MOVEMENT IN THE UINTA MOUNTAINS, UTAH, USA

BRENCHER, George[1], HANDWERGER, Alexander[2,3], and MUNROE, Jeff[1], (1) Geology Department, Middlebury College, Middlebury, VT 05753, (2) Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, USA, (3) Jet Propulsion Laboratory, California Institute of Technology, USA

Rock glaciers are perennially frozen bodies of ice and rock debris that move downslope primarily due to deformation of internal ice. These features play an important role in alpine hydrology and landscape evolution, and constitute a significant water resource in arid regions. In the Uinta Mountains, Utah, nearly 400 rock glaciers have been identified on the basis of morphology, but the presence of ice has been investigated in only two. Here, I use satellite-based interferometric synthetic-aperture radar (InSAR) from the Copernicus Sentinel-1 satellites to identify and monitor active rock glaciers over a 10,000 km^2 area. I also compare the time-dependent motion of three individual rock glaciers over the summers of 2016-2019 to search for relationships with climatic drivers such as precipitation and temperature. Sentinel-1 data from August-October of 2016-2019 are used to create 108 interferograms

of the entire Uinta range with time spans ranging from 6 days to ~1 year, which are processed with the NASA/JPL/Stanford InSAR Scientific Computing Environment (ISCE) software package. We use average velocity maps to generate an active rock glacier inventory for the Uinta Mountains containing 255 active rock glaciers. Active rock glaciers are 10.8 ha in area on average, and found at an average elevation of 3290 m. Line-of-sight (LOS) velocity, a low estimate of total velocity, is 1.4 cm/yr on average, but individual rock glaciers have LOS velocities ranging from 0.8-9.3 cm/yr. Our time series analysis suggests that rock glacier motion does have a significant seasonal component, and was more than 5 times faster during the late summer than during the rest of the year on average. Rock glacier speeds may also be correlated with the snow-water equivalent of the previous winter's snowpack. Our results highlight the ability to use satellite InSAR to monitor rock glaciers over large areas and provide insight into the factors that control their kinematics.

GEOCHEMICAL AND HYDROLOGICAL PROCESSES GOVERNING TRANSPORT OF AFFF-DERIVED PFAS IN FRACTURED BEDROCK AQUIFER, CLARENDON, VT

COBB, Alexandra, RYAN, Pete, Geology Department, Middlebury College, Middlebury, VT 05753

Contamination of drinking water by aqueous film-forming foam (AFFF)-sourced per- and polyfluoroalkyl substances (PFAS) is a growing concern globally. In Clarendon, Vermont, the use of AFFFs since the 1980s at the Southern Vermont Regional Airport (SVRA) is the primary source of PFAS contamination in local groundwater. SVRA is surrounded by a rural landscape with numerous private water wells producing from the regional fractured rock aquifer (FRA). The bedrock comprising this aquifer is Cambrian-Ordovician carbonates folded in a N-S syncline, with Green Mountain gneisses and schists located within 2-3 km east. Structural mapping has documented prominent N-S and E-W fractures that may strongly influence groundwater and PFAS flow in the FRA.

This project investigates geochemical and hydrological processes governing the transport of PFAS from SVRA. The study uses PFAS data from 48 wells and hydrogeochemical data from 25 of these wells, including major and trace elements, CFC and tritium analysis for age dating, and hydrogen and oxygen isotopes for tracing groundwater recharge. Spatial mapping of individual PFAS compounds indicates four potential PFAS groups distinguished by carbon chain length: proximal-to-source fluortelomersulfonate (FTS)-enriched waters; down-gradient water enriched in C4-C7 PFAS compounds; farther down-gradient water relatively enriched in C8 and C9 (PFOA, PFOS and PFNA); and distal waters with no detectable (ND) PFAS. This implies that N-S fractures with some along E-W fractures are controlling SSW dominated PFAS migration. Hydrogeochemical analysis indicates two end-member water signatures and one mixture of the end-members that correspond to PFAS distribution: (1) Ca-Mg-bicarbonate waters (alkalinity > 250 mg/L) with high PFAS and typical recharge age of 35-40 years ago; (2) low alkalinity (< 120 mg/L) water with non-detect PFAS and recharge ages from 45 to > 60 years ago; and (3) water with intermediate alkalinity, ages, and PFAS that is a mix of the two end-members. The low-alkalinity waters most likely are the result of regional flow along faults and fractures from a recharge area in the Green Mountain foothills to the east, where rocks are silicate-dominated and foster low-alkalinity waters. The recognition of a distal, PFAS-free source of groundwater that occurs locally (4 of 25 wells) is significant because these wells are likely to remain PFAS-free.

GEOCHEMICAL CHARACTERIZATION OF DISCRETE GRAIN SIZE FRACTIONS WITHIN CONTEMPORARY ALPINE DUST, UINTA MOUNTAINS, UTAH, USA

OLSON, Pratt, MUNROE, Jeff, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

Mineral dust is mobilized in the world's arid regions, becoming suspended in the atmosphere where particle transport can occur on the order of thousands of kilometers. The deposition of mineral dust enriched in exotic and/or anthropogenic elements impacts regional-scale soil development, hydrologic systems, and biogeochemical cycling. The contemporary aeolian system is poorly understood due to a scarcity of direct measurements of modern dust deposition.

The Uinta Mountains (Utah) are well-suited for the study of contemporary dust owing to their gently sloping, soil-mantled alpine zones and relatively inert, quartzite-dominated bedrock. This project focuses on dust collected in the Uintas by passive marble dust traps during a continuous two-year sampling period, from 2017 to 2019. The large mass of these multi-year samples allowed each to be split into a coarse and fine fraction prior to further analysis. This analytical technique allows for the comparative analysis of material that is more likely to be local versus exotic in origin. Coarse material is enriched in quartz and feldspar, and is more mineralogically similar to local bedrock relative to fine dust, which is dominated by clay minerals. Anthropogenic trace elements are relatively less abundant in coarse versus fine Uinta dust, supporting the theory that smaller particles spend more time suspended in the atmosphere than larger particles. Sr and Nd isotopic fingerprinting of coarse and fine sample fractions offers further distinction, suggesting that dust source regions can be differentiated, to a generalized extent, based on particle size. These results support an increased understanding of how dust source regions influence the properties of mineral aerosols arriving in remote alpine environments.

A CHARACTERIZATION OF MICROBIAL DIVERSITY IN THE WINTER WONDERLAND ICE CAVE, UINTA MOUNTAINS, UTAH, USA

SEIXAS, Miranda[1], EGGLESTON, Erin[2], MUNROE, Jeff[1], and HERRON, David[3], (1) Geology Department, Middlebury College, Middlebury, VT 05753, (2) Biology Department, Middlebury College, Middlebury, VT 05753, (3) USDA Forest Service, Ashley National Forest, Duchesne, UT

Winter Wonderland is an ice cave in the Uinta Mountains of northern Utah, USA. The cave, which has an entrance at 3140 m a.s.l., extends 245 m into a north facing cliff of Mississippi Madison Limestone. The cave was discovered by the U.S. Forest Service in 2014. Winter Wonderland Ice Cave likely originated in the Late Mississippian to Early Pennsylvanian when joints opened up in the vadose zone. The interior of the cave is perennially below freezing with ice covering sections of the floor to a thickness of at least 2 m. Seasonally, meltwater from the epikarst enters the cave, pools on the surface of the older ice and freezes, creating a layered ice mass containing organic matter dating back several centuries. As this water freezes, cryogenic cave carbonates (CCCs) precipitate and are incorporated in the ice. In this study, ice, water, and CCC samples were collected to investigate the microbial communities that may be present within the Winter Wonderland ice cave, identify what they are, and investigate whether the composition of the microbial community changes spatially within the cave and between sample types.

An intact block of ice (18x10x10 cm), liquid water samples (n=8), and CCC samples (n=13) were collected in August 2019. The ice block was removed from a vertical exposure of ice at the back of the cave using a hand saw, water was collected from a pool on the ice surface, and the CCCs were sampled from the surface of the ice in multiple sections of the cave. The ice crystallized vertically with some variation in crystal size. Flow cytometry revealed more cells on an order of magnitude difference in water samples than in ice. Preliminary fluorescence microscopy and SEM imaging revealed the presence of cocci and bacilli type microorganisms within water samples and ~10um wide eukaryotic organisms within the CCCs, suggesting that the CCCs may provide much needed nutrients for the microbes or that the CCCs themselves are products of biomineralization. Sequencing provided evidence of *Actinobacteria*, *Bacteroidetes*, *Firmicutes*, and *Chloroflexi*, with most diversity in the CCCs. Beta diversity showed distinctions in microbial communities between water, ice, and CCCs, and between CCCs sampled from different rooms, revealing that the microbial community does change spatially and between sample type.

ANALYSIS OF VOLCANICLASTIC SEDIMENTS AS A POTENTIAL SOURCE OF GROUNDWATER ARSENIC IN THE GUANACASTE REGION OF COSTA RICA WALDMAN, Kira, RYAN, Pete, Geology Department, Middlebury College, Middlebury, VT 05753

Drinking water from aquifers in the Guanacaste region of Costa Rica does not meet global health standards. The World Health Organization (WHO) advises a standard mean daily intake of arsenic from drinking-water to be less than 10 ppb (WHO, 2011). The towns of Bagaces and Cañas have elevated concentrations of wellwater arsenic (As), with average values of 25 and 33 ppb. Groundwater has been the primary source of drinking water, crop irrigation and food preparation throughout this rural landscape for decades, and arsenic exposure can result in cancer and skin lesions, cardiovascular disease and diabetes, and worsened cognitive development. The purpose of this research is to determine the source of arsenic in the volcaniclastic sediments that host the regional aquifers. The study area is located within the Meseta Ignimbritica volcanic plateau, and the aquifer is dominated by Unit 3 of the Bagaces Formation, a series of thick-bedded rhyolitic to andesitic tuffs and ignimbrites with intercalated paleosols. To explore the possibility that volcaniclastic sediments from this formation are the source of arsenic in the groundwater supply, samples of aquifer sediments from 16 different sites were collected and analyzed using X-ray diffraction (XRD), X-ray fluorescence (XRF), and inductively coupled plasma mass spectrometry (ICPMS). Laser ablation ICPMS indicates that volcanic glass contains elevated As and K compared to other primary phases in the aquifer, and Bagaces-Cañas groundwater contains more dissolved K than Ca, an unusual occurrence in groundwater (and one that suggests influence of volcanic glass weathering). Unweathered ash contains a mean As concentration of 3.5 ppm (range of 2.5-4.5 ppm), while weathered samples containing secondary iron hydroxides have mean [As] = 8.1 ppm (the most Fe-hydroxide-rich sample contained 21 ppm As). These results suggest that volcanic glass is a primary As source, and that As sorbs to iron hydroxides when the glass decomposes by chemical weathering. Given that iron hydroxides are prone to dissolve when exposed to chemically reducing conditions, introduction of organic compounds to the aquifer whether from a leaking landfill or myriad septic systems might be assessed as possible triggers for arsenic release into solution.

COMPARING CL, S AND F GAS EMISSIONS FROM CINDER CONE ERUPTIONS IN THE LASSEN VOLCANIC REGION AND LA PALMA, CANARY ISLANDS

WEINER, Cameron, WALOWSKI, Kristina, Department of Geology, Middlebury College, Middlebury, VT 05753

The Lassen volcanic region, northern California and La Palma, Canary Islands are populous and agriculturally productive regions as well as active volcanic fields dominated by cinder cones. While numerous populated and important agricultural communities are located near zones of active cinder cone volcanism, few studies exist that assess the hazards associated with explosive cinder cone eruptions. One such understudied hazard associated with cinder cone eruptions is the emission of volatile gasses, including water vapor, CO_2, SO_2, HCl, and HF. These volatile gases are known to cause respiratory distress to humans and animals upon inhalation, damage or kill plants, and decrease long term agricultural productivity. Thus, this study seeks to better understand the gas release of S, Cl, and F volatiles from cinder cone eruptions, in the Lassen volcanic region and La Palma, Canary Islands.

Here, we determine the mass of volatiles (SO_2, HCl, and HF) degassed from 5 different eruptions through a geochemical mass balance method. Volatile and major element concentrations were measured in glassy scoria by Electron Microprobe Analysis and compared to previously published melt inclusion data. The mass of volatiles degassed during eruption is calculated by methods developed in Walsh (2012), which take the difference of the initial volatile concentrations preserved in melt inclusions from concentrations measured in erupted ash and scoria groundmass (not emitted), corrected for fractional crystallization and assimilation. We find that while La Palma magmas have higher initial concentrations of volatiles (e.g., ~4000 ppm SO_2) than Lassen magmas (e.g., ~1400 ppm S O_2), the total mass of volatiles degassed during individual cinder cone eruptions on the island of La Palma (0.03-0.008 megatons SO_2) is much lower than estimates for Lassen cinder cone eruptions (0.3- 3.3 megatons SO_2). Further analysis of these Lassen and La Palma magmas will provide an important comparison between the hazard potential of subduction zone and hot spot cinder cones and contribute to risk assessment of volatile emissions during future cinder cone eruptions.

EXPLOSIVITY OF PLEISTOCENE CINDER CONES IN THE LASSEN REGION DETERMINED BY TEXTURAL AND GEOCHEMICAL ANALYSIS OF SCORIA

ZYATITSKY, Karina, WALOWSKI, Kristina, Department of Geology, Middlebury College, Middlebury, VT 05753, USA

Cinder cones are the most numerous subaerial volcanic features worldwide, yet, they are largely understudied, especially in the vicinity of Lassen Volcanic National Park (LVNP), California, US, where only two in-depth studies on cinder cone explosivity have been done (Kaelin, 2019; Marks, 2012). In this study, I compare ~1m stratigraphic sections from the explosive deposits of two cinder cones, BORG and BRVB, that erupted during the Pleistocene (2.5 Ma to 11,700 years ago) in the Lassen region, in order to determine the parameters of their explosivity. Macro-textural analyses of grain size and componentry distribution are used in conjunction with micro-textural analyses derived from petrographic microscope and Scanning Electron Microscope images to determine eruption style and the subsurface processes that contributed to the explosivity. Initial results from grain size and componentry analyses suggest that both cinder cones exhibited Strombolian paroxysms, or moderately explosive eruptive pulses. Interestingly, the studied section of BRVB displays a shift from a Strombolian to a less explosive Hawaiian paroxysm, demonstrating the shifting and variable nature of eruptive styles during a single cinder cone eruption event. Further geochemical analyses will provide data to further understand the relationships between parameters such as viscosity and gas content with explosivity. Overall, I aim to increase understanding of eruption dynamics and constrain the volcanic hazards posed by cinder cone volcanoes in the Lassen region of northern California and globally.

EVIDENCE FOR POLYPHASE DEFORMATION IN THE SHEAR ZONES BOUNDING THE CHESTER AND ATHENS DOMES, SOUTHEASTERN VERMONT, FROM ^{40}AR/^{39}AR GEOCHRONOLOGY

SCHNALZER Kristin, Webb Laura E, and McCarthy, Kyle Department of Geology, University of Vermont

The Chester and Athens Domes are a composite mantled gneiss dome in SE Vermont. While debate persists regarding the mechanisms of dome formation, most workers consider the domes to be Acadian. This study integrates ^{40}Ar/^{39}Ar step-heating of small aliquots and microstructural analyses from samples collected in multiple transects across the dome-bounding shear zone(s) in order to understand the relationship between metamorphism and deformation. Results from the sheared units along the north and south transects are presented from west to east. In the north, hornblende from the Barnard gneiss yielded a weighted mean age of 406 Ma from a plateau-like segment and biotite yielded a weighted mean age of 344 Ma. Muscovite from a second sample of the Barnard gneiss yielded a weighted mean age of 388 Ma for a plateau-like segment and biotite yielded a plateau age of 334 Ma. One analysis of biotite from the Devonian Waits River Formation yielded a plateau age of 403 Ma, and muscovite yielded a plateau age of 362 Ma, consistent with microstructural evidence of muscovite growing at the expense of biotite. In this transect, the deformation ages inferred for the samples begin at 406 Ma and generally get younger to the east. In the south, muscovite from the basement cover contact yielded a weighted mean age of 365 Ma. Biotite from this sample yielded a weighted mean age of 358 Ma. A hornblende analysis from the Moretown Formation yielded a weighted mean age of 392 Ma. Muscovite from another sample of the Moretown Formation yielded a weighted mean age of 365 Ma and biotite yielded a weighted mean age of 406 Ma. The geochronology, along with the local preservation of crenulation cleavage in thin section, indicates that the samples experienced multiple phases of deformation. We also analyzed muscovite from a leucocratic Acadian dike that crosscuts the dominant penetrative foliation along the W margin of the Dome. Muscovite from this sample yielded a plateau age of 344 Ma. While all samples within the attenuated mantling units appeared to exhibit a single dominant foliation in the field, our results suggest a complex history of deformation based on the variety of plateau/weighted mean ages obtained and the complexity of age gradients in the individual age spectra.

MAPPING AND INTERPRETING THE GLACIAL HISTORY OF THE STOWE QUADRANGLE, NORTHERN VERMONT

POWERS, Sarah, Zani, Abby, Bogin, Caleb, Beutel, Corey, Wright Stephen Department of Geology University of Vermont

Glacial history is an important factor in the evolution of the New England landscape. Ice movement and associated sediment deposition have left behind a record that can be used as a tool to reconstruct the geologic past and understand the current layout of surficial materials. In Vermont in particular, glacial history has played an important role in shaping the landscape. This project aims to focus on interpreting

that history in the Stowe Quadrangle in northern Vermont; an area that extends across the Little River Valley from the Green Mountains to the west and the Worcester Mountains to the east. We recorded evidence of glacial movement by collecting striation measurements and mapped the different glacial materials and landforms in the area. Our findings are presented as a geologic map of surficial materials, geologic cross sections that illustrate the 3-D distribution of those materials, and an interpretation of the glacial history of the area. Field work was conducted in June 2019 using the mobile app Fulcrum to record observations at over 2,500 sites. Traditional topographic maps, aerial imagery, and LiDAR shaded-relief imagery were used in conjunction with our field observations to create a surficial geologic map of our field area in QGIS software.

Glacial striations in the quadrangle are dominated by two distinct sets, one striking NW-SE, which can be found particularly at higher elevations, and another striking N-S, which are most common at lower elevations in the valley. Using these data, we determined that the Laurentide Ice Sheet had originally flowed NW-SE obliquely across the mountains. As the ice thinned and became confined by the topography, it flowed N-S, parallel to the Little River valley. Examining our data shows that glacial till is the most wide-spread surficial material deposited across the mapping area. The till varies in thickness, from areas where bedrock exposures are numerous, to areas where thick till produces a smooth land surface masking bedrock outcrops.

The retreating ice sheet dammed the Winooski River, forming a series of glacial lakes at successively lower elevations. The two lakes that formed as a result and flooded this part of north-central Vermont, were Glacial Lakes Winooski, which had an elevation of approximately 315 m, and Mansfield, which occupied a lower elevation of approximately 225 m. These glacial lakes deposited the widespread fine-grained lacustrine sediments observed at lower elevations. Following the Laurentide Ice Sheet's retreat from the Winooski River Valley and the draining of the glacial lakes, the Little River and its tributaries have been incising through the lacustrine sediments, forming the abandoned terraces and eroded deltas that we observed. Mapping these surficial materials allows us to interpret the history of features, such as the Little River, which previously occupied a stream channel that got buried by successive glacial deposits.

SECRETARY'S REPORT

The secretary's report is not available at this time

ANNOUNCEMENTS

Peter Thompson sends us a book that he highly recommends:
"Timefulness: How Thinking Like a Geologist Can Help Save the World", by Marcia Bjornerud, who teaches geology at Lawrence University.

Peter says this book would not lend itself for use as a textbook, except as supplemental reading, but it would be at the top of the list to recommend to students for "summer reading". It is very readable, and the overviews on dating rocks and climate change are clear and concise.

This section is an open forum for announcements pertinent to VGS members. Please feel free to send them in for the next newsletter.

CALENDAR

2020 GSA Annual Meeting
Montreal, Quebec, Canada
25-28 October

AIPG 2020 National Conference
Sacramento, California
October 3-6 2020

EXECUTIVE COMMITTEE

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

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Vice President	Laurie Grigg	(802) 656-0247	lgrigg@norwich.edu
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