New Hampshire Geological Survey's Annual
Geologic Mapping Workshop 2017

Wednesday March 29, 2017
9:00 AM – 12:30 PM*
DES Auditorium, NHDES, Concord
29 Hazen Drive, Concord, New Hampshire 03302-0095

Public Session Agenda

8:30 – 9:00 AM **Coffee and Poster Session in Auditorium Anteroom****

9:00 – 9:10 **Welcome and NHGS Program Update**
Rick Chormann, NH State Geologist

Guest speakers:

9:10 – 9:35 **Scott Bailey, US Forest Service** – ***"A hydropedologic approach to mapping at the Hubbard Brook Experimental Forest."***

Soil forming theory considers factors of soil age, climate, vegetation, topography, and geologic parent material to explain the distribution of soils at regional to global scales. The role of water in soil formation is implicit in several of these factors. Alternatively a "hydropedologic" approach to soil mapping explicitly considers differences in how water moves through soils and is more predictive of soil variation at local scales. At Hubbard Brook Experimental Forest, we have developed a hydropedologic approach to soil mapping that focuses on topography and geologic substrate as factors controlling water flow through soils. This approach has promise to explain local variation in soil physical and chemical properties, as well as spatial patterns in groundwater and stream water chemistry. This may be a better method for evaluating soils for applications rated to forestry and watershed management.

9:35 – 10:05 **Marjorie Gale and Jonathan Kim, Vermont Geological Survey** – ***"Groundwater Contamination and Aquifer Characterization, North Bennington, Vermont."***

In February 2016 the Vermont Agency of Natural Resources discovered PFOA-contaminated water in 5 private drinking water wells near the former Chemfab property in North Bennington, VT. Concentrations of perfluorooctanic acid (PFOA) in the water ranged from 40 to 2,880 parts per trillion, above the Vermont Department of Health's drinking water health advisory level of 20 parts per trillion. By June 2016, DEC had received sampling results from 462 private wells in the area, of which 244 had PFOA concentrations greater than 20 ppt. PFOA is used in the production of Teflon and as a surfactant and dispersant in the application of Teflon to fabrics and wires. Chemfab primarily applied PTFE (Teflon) coatings to fiberglass fabrics.

Vermont's active response to the contamination issue included strong communications and outreach, establishment of an incident command center and staffed public information centers, delivery and distribution of bottled water and water buffaloes, drinking water sampling/testing, surface water and soil sampling, fish testing, and blood sampling clinics (Health Department).

In March 2016, the Geological Survey (VGS) was asked to review geologic and hydrogeologic information and develop a plan for aquifer characterization. The importance of coordinating Agency science and developing and interpreting regional sub-surface data was clear. In order to characterize the aquifer(s) contaminated with PFOA in Bennington, the VGS partnered with Middlebury College, SUNY at Plattsburgh, University of Vermont, USGS, and DeSimone Geoscience Investigations to conduct 1) bedrock mapping, 2) surficial mapping, 3) correlation of well locations with driller's logs, 4) comprehensive geochemical analysis of groundwater (bedrock wells and springs) and surface water (rivers and brooks), and 5) geophysical logging of selected bedrock wells. The analysis and integration of data from all aquifer characterization tasks is ongoing.

10:05 − 10:35 **David Boutt, Department of Geosciences, UMass-Amherst** – ***"Annual to Decadal Changes in Groundwater Storage Across Southern New England: Insights from Physical Hydrologic and Isotopic Tracers."***

The Northeast US is experiencing rapid changes in hydrology due to natural and human-induced changes. This talk explores subsurface hydrologic change in shallow and deep aquifer systems using physical and isotopic tracers of water movement. Through the integration of surficial geologic materials mapping and well monitoring the role of thin upper till deposits in annual hydrologic budgets is quantified. Isotopic monitoring of streams and groundwater identify the importance of intense summer and fall precipitation on groundwater recharge in these systems.

10:35 − 11:00 **Break (Posters)**

George Springston, Earth and Environmental Sciences, Norwich University – ***"Distribution of major and trace element geochemistry of till, Montpelier 1:100,000 sheet, central Vermont."***

A study of major and trace element geochemistry of glacial till has been undertaken in order to explore the connection between till chemistry, surface water and groundwater chemistry. Of specific interest is the distribution in till of arsenic, uranium, and phosphorus, and their spatial relationship to bedrock sources. The study area includes samples from multiple geologic domains from the Green Mountains to the Connecticut Valley Trough. A total of 94 till samples were collected from 67 sites (e.g. stream banks, road-cuts, excavations), and a strong effort was made to access unweathered samples. 40 bedrock sites across Vermont were sampled in 2013 for a study of geothermal properties. The distribution of elements from these metasedimentary rocks in concert with mineralogy reported in the literature is a preliminary proxy for bedrock chemistry in the study area. This study confirms the strong link between bedrock lithology and the composition of till derived from it. Our results confirm the idea that the background geochemistry of soils, surface water, and groundwater in this area will vary as the composition of the till varies. This, in turn, has been extensively shaped by the lithologies of the bedrock and bedrock-derived sediments that have served as the source materials for the till.

Jill Getchell, UNH Department of Earth Sciences – ***"The effect of groundwater flow on the design of vertical geothermal heat pump ground loops."***

Geothermal heat pumps (GHP) are one of the cleanest sources of energy for heating and cooling systems used in buildings and residential homes. The increased interest in the use of GHPs warrants an improvement in understanding how the local geological conditions affect the design of these systems. Typical closed loop GHP designs currently do not account for the influence of groundwater on the portions of the system (e.g. boreholes) extending beneath the water table. Our analysis utilizes the semi-analytical solution of the heat flow equation with groundwater flow compared to the commonly used design software (GLGEPRO) that neglects groundwater flow. The results of these modeling efforts are expected to enhance the understanding of the GHP system performance and lead to a more efficient design for residential systems in New England, where shallow groundwater depths are common.

Chase, Ryan, UNH Department of Earth Sciences – "*Analysis of underground thermal energy storage for greenhouse heating: Case study of an organic dairy farm in New Hampshire.*"

One strategy for reducing the reliance on fossil fuels is to utilize waste heat for other useful purposes, such as space heating. The strategy of underground thermal energy storage (UTES) has been widely adopted in Europe and has been getting increased attention in the US in recent years. Industrial, agricultural, and co-generation facilities often have waste heat that has the potential to be stored and used, offsetting the need for fossil fuels. This study investigates the feasibility of using waste heat generated from an aerobic compost facility at the University of New Hampshire's Organic Dairy Farm as an economical means to extend the growing season of a greenhouse. Smith (2016 UNH PhD dissertation) reports that the compost facility has the potential to produce 80,000 BTUs per hour throughout the year, a thermal equivalent of approximately 5,000 gallons of fuel oil. Implementation of UTES to use waste heat from other sources could potentially further increase the availability of locally grown produce without increasing the use of fossil fuels.

11:00 − 11:20 **Greg Walsh, US Geological Survey** – ***"Tectonic Evolution of the Connecticut Valley Region in South-Central Vermont and West-Central New Hampshire."***

This talk will present the results of nearly completed mapping as part of the FEDMAP component of the USGS National Cooperative Geologic Mapping Program. Work is primarily focused in the Connecticut River Valley region in a four-quadrangle area around Littleton and an eight-quadrangle-area from Lebanon to Alstead. The discussion will focus on advances in our knowledge of the evolution of the Bronson Hill anticlinorium and the Connecticut Valley. A summary of our findings is reported in Walsh and others (2017; doi: 10.1130/abs/2017NE-290895).

11:20 − 11:40 **Dykstra Eusden and Sarah Baker** – **Dept. of Geology, Bates College and NH Geological Survey –** ***"Bedrock Geology of the Jefferson 7.5' Quadrangle, New Hampshire."***

New mapping and detrital zircon geochronology in the northern part of the Jefferson 7.5' Quadrangle has revealed a previously unknown region of Cambrian Albee Formation. The region, near Lancaster, NH, contains two Appalachian lithotectonic units: 1) a section of the Bronson Hill Anticlinorium including the Ordovician Ammonoosuc and Cambrian Albee Formations and intrusive rocks of the Ordovician Oliverian Dome and Lost Nation Pluton; and 2) Jurassic igneous cone sheets of the Pliny Range Caldera Complex.

The Albee is likely in unconformable (Penobscottian?) contact with the Ammonoosuc and is significantly more deformed showing classic pin-striping and transposition. Newly discovered quartzite units in the Ammonoosuc are interlayered and gradational with the more typical mafic Ammonoosuc amphibolites. The Ammonoosuc and Albee units are complexly folded by NNE plunging reclined folds of Acadian (?) age and then deformed by the Oliverian Jefferson Dome.

Lyons et al., (1997) show the Ammonoosuc Fault juxtaposing the Lost Nation and a sliver of Albee against the Ammonoosuc then continuing east through the Pliny Caldera Complex. Our mapping shows instead a chilled intrusive contact between the complex mafic intrusive rocks of the Lost Nation Pluton and the Albee that extends south to become folded with the Ammonoosuc. No Ammonoosuc fault was recognized there or in the Pliny Complex.

Previous detail mapping of the Pliny Complex in the southern portion of the Jefferson quadrangle identified a newly discovered Jurassic rhyolite, a likely source of the long sought after Jefferson Rhyolite. This stone was used to make characteristic fluted spear points used by Paleoindians 13,000-11,000 years ago, and has been documented at numerous archaeological sites in the Northeast. A comparison of outcrop and artifact samples of rhyolite showed the rocks were geochemically similar according to XRF analysis, in addition to their near identical petrologic textures.

11:40 − 11:55 **Peter Thompson, University of New Hampshire (retired)** – ***"Bedrock Geology of the Northern Half of the North Grantham 7.5' Quadrangle, New Hampshire."***

Bedrock geology in the northern half of the North Grantham 7.5' quadrangle has been remapped, reconciling differences between Chapman (1939) and Thompson (1988). The overturned limb of the Cornish nappe is exposed in the western part of the quad, displaced somewhat by the Northey Hill shear zone. Metamorphic grade in the Ammonoosuc Volcanics increases eastward from biotite to garnet grade, indicated by appearance of hornblende. Rusty garnet schists and felsic metavolcanics of the Partridge Formation occupy a wide swath to the east, in contact with about 23 m of the "Hardy Hill" horizon of Clough Quartzite, where a basal polymict conglomerate horizon was discovered north of I-89. To the east, the Littleton Formation increases in metamorphic grade from garnet to staurolite to sillimanite. A felsic metavolcanic horizon within the Littleton would be a good target for zircon dating. The most challenging geology lies in the eastern part of the quad, around Smith Pond, where interlayered quartzite and schist horizons are interpreted as facies of the Clough (similar to Chapman's interpretation) rather than repeated isoclinal folds involving Partridge, Clough and Littleton as proposed by Thompson (1988). However, isoclinal, nappe-stage folds are indeed present within the Clough, deformed by at least two sets of younger folds. One of the layers that Thompson assigned to Partridge is now believed to be a minor isoclinal syncline of Fitch Formation, with Clough above and below. A minor isoclinal anticline of Clough is cut by the overlying Bethlehem gneiss, presumably in the Fall Mountain thrust nappe. Thompson (1988) interpreted the minor anticline as the root of the Skitchewaug nappe. I am convinced that all the rocks between the Littleton and the Bethlehem lie on the autochthonous, upright limb of a major, westward-opening syncline below the Cornish nappe. According to this reinterpretation, the Cornish and Skitchewaug nappes are one and the same, with the Fall Mountain nappe above.

11:55− 12:00 **Woodrow Thompson, Maine Geological Survey (retired)** – ***"Surficial Geology of the 7.5' Jefferson Quadrangle, Northern New Hampshire"***

Much of the Jefferson quadrangle is mountainous terrain with extensive till cover on mid to lower slopes, and bedrock exposure mainly at the highest elevations. An unusual and extensive moraine field was found on the lower NE side of the Israel River valley SE of Jefferson village. These moraines consist of short till ridges and hummocks. They are in the proximal part of the White Mountain Moraine System, and formed during the waning phase of the Older Dryas cold-climate event ca. 14 ka BP (Thompson et al., 2017). Water-laid sediments occur chiefly in the Israel valley and along several of its tributaries. A SE-trending esker extends along the NE side of the valley near Jefferson. Otherwise, the glaciofluvial and glaciolacustrine deposits have been extensively reworked by the postglacial river, with the result that much of the valley bottom now consists of stream terraces and the modern flood plain. Several generations of large alluvial fans occur on lower mountain slopes in the northern and eastern parts of the quadrangle, and there are slump scars on till slopes upstream from the Bunnell Brook fan. LiDAR imagery was extremely helpful in defining the moraine field, revealing an unusual esker on the SE side of Pliny Mountain, and mapping the alluvial fans.

12:00 − 12:15 **Brian Fowler, NH Geologic Resource Advisory Committee** – ***"Surficial Geology of the Jackson 7.5' Quadrangle, New Hampshire*."**

Mapping suggests the quadrangle was rapidly deglaciated, with late Wisconsinan ice thinning and separating around higher elevations. No systematic moraines were identified, and most till appears collapsed onto underlying surfaces. Till was then winnowed on steeper slopes and redistributed at lower elevations by high-volume runoff. Significant fluvial deposition was limited to bed-grade relaxation areas in principal stream valleys with the most substantial deposition at Jackson Village into an ephemeral lake dammed to the south by a ridge of collapsed moraine. This dam was quickly breached leading to deep erosion in the Ellis River channel below to the south and to the bedrock threshold at the Goodrich Dam.

The mapping also identified in the northeast corner of the quadrangle near No Ketchum Pond, a dry meltwater channel draining south over a low col between the southerly-flowing Saco and the northerly-flowing Wild River basins. The degree of erosion in the upper southern part of this channel and the extensive alluvial deposits below in the Saco River-East Branch suggest a lengthy period of substantial meltwater flow over the col, likely until lower drainage opened to the north. Forthcoming LiDAR coverage of the region's rugged, densely-vegetated, often inaccessible terrain will improve the current map.

12:15 − 12:30 **Greg Barker and Neil Olson, NH Geological Survey** – ***"Surficial Geology of the Danbury 7.5' Quadrangle, New Hampshire*."**

The Danbury Quadrangle was mapped in 2016 under the STATEMAP Program. Stoss and lee topography is obvious in the quadrangle with three successive, parallel ridge lines that are oriented generally northeast to southwest. No systematic moraines were identified and most till often appears to have collapsed onto underlying surfaces and to have been winnowed on steeper slopes and redistributed at lower elevations by runoff. Because of the general SW-NE trend of ridgelines in the quadrangle and the thinning of ice, a pattern of stagnation and down-wasting followed by drainage perpendicular and sub-parallel to the ice front progressed in successive drainages from south to north in the order of Needleshop Brook, Smith River, and Bog Brook/Patten Brook . The drainage orientations were constrained by bedrock topography but also stagnant ice zones. Abundant subglacial deposits in the form of eskers are also present in the quadrangle, especially in the Southeastern portion of the quadrangle.

This talk will also examine mapping observations and conclusions that pre-date and post-date availability of LiDAR derived topography. While overall understanding of the timing of deglaciation features was unchanged, there were several revelations that improved the interpretations of this map. Many small glacial and periglacial features were readily visible in the LiDAR that would have been nearly impossible to detect using traditional mapping techniques. It should also be noted that LiDAR is not a panacea and field validation of morphology is still a critical component of interpretation for map compilations.

12:30 **Questions and closing remarks**

Rick Chormann, NH State Geologist

Private Working Session for NHGS Mappers in the Anteroom

1:15 – 3:15 Mapping contractor meeting for those who map for the NHGS under the STATEMAP program.

Directions to NH Department of Environmental Services
The main offices of DES (including the New Hampshire Geological Survey) are located at 29 Hazen Drive, Concord, NH.

From the South and West
Take I-93 north to Exit 14 turning right at the end of the exit ramp. At the third light (at top of the hill), turn left onto Hazen Drive. Turn left at sign for Health & Human Services. Visitor parking is available in front of building.

From the North
Take I-93 south to Exit 15E onto I-393. Take Exit 2 and turn left at end of exit ramp (East Side Drive). Stay to the right and turn right at light onto Hazen Drive. Turn right at sign for Health & Human Services. Visitor parking is available in front of building.

From the East
Take Route 4 west to Concord (Route 4 becomes I-393 in Concord). Take Exit 2 and turn left at end of exit ramp. Stay to the right and turn right at second light onto Hazen Drive. Turn right at sign for Health & Human Services. Visitor parking is available in front of building.

Note: If you have not already done so, please respond by email if you plan to attend so that we can anticipate the number of attendees. If you need further information on the program or **to R.S.V.P., please contact the NH Geological Survey at: geology@des.nh.gov**

Attendance at the entire public session part of the workshop qualifies for 3.5 CEU's

Please bring photographic identification (*e.g.* driver's license) in order to be admitted to the DES Building. Thank you.

* NHDES employees should confirm their attendance and schedule of the workshop with their supervisors.
** Posters will be on display until the end of the public session of the workshop.