THE
GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

SPRING 1992 VOLUME 19 NUMBER 1

Vermont Geological Society's Spring Meeting

Presentation of Student Papers

Saturday April 25, 1992, 9:30 AM
Room 1, Kalkin Building
University of Vermont, Burlington, Vermont

Directions: Kalkin Building lies immediately behind the Perkins Geology Building. Both are accessed from Colchester Ave. Room 001 is one of the basement rooms. The parking lot immediately in front of Perkins Hall will be available for VGS members attending the meeting.

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PRESIDENT'S LETTER

Dear Members,

We had a successful Winter Symposium this February at Norwich University. The weather was cold but clear, and we had a good turn-out. I would like to thank our speakers and co-authors again—Char Mehrtens, Dave Westerman, Wally Bothner, Rolfe Stanley, Barry Doolan, Diane Conrad, Nick Ratcliffe, and Vincent Dellorusso—for giving us a good overview of Vermont's bedrock geology and its tectonic framework in light of Wally Cady's extensive mapping in western and central Vermont.

We also had a successful Executive Committee meeting afterwards with a number of regular members joining the Board and Officers in the discussion. The important topic was finalizing the policies, procedures, and application form for the student research grant. Lucy Harding has put a considerable amount of time and effort into designing, writing, and revising these forms and most of the credit for a well thought-out grant program is hers. The finished grant description and application forms have recently been mailed to the geology departments of nearby schools with an application deadline of May 15. Proposals will be accepted from any graduate or undergraduate student or secondary school teacher doing research related to Vermont geology. If you want more information and/or application forms, look for the notice published elsewhere in this issue of the *GMG*.

This is the first issue of the *Green Mountain Geologist* for which we have a guest editor. Larry Gatto is responsible for the material on the Cold Regions Research and Engineering Lab in Hanover, where he works. The idea, initiated last year by Chris Stone, is for a guest editor to solicit, write, and/or collate articles on some theme for each issue. This would provide our readers with interesting articles on a diversity of topics while leaving our editor more time for the mundane but necessary activities of putting the issue together. We are currently looking for volunteers for the Fall issue and beyond. If you would like to volunteer your services or have a topic you'd like to see pursued, please let Stephen or myself know.

Sincerely,

Bruce Wilson
Brattleboro, VT

SPRING MEETING PROGRAM

Room 1, Kalkin Hall

9:00 Coffee

9:30 Robert C. Pederson: *Pockmark formation in Burlington Harbor*

9:50 Edward L. Kyle: *Temporal changes at long-term sand bar study sites in Grand Canyon, Arizona*

10:10 Jeffrey J. Clark: *Analysis of sediment storage changes in the Colorado River, Grand Canyon National Park, Arizona*

10:30 Daniel B. Thomsen: *Structure of South Mountain, Bristol, Vermont*

10:50 Coffee

11:10 Steven G. Gurney: *Trace metals in landfill impacted fluvial sediments*

11:30 Daniel R. Jahne: *The migration of heavy metals in water originating from source areas within a landfill, Barkhamsted, Connecticut*

11:50 Amie Yuskaitis: *Chemical composition of surface and high-uranium well water, southwestern New Hampshire*

12:10 Lunch: *Sandwiches and drinks will be catered for a cost of $4–5 per person.*

1:00 Susan Lipinski: *Variations in the Forestdale dolostone in west central Vermont*

1:20 Philip R. Royce: *Provenance analysis of synorogenic strata using Cr and Ni concentrations in shale deposited during the Middle Ordovician Taconic Orogeny, western Newfoundland*

1:40 Christopher J.Y. Clark: *Geochemistry of the Underhill and Hazens Notch greenstones: Evidence of early stages of continental rifting*

2:00 Todd K. Kafka: *Geochemistry of a sheared greenstone in the Pinney Hollow formation: Igneous and metasomatic variations*

2:20 VGS Executive Committee Meeting: *All members are invited to attend!*

SPRING MEETING ABSTRACTS

GEOCHEMISTRY OF THE UNDERHILL AND HAZENS NOTCH GREENSTONES: EVIDENCE OF EARLY STAGES OF CONTINENTAL RIFTING

Clark, Christopher J.Y., Department of Geology, Middlebury College, Middlebury, VT 05753

Major and trace element analyses have been conducted on two previously unmapped greenstone bodies from the Camels Hump group. The Bald Hill greenstone, part of the Hazens Notch formation, is located a few miles west of Camels Hump on Bald Hill. The Taylor Lodge greenstone, in the Underhill formation, is located in Nebraska Notch on the long trail south of Mt. Mansfield at Taylor Lodge. Both greenstones have been metamorphosed to the greenschist facies, removing any original texture of the rocks. The metamorphic mineral assemblage consists dominantly of chlorite, albite, epidote, and amphibole with lesser amounts of biotite, magnetite, and sphene.

In spite of metamorphism and deformation, selected chemical elements can be used to classify these coarse-grained greenstones as basalts. In particular, high Ti, P, Zr, Y and enriched LREE patterns in both greenstones indicate they may have been mildly alkalic (transitional) basalts. The original tectonic setting of the greenstones was determined by plotting relatively immobile trace and major elements. For example on Zr/Y vs Zr, Ti-Y- Zr, and Fe-Mg-Al diagrams, the greenstones plot in within-plate basalt fields.

Four zones have been suggested to differentiate environments of greenstone formation in Vermont (Coish,1989). Zone two greenstones are interpreted to be transitional basalts produced during the early stages of continental rifting that later led to the opening of the proto-Atlantic ocean. The Bald Hill and Taylor Lodge greenstones are similar geochemically to zone two greenstones; this suggests they may also be associated with the early stages of continental rifting.

ANALYSIS OF SEDIMENT STORAGE CHANGES IN THE COLORADO RIVER, GRAND CANYON NATIONAL PARK, ARIZONA

Clark, Jeffrey J., Department of Geology, Middlebury College, Middlebury, VT 05753

The construction of Glen Canyon Dam in 1963 has changed the hydrology, sediment transport, and geomorphology of the Colorado River in Grand Canyon. Changes in sand bars were evaluated in a wide reach 111–118 km downstream from Glen Canyon Dam by repetitive mapping of surficial geology. Mapping was on a base of 1:24,000 scale topographic maps for 1965, 1973, 1980, 1984, 1985, 1987, 1988, 1989, and 1990. Changes in deposits were compared in terms of spatial pattern and area of exposed deposit. Longitudinal fathometer traces of the thalweg taken in 1973 and 1984 were compared. Topographic data collected between 1974 and 1987 at Lower Nankoweap camping beach were also analyzed.

Comparison of the area of exposed deposits show that the system was aggrading from 1965–1982, eroding from 1983–1986, and aggrading from 1987–1990. Topographic profiles from Lower Nankoweap Beach show degradation from 1974–1982 and aggradation from 1983–1987. Results of the fathometer trace show net degradation of 2.4 meters for the bed from 1973–1984.

These results indicate that regulated floods occurring within a year of a previous flood cause widespread degradation both on the bed and in the banks of the river. Individual sand bars, however, respond differently in detail and can generally be divided into stable (changing in a predictable fashion) and unstable (changing unpredictably) sand bars. Variability may be due to the geometry of debris fans and the geometry of channel expansions. Because of this variability, inferences drawn from the evaluation of change at a few study sites may misrepresent reach-scale changes.

TRACE METALS IN LANDFILL IMPACTED FLUVIAL SEDIMENT

Gurney, Steven G., Department of Geology, University of Vermont, Burlington, VT 05405

The accumulation and transport of trace metals emanating from Hartford Landfill leachate in fluvial sediment was investigated to improve our ability to evaluate transport mechanisms and environmental impacts of these substances. The distributions of nine trace metals (Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Zn) among four chemical fractions and two sediment size fractions have been determined in bottom sediments that were sampled at eight locations along Russtown Brook, which drains the northern and southern boundaries of the Hartford Landfill. The size distribution and organic content of the sediment were also measured. Measurements of pH, conductivity, chloride concentration, and alkalinity were used to assess the water quality of the brook. Chemical partitioning of trace metals into operationally defined phases (exchangeable, carbonate, oxide, organic) provides an estimate of their biological availability or physicochemical reactivity.

Water quality parameters noted above are substantially elevated in the surface water of Russtown Brook's southern branch and in groundwater from wells located on the landfill's southern and eastern margins. The probable existence of the Monroe Fault below the west portion of the landfill is of concern as a potential pathway for landfill leachate to bedrock aquifers.

The most dominant trace metal chemical fraction in both sediment sizes at all sample sites is the Fe-Mn oxide fraction. The organic phase is also important for Cr, Cu, and Fe. The carbonate fraction contains appreciable Cr, Mn, and Zn. The concentration of the most available 'exchangeable' fraction is near or below detection for most of the metals with the exception of Pb, Mn, and Zn. The metal concentrations for most chemical fractions are significantly higher in the south branch where leachate can be observed entering the stream. Metal concentrations downstream of the confluence of the two branches at site 7 are generally intermediate between the concentrations from the north and south branches.

Particle size has a significant effect on the metal concentrations at different sites. Metal concentrations associated with the silt and clay size fractions from most samples are 2 to 123 times greater than bulk concentration values. The total metal concentrations in silt and clay are greatest at sites 1, 2, 3, and 5 of the south branch, while in bulk sediment the highest total metal concentrations are from sites 9, 7, and 11 with the exception of Pb and Zn. Trace metal and water quality data indicate that leachate from the Hartford Landfill has a negative impact on the water and sediment in Russtown Brook.

THE MIGRATION OF HEAVY METALS IN WATER ORIGINATING FROM SOURCE AREAS WITHIN A LANDFILL, BARKHAMSTED, CONNECTICUT

Jahne, Daniel R., Geology Department, Union College, Schenectady, New York 12308.

The Regional Refuse Disposal District #1 (RRDD# 1) landfill in Barkhamsted, CT is classified as an EPA Superfund site and is on the National Priorities List for government remediation. The landfill contains a wide variety of metallic and organic municipal and industrial wastes that are leaching into the groundwater. Samples from local surface water, surface residue, and monitoring wells within the landfill were analyzed by Inductively Coupled Plasma Mass Spectrometry for Chromium, Manganese, Iron, Nickel, Copper, Zinc, Rubidium, Strontium, Molybdenum, Barium, Lead, and Uranium. The results reveal a plume of contamination in the shallow bedrock and overburden that has migrated approximately 400 meters down gradient from the landfill. Manganese, Nickel, Zinc, Strontium, Barium, and Uranium have apparently intersected the stream that borders the landfill and can be linked to a number of source areas buried within the overburden of RRDD# 1. Concentrations of metals seem to undergo dilution away from these source areas. These data indicate that the metal contamination from the landfill has infiltrated the groundwater and is moving into surface runoff and is therefore a threat to the surrounding watershed.

Geochemistry of a sheared greenstone in the Pinney Hollow Formation: Igneous and metasomatic variations

Kafka, Todd K., Department of Geology, Middlebury College, Middlebury, VT, 05753

Thirty-two samples from a meta-volcanic greenstone body in the Lower Cambrian Pinney Hollow Formation in Lower Granville, Vermont include two types of igneous protoliths and reveal metasomatic changes in greenstone chemistry during shearing. At this location, the greenstone is tightly folded within a pelitic schist and divided into an eastern and western body by a minor thrust fault. This thrust fault is an extension of the Granville thrust and is associated with an ~5 m wide mylonitized zone incorporating adjacent schists. The greenstone mineral assemblage contains epidote-amphibole-chlorite-albite-quartz, whereas the Pinney Hollow schist contains garnet-muscovite-chlorite-plagioclase-quartz.

Chemical profiles were constructed across the greenstone. Spatial variation in chemistry and petrography reveals whole-rock changes in greenstones adjacent to and in the shear zone. Many of the major elements (Na_2O, Fe_2O_3, MgO, TiO_2, and Al_2O_3) and some of the trace elements (Cr, V, Co, and Ni) show depletion within ~5 m of the shear zone, a prominent spike immediately before the contact, and depletion within the shear zone itself. SiO_2 remains relatively constant throughout the greenstone, increasing greatly within the mylonite. K_2O increases in the shear zone while CaO is depleted. No relationships are evident in P_2O_5 and MnO. These trends appear to be largely due to mixing of schist and greenstone components.

Greenstones within the Pinney Hollow Formation show more chemical variation than other meta-volcanics in the region. This may be explained by this detailed study of one body which reveals well defined igneous trends and two distinct groups of greenstones. These two groups are clearly defined on a Ti-Y-Zr discriminant diagram and easily separated from interleaved schist samples. Group 1 greenstones are high-Ti and consistently plot in the Within-Plate-Basalt region. Group 2 greenstones are low-Ti and lie on the MORB and Island-Arc boundary. These groupings correspond with major element data. Whereas the significance of the tectonic discrimination remains unclear, the presence of two, intermixed igneous protoliths gives new insight into the geochemical variation of Pinney Hollow greenstones.

TEMPORAL CHANGES AT LONG-TERM SAND BAR STUDY SITES IN GRAND CANYON, ARIZONA

Kyle, Edward L., Department of Geology, Middlebury College, Middlebury, VT 05753

Sediment storage sites along the Colorado River in Grand Canyon occur in channel expansions. These storage sites are sand bars formed by recirculating flow in the channel expansions. High-elevation sand bars are frequently used as campsites by the 20,000 river recreationalists who raft the river each year. The presence of Glen Canyon Dam upstream from Grand Canyon has caused concern about the future of these campsite beaches.

Topographic surveys have been undertaken, since 1974, to monitor changes at campsite beaches. These surveys record the history of change at these beaches. Aerial photographs exist for the Grand Canyon dating back to 1965. These survey data were quantified to understand the effects of flow regulation, by Glen Canyon Dam, on sediment storage. Aerial photographs were used to create overlay maps. These helped to assess the representativeness of the campsite beaches in monitoring reach-scale changes.

Sediment storage in Grand Canyon varies from one channel expansion to the next. Complete analysis of topographic and plan-view changes must be undertaken in order to represent reach-scale changes. During the high flow period, 1983–1986, rates of aggradation and degradation were significantly higher than those of the periods before and after the high flows. Generalized benefits of the high flow period cannot be assumed to form short term gains on campsite beaches; in fact, reduced total sediment storage during this period caused the high flows to have a net negative effect.

VARIATIONS IN THE FORESTDALE DOLOSTONE IN WEST CENTRAL VERMONT

Lipinski, Susan, Department of Geology, Middlebury College, Middlebury, VT 05753

The Forestdale Dolostone was studied along the Green Mountain Front to look for variations in stratigraphy and petrology. It is exposed as a tan to pink, thickly bedded to massive, fine- to medium-grained dolostone. It is considered to be part of the Eocambrian rift facies exposed along the Green Mountain Front and records sedimentation during the rifting of Iapetus and the development of a stable, passive continental margin (DelloRusso and Stanley, 1986).

Samples were collected from the Forestdale Dolostone at Bristol Notch and Sucker Brook to determine the variation in diagenesis of the dolostone. Unlike some locations, stratigraphic relationships of the Forestdale at Bristol Notch and Sucker Brook are essentially the same: the Forestdale overlies the Fairfield Pond Phyllite or the equivalent Moosalamoo Phyllite which in turn overlies the Pinnacle Formation and the Cheshire Quartzite overlies the Forestdale.

Geochemical analysis was done using the ICAP. Molecular weight ratios were used to show that the Forestdale at Sucker Brook has a lower Mg/Ca ratio relative to the trace elements/Sr ratio than the Forestdale at Bristol Notch. This conspicuous difference may indicate that the two dolostones had different original compositions.

This difference is further supported petrographically. The Sucker Brook rocks are typically polymodal, fine-grained, and contain significant amounts of detrital material including quartz, feldspar, muscovite, and zircon. Bristol Notch rocks are coarser-grained and contain fewer detrital material. Bristol Notch rocks show non-planar grain boundaries whereas Sucker Brook rocks commonly have planar grain boundaries.

POCKMARK FORMATION IN BURLINGTON HARBOR

Pederson, Robert C., Department of Geology, Middlebury College, Middlebury, Vermont 05753.

A high resolution, dual frequency (100 kHz and 500 kHz) side scan sonar system was used to survey Burlington Harbor from the breakwater out to Lone Rock and Shelburne Points. The side scan sonar revealed a mud dominated, morphologically flat lake bottom interrupted by circular depressions termed pockmarks. Pockmarks range in size from >1 m in diameter to 30 m in diameter. They occur as (1) single features, (2) in strings 50 m long, and (3) in fields 300 m by 600 m. Two pockmark fields are locate directly over the Champlain Thrust while several larger pockmarks lie 200 m to the east. Cores taken in one of the large pockmarks (30 m in diameter and 3 m in depth) showed that the center of the pockmark consisted mostly of alternating sand and silt in 3 cm thick layers for the upper 50 cm while the sediments outside the feature were silts and clays. The alternating grain size in the center of the pockmark suggests sporadic, upward migration of either biogenic gas or groundwater placing fine sediments into suspension in the water column. Side scan sonar and PDR records show plumes in the water column over these features indicating outflow through the lakebed.

PROVENANCE ANALYSIS OF SYNOROGENIC STRATA USING CR AND NI CONCENTRATIONS IN SHALE DEPOSITED DURING THE MIDDLE ORDOVICIAN TACONIC OROGENY, WESTERN NEWFOUNDLAND

Royce, Philip R., Department of Geology, Union College, Schenectady, NY 12308

Shale deposited in the foreland basin of the Taconic Orogeny in western Newfoundland was analyzed for trace element concentrations in order to determine whether fine-grained sediments can be used as a provenance indicator for ultramafic rocks in the source terrane. Previous work has shown that sandstones deposited in the foreland basin contain detrital chromite which is interpreted to have been derived from adjacent uplifted ophiolites (Hiscott, 1984). Sixty-eight shale and thirteen sandstone samples were analyzed using an Inductively Coupled Plasma-Mass Spectrometer for Ti, V, Cr, Ni, Mn, Co, and Cu using Sc, Nb and Ga as internal standards. Samples were taken from autochthonous and allochthonous flysch sequences that are located within and adjacent to the Humber Arm Allochthon. The autochthonous sequences show an increase of Cr and Ni values up-section, with a significant increase of Cr and Ni in the east-derived strata. The allochthonous units also show an increase up-section of Cr and Ni and contain the highest Cr and Ni values of all shale in this study. The difference between autochthonous and allochthonous Cr and Ni values is attributed to two factors: (1) proximity to ultramafic source and (2) dilution of an ultramafic source as additional material was added to tectonic highlands.

Grain size significantly affects the trace element composition of clastic rocks. Sandstone samples contain much higher values of Cr with respect to shales from the same units. The higher concentrations of Cr present in the sandstone samples may be due to the presence of detrital chromite. The shale samples have lower Cr values, but Cr and Ni concentrations follow a regular pattern suggesting the shale acts as a more homogeneous representation of the source terrane.

Structure of South Mountain, Bristol, Vermont

Thomsen, Daniel B., Department of Geology, Middlebury College, Middlebury, VT 05753

Rock samples and structural data were collected in an area south of Bristol, Vermont known as South Mountain. South Mountain contains rocks of the Pinnacle Formation, the Fairfield Pond Member of the Underhill Formation, and the Cheshire Formation which record the depositional history of the western margin of Iapetus from the rift stage to the development of a stable continental shelf during late Proterozoic to early Cambrian time (Dellorusso and Stanley, 1986). Cleavage to bedding relations show that South Mountain is folded massively and flexurally into an anticline, apparently bearing a fanned cleavage which is predominantly axial planar to the fold. Bedding-cleavage intersections show that the South Mountain anticline plunges north-northeast at an average angle of approximately fifteen degrees. Since the anticline plunges north-northeastward, the dolostone south of Bristol Notch must be of the Forestdale formation, in agreement with Dellorusso and Stanley (1986). Small folds throughout the area are sympathetic to the form of the anticline. Bedding in the Cheshire suggests that the eastern limb of the anticline is bounded by a fault which puts the stratigraphically lower Fairfield Pond member and Pinnacle formation above the Cheshire. Cheshire rocks show higher grades of metamorphism near this fault which could be related to the southern continuation of the Hinesburg Thrust. Interpretation of the cross sections of South Mountain has provided a good understanding of the structure in the area, while thin sections show the petrography of the formations, as well as a mineral alignment which defines the penetrative cleavage in the metamorphosed sedimentary rocks.

Chemical composition of surface and high-uranium well water, Southwestern New Hampshire

Yuskaitis, Amie, Department of Geology, Union College, Schenectady, NY 12308

Thirty-nine water samples were collected from various surface waters and ground water wells from the Lake Sunapee–Mt. Kearsarge area, NH. The wells include those in unconsolidated sediment and bedrock wells with depths from 25 to 200 m. Dissolved oxygen, alkalinity, pH, and temperature were measured in the field. The samples were analyzed in the laboratory by ICP-MS for 26 elements: Li, B, Na, Mg, Al, Si, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Cs, Ba, W, Pb, and U. Uranium concentrations of 2.5 to 495 ppb were found in water from wells drilled into the Conway granite, compared to concentrations of zero to 1.5 ppb in water from bedrock wells drilled into other units. These measurements compare to concentrations of 0.1–0.3 ppb found in the surface water samples, which are typical of most surface waters elsewhere. Several correlations were found between the high-U bedrock wells, surface waters, and other wells, including the elements U, Li, Cs, Rb, Sr, As, W, Ca, and Si. Surface waters in the area have a much more restricted composition range than ground waters. Surface waters also have a lower concentration of most elements than ground waters probably because surface waters are not, in general, in contact with the rocks for as long a period of time. Most elements in the low-U bedrock wells can be attributed to rock dissolution, although some sodium and chlorine apparently come from sea salt in rain and road salt in some cases. High concentrations of U, Cs, Li, As, and W are found in water from wells drilled into the Conway Granite probably because these elements are more soluble in the Conway granite than in other geologic formations. In particular, U mineralization in microcracks is known to occur in the Conway granite, increasing the exposure of U-bearing minerals to groundwater and therefore increasing its solubility. A leaching experiment was set up to see if the U solubility of the Conway Granite was high. The deionized water in contact with crushed Conway granite was found to have nearly 100 times the concentration of U as water in contact with another igneous rock of similar U content.

An Introduction to the U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL)

Larry Gatto

Introduction

Nearly half of the Earth's landmass is subject to snow, ice and seasonally frozen ground; 20% is underlain by permafrost, 10% is overlain by glaciers, nearly all of its land mass north of 40°N latitude is seasonally affected by snow, ice and frozen ground, 10% of the world's oceans may be, at times, covered by sea ice and the Arctic Ocean is almost completely ice-covered throughout the year.

Headquartered in Hanover, New Hampshire, with an Alaskan projects office in Fairbanks, CRREL is the only Department of Defense (DOD) laboratory addressing the problems unique to the world's cold regions. CRREL's mission is to gain knowledge of these areas through scientific and engineering research and to apply that knowledge within the DOD, other Federal and State agencies and the private sector. With its special scientific and engineering expertise and a collection of laboratory facilities unique in the free world, CRREL is the world's premier center for cold regions research and technology.

This article is a brief overview of CRREL and some of its research programs. Many on-going research projects are not mentioned. Interested readers can contact the CRREL Public Affairs Officer for more information.

CRREL's History

CRREL was established in 1961 with the merger of the Snow, Ice and Permafrost Research Establishment (SIPRE) in Wilmette, Illinois, and the Arctic Construction and Frost Effects Laboratory (ACFEL) in Boston, Massachusetts. CRREL's heritage is closely tied to the construction of strategic defensive sites, such as airfields, the DEW Line and BMEWS facilities in Alaska, Iceland and Greenland during World War II and the 50's and 60's, and of the trans-Alaska pipeline in the 70's. Experts from SIPRE, ACFEL and CRREL contributed to Antarctic research and development activities during construction of scientific stations at the South Pole and elsewhere, and have been involved in research focused on general construction, drilling technology, offshore engineering, pipeline construction, sea transport and hydrologic, hydraulic and geologic topics throughout the Arctic and Antarctic during the last 40 years.

All of this experience is the basis for CRREL's current involvement in designing and constructing the new North Warning System, the Over-The-Horizon Backscatter Radar, the proposed Alaska Chilled Gas Pipeline, the Greenland BMEWS Radar sites, and new facilities at Ft. Wainwright, Alaska, and Ft. Drum, New York. Just a single accomplishment—CRREL's engineering design for the extension of the life of the Greenland radar sites—has saved taxpayers more money than the cumulative research budget of CRREL since its founding.

Current Research Programs

CRREL's 150 scientists and engineers conduct a $30 million research program that addresses all aspects of snow, ice, and frozen ground, and their effects on military and civilian construction, transportation and operations. CRREL develops the national standards for military and civilian facility construction, operation and management in cold climates (including development of the national criteria for snow-load roof design), for design of building envelopes to increase R-values and prevent vapor damage, for testing frost-susceptibility of soils for roadways, for design of pavement systems to reduce frost heave and for nondestructive testing of roofs for construction quality. These accomplishments have provided significant savings to the Department of Defense, as well as strongly affecting the private sector, where R&D in this area is virtually nonexistent. Nearly all aspects of engineering and the sciences are represented at CRREL, and its research projects reflect that diversity.

Military Research

CRREL has become a principal contributor to the research on materiel that must operate reliably in the winter. The CRREL winter battlefield environment program is providing the characterization of the winter operational environment and its effect on the performance of current and future smart weapons, target signatures, obscurant and screening systems, sensor systems and electro-optical phenomena as they relate to high technology weapons.

CRREL's combat support research concentrates on more traditional combat engineering operations, including winter battlefield mobility, minefield effectiveness, expedient winter bridging, minefield detection and neutralization, survivability, terrain intelligence, winter water location and supply, winter nuclear, biological, and chemical decontamination and persistence, icing effects on communications systems, the Army's water treatment and distribution system, the vulnerability of field medical facilities to cold climates, and the impact of low temperature thermal cycling on the strength of composite materials.

CRREL's chemistry research provides fundamental data on chemical properties and interactions in freezing and frozen soils as applied to hazardous material control, addresses new analytical techniques to determine levels of contaminants in soils and develops quality assurance methods now used by the U.S. Army Toxic and Hazardous Materials Agency and the EPA.

The development of basic snow mobility relations has recently broadened the scope of the Army Mobility Model and allows more comprehensive analyses for planning of future military vehicles. Knowledge of ice growth and strength has created new doctrine for winter tactical bridging. Rapid geophysical survey methods are being developed at CRREL to find water in the Arctic and sub-Arctic, to determine subsurface deterioration of asphalt and concrete pavements, and to measure ice thickness for military traffic.

CRREL serves as a principal source of cold regions expertise to both the Navy and Air Force. A significant portion of the Navy research on sea ice characteristics, ice mechanics, and Arctic boundary layer conditions is conducted at CRREL. This includes the use of the CRREL facilities to test ice penetration for submarine and anti-submarine operations. With the location of the Naval Oceanographic and Atmospheric Research Laboratory's Polar Oceanography Branch at CRREL, the principal sea ice technologists in the DOD are now together. CRREL is also addressing Navy problems in surface ship icing and deicing along with studies on ice adhesion and deicing concepts for aircraft and antennas. Air Force support addresses strategic surveillance systems in the Far North as well as maintenance of air bases in high latitudes.

CRREL has redesigned and field-tested two military versions of standard winter tools: a towed snow plow for winter tactical maneuvering and a 16-inch ripper bucket. The plow creates a passable snow road for wheeled vehicles in all kinds of winter weather. The 16-inch ripper bucket is the optimum size ripper bucket for Army use and will dig in all types of frozen soils, as well as caliche and weak rock.

Civilian Research

CRREL's civil works programs address the unique problems faced by the Corps' Districts operating in cold regions. The recently completed River Ice Management Program provided the principles and specific guidelines for reducing the impact of ice on winter navigation and for operating navigation and flood control structures in winter. Continued flood control and navigation research addresses the impacts of ice on the nation's waterways, and reduction of flood damage caused by ice jams.

CRREL's Water Resources of Cold Regions Program evaluates and modifies runoff models to more accurately predict snowmelt, evaluates hydrometeorological sensors, develops frequency methods for winter flows, evaluates (in the field) the magnitude of freeze-thaw bank erosion, and assesses the effects of frozen ground, ice, and snowfalls on basin discharge and sediment transport.

The Corps of Engineers Civil Works Remote Sensing Program is managed by CRREL. The remote sensing research addresses the capabilities of new sensors and results in demonstration projects with Corps Districts to improve their data collection and analysis capabilities through remote sensing technology.

CRREL developed a new process called a 'sludge freezing bed' as part of its environmental engineering research. Sludge produced by waste water treatment plants is about 95% water and approximately 60% of the total cost of waste treatment is associated with sludge dewatering. The freezing bed allows natural freezing to separate the solids and liquids.

CRREL and the Minnesota Department of Transportation are cooperating on a project to improve the design and construction of roadway pavements in seasonal frost areas by applying design methods and supplementing data bases recently developed at CRREL. CRREL and the Alaska Department of Transportation are jointly developing a cost-effective bioremediation technique for northern climates to clean fuel contaminated soil and groundwater from leaking underground storage tanks without extensive excavation. It is anticipated that in addition to DOD agencies, state and local highway agencies, and supplier and contractor groups will use the results from these studies.

The U.S. technologies for drilling and digging in frozen soils and ice were developed and are evolving at CRREL, starting with the first successful coring of both the Greenland (4550 ft) and Antarctic (7100 ft) ice sheets. CRREL is currently reviewing alternatives to causeways for off-shore oil and gas development on Alaska's North Slope. A sensor developed in cooperation with Dartmouth College is being evaluated as a method to continuously monitor soil moisture. Researchers are in their 15th year of monitoring test crude oil spills on Poker Creek near Fairbanks to assess the movement of the oil, and changes to soils and vegetation. CRREL has determined that white phosphorus in marsh sediment caused the deaths of ducks at the Eagle River Flats, an artillery range near Anchorage, through a 3-year field research project. For over 10 years, the cause of the catastrophic waterfowl mortality was unknown. Damage assessment and remediation techniques are being researched now.

CRREL conducts collaborative work with other federal agencies such as the FAA, FHWA, NASA, DOE and EPA. CRREL is an active research partner in the Strategic Highway Research Program components on snow and ice control and long-term pavement performance. These cooperative programs provide benefits to both the Army and civilian needs.

Research Facilities

CRREL has about 300 scientists, engineers, research technicians and administrative personnel, and has unique facilities to support its research programs. The CRREL Library is maintained to support the research programs with a collection of over 135,000 citations of world literature on snow, ice and frozen ground. The main laboratory building contains 24 cold-rooms that can be operated at temperatures as low as -50°F, a computer center, a clean-room complex, a photo/video laboratory and center, a soils-testing laboratory, a machine shop, an electronics laboratory, and the following additional specialized laboratories: Environmental and analytical chemistry, heat sink, heat transfer and energy, laser, materials testing, optics, sanitary engineering, seismic, thermophysics, x-ray, calibration, climatic data, and electromagnetics. The facility includes specialized equipment such as materials testing machines, mass spectrometers, a low-temperature scanning electron microscope, a dual-gamma scanning device for monitoring frost penetration in soils, a Hopkinson pressure-bar impact test setup for measuring stress within soils caused by temperature changes, nuclear magnetic resonance equipment, and a falling weight deflectometer for pavement research.

The CRREL Ice Engineering Facility (IEF), one of the largest refrigerated hydraulics laboratories in the world, is a 71,000 square foot building with temperature control from 65° to -20°F that allows researchers to construct large-scale physical models of sections of rivers and lakes and can be operated to simulate natural conditions and test scale models for basic research and to develop solutions to practical problems. Primary testing areas within the IEF include a test basin, research area and flume. The basin is used to study ice forces, ice control and management techniques, vessel dynamics in ice, brash-ice refreezing, the formation of ice pressure ridges, ice-sheet bearing capacities and fracture toughness and crack propagation in ice. The research area (an 80 by 160 foot refrigerated room) is used for modeling river bends and changes in slope, for studying waves, for duplicating frozen soil masses for various purposes, for testing the bearing capacity of large sheets of ice and for testing vehicles and other outdoor equipment. The refrigerated flume is used to study frazil ice formation, ice jams, sediment movement under ice cover, bank erosion when ice jams are present, and to test ice booms and other ice control techniques.

The Frost Effects Research Facility (FERF) is a 29,000 square foot refrigerated soils laboratory that contains a 182-foot-long and 75-foot-wide testing area that can be maintained below 30°F. In its twelve test basins, soils can be frozen from the top down, simulating the natural freezing process. Six to eight natural freeze-thaw cycles can be simulated in a single year. Scientists test pavements, foundations, base and sub-base courses for roads, and buried utilities in the FERF.

The permafrost tunnel and a permafrost test site near Fairbanks, Alaska, are operated by the Fairbanks CRREL office. The tunnel extends 400 feet into Gilmore Dome, wherein scientists can examine frozen soils and conduct experiments in temperatures that never exceed 32°F. Additional research sites include Sleepers River Watershed in Danville, Vermont, sea ice ponds, a refrigerated deep well for testing ice coring equipment at the Hanover laboratory, and a physical security test site in Randolph, Vermont.

New Research Programs

CRREL's involvement in the Strategic Environmental Research Program (SERP), a climate change research program, will focus on evaluating and predicting the potential effects of climate change on permafrost, Arctic wetlands, and glaciers, and will develop response strategies for dealing with such impacts.

A Remote Sensing/GIS Assistance Center will soon be built at CRREL to develop applications, conduct training courses, and transfer technology to help Corps' Divisions and Districts around the country in using state-of-the-art remote sensing and spatial data management technologies.

The proposed River Confluence Ice Program is designed to develop practical methods for Corps personnel to reduce the incidence and the severity of ice-induced problems at river confluences. Confluences are often sites of major ice jams when ice breakup in a tributary sends additional ice into an already ice-laden mainstream. The St. Louis District of the Corps estimates the overall costs related to ice problems at the confluences of the Mississippi River and its tributaries average $2 to $3 million per year.

The National Science Foundation recently requested CRREL's technical support for its Antarctic activities in facilities design and logistics. In the facilities area, CRREL is working with NSF and its consultants to evaluate design concepts for a new base at the South Pole. CRREL's logistics support is focused on the development of ice runways at McMurdo Sound and near the South Pole. Currently, all air transport to the South Pole requires HC-130's to use skis for take-offs and landings, which is extremely inefficient because ski-equipped aircraft cannot transport as much as the same aircraft can when wheel-equipped. Through exploration surveys, CRREL discovered two natural "blue ice" airfield sites that will allow wheeled take-offs and landings, thus providing a three-fold improvement in logistics capabilities.

CRREL is developing four new collaborative research projects addressing ice forces on structures and basic research on frozen soils with private industry, as authorized by the Stevenson-Wydler Act of 1980 and the Federal Technology Transfer Act of 1986. This type of research provides excellent opportunities to expand CRREL's research sponsors.

The highly focused mission, critical mass of unique research facilities and strong in-house technical and support staff have made CRREL the international leader in cold regions science and technology. A relatively small national investment results in a very large capability for the Corps of Engineers, Army and DOD, and for national priority needs in this specialized area.

VERMONT GEOLOGICAL SOCIETY BUSINESS AND NEWS

New Members

We want to welcome the following new members who have joined the Vermont Geological Society since the Winter *GMG* was published:

William D. Norland	Bristol, VT	Geologist, Hydrogeologist Applied Geology, Inc.
Michael K. Sparks	So. Burlington, VT	Hydrogeologist Wagner, Heindel & Noyes, Inc.
Mary Ann Schlegel	Colchester, VT	Graduate Student, Paleontology, University of Vermont

In Memoriam

William E. Stockwell	Cary, NC	March 1992

Treasurer's Report

Balance as of 1/1/92		$1,817.25
Income		
Interest	25.08	
Dues	1,712.33	
Sales	12.00	
Donations	80.00	+ $1,829.41
Expenses		
Printing	329.03	
Postage	106.43	
Travel	95.75	
Telephone	31.41	
Winter Meeting	3.00	
Money Orders	0.75	- $ 566.37
Balance as of 4/1/92		$3,080.29

Respectfully submitted,

David S. Westerman

Executive Committee Meeting Minutes

November 2, 1991, Johnson State College, Johnson, Vermont

Present:

Stephen Wright, Bruce Wilson, Lucy Harding, Brad Jordan, Leslie Kanat, Chris Stone, Larry Gatto, and Ron Parker

Meeting Summary:

The meeting convened in a conference room at the college and started off with a sumptuous feast of coffee, doughnuts, and bagels. Bruce Wilson offered to be guest editor for the Winter issue of the *GMG* and suggested that the meeting be dedicated to Wally Cady. Bruce suggested that the meeting consist of a core of invited speakers who could summarize the current understanding of bedrock geology in the state. The committee agreed that this would be a fitting tribute to Wally Cady's extensive work in the state. A preliminary "Call for Papers" announcement was outlined which Stephen and Brad decided to send out separately from the dues notice.

Larry Gatto volunteered to put together a summary of activities at CRREL for the Spring issue of the *GMG* and Ron Parker agreed to take the reins of the Summer issue.

Stephen presented a summary of his "Field Geology for Teachers" course which he will teach for the first time next summer. In this course teachers will be writing a field guide suitable for their colleagues and students. Stephen asked for and received support from the executive committee to publish this field guide as an issue of *Vermont Geology*.

Leslie Kanat led a tour of the new geology facilities at Johnson, allowing legs and minds to stretch for a bit. The meeting continued with a discussion of the Vermont Geological Society Student Grant Program. Following approval by the membership for a dues increase to fund the grant at the Fall meeting, Lucy agreed to write up an outline of rules for the grant and an application form. The committee felt that the grant should be constructed along the lines of those offered by the Geological Society of America and several of the honor societies.

Several suggestions for summer and fall field trips were entertained. Bruce, feeling the strain of yet another 3 hour-long drive, concluded by warning everyone that there would indeed be an executive committee meeting in southeastern Vermont before his term expires.

Respectfully submitted,
Stephen Wright & Ron Parker

Executive Committee Meeting Minutes

February 29, 1992, Cabot Science Annex, Norwich University, Northfield, Vermont

Present:

Sharon O'Loughlin, Eric Lapp, Lucy Harding, Larry Gatto, Leslie Kanat, Bruce Wilson, Chris Stone, Dave Westerman, Stephen Wright, Vincent Dellorusso, A.W. Gilbert, Sue Hadden, Bob Cushman, Ron Parker, and others.

Meeting Summary:

The executive committee convened at approximately 1:40 PM, at the conclusion of the winter meeting.

The meeting commenced with a discussion of the first draft of the proposed Vermont Geological Society Research Grant Program. It was acknowledged by all that this topic was of sufficient importance to require the bulk of the time allotted for the meeting. The first draft had been prepared by Lucy Harding, who had mailed it to committee members. Those who had not read the draft did so hastily (between bites of sandwich).

Lucy first provided a sketch of the proposed grant program. The purpose of the program is to foster original student research on topics related to the geology of Vermont. The program is tailored after the Geological Society of America and Sigma Xi Grants-in-Aid programs and will make monetary awards toward the progress of a student research project.

After Lucy's brief introduction, various topics related to the administration of the program were discussed at length by those present. Among the items visited were eligibility requirements, budget constraints, award limitations, research completion and presentation, application review protocols, and many others. As predicted, this discussion consumed the bulk of the afternoon.

Many good, constructive comments were made, however, and Lucy has incorporated many of them into a second version that is ready for a trial run.

After the discussion on the grant program, the committee considered several options for the summer and fall field trips. A suggestion from one of the consulting geologists at the meeting was that we attempt to conduct a summer field trip that focuses upon an active groundwater remediation site. This would allow some of the membership to experience first hand the kind of societal problems that are regularly being addressed by geologists today. The membership is requested to call Ron Parker (658-0820 days or

862-4928 evenings) if you have an illustrative site or two that you would like to feature as a field trip stop.

Someone mentioned that a good idea for a fall field trip would be a swing through the economic mineral belt in the Proctor area. Duncan Ogden and Lance Meade were mentioned as prospective leaders. (Duncan...Lance...are you out there?).

The Spring Meeting date was set at April 25 and the meeting adjourned at 4:45 PM.

Respectfully submitted,

Ronald L. Parker

VERMONT GEOLOGICAL SOCIETY RESEARCH GRANT PROGRAM

"The primary goal of the Vermont Geological Society Research Grant Program is to promote and support *original* research on Vermont geology by undergraduate and graduate students and secondary school teachers (grades 7–12). The grant program does not seek to cover all of the researcher's expenses but instead should be viewed as a porfessional endorsement of the research endeavor. Requests for grants are judged on how well the proposed research will advance the science of geology and its related branches within the State of Vermont. Since the grant program budget is not anticipated to be large enough to fund every research proposal, the grants will be awarded on a competitive basis."

The above paragraph is the preamble to the Policy and Procedures statement for the Vermont Geological Society Research Grant Program. A complete copy of the Policy and Procedures document and application forms have been mailed to the geology departments of Vermont Colleges and Universities as well as neighboring schools. Anyone interested in a copy of these documents should address their request to Lucy Harding at the Geology Department, Middlebury College, Middleburyl VT (388-3711 Extension 5444).

SEMINARS, MEETINGS, AND FIELD TRIPS

April 25: Vermont Geological Society Spring Meeting, Presentation of Student Papers, University of Vermont, Burlington, VT.

May 1: Middlebury College Geology Department, 12:15 PM, (Lunch Talk): *"Facts, flies, and drilling bits: The science and politics of landfills"* Steve Maier and Paul Vachon, Addison County Solid Waste Management District.

June 20–21: *Geology of the Taconic Orogen: A Sesquicentennial Field Conference,* Shoreham, Vermont, Contact Paul A. Washington, 919-733-1330.

August 1–2: *Mines and Minerals of New Hampshire,* Burlington Gem and Mineral Club Annual Show: Contact Ethel Schule for details.

THE GREEN MOUNTAIN GEOLOGIST
VERMONT GEOLOGICAL SOCIETY
P.O. BOX 304
MONTPELIER, VERMONT 05601

The *GREEN MOUNTAIN GEOLOGIST* is published quarterly by the Vermont Geological Society, a non-profit educational corporation.

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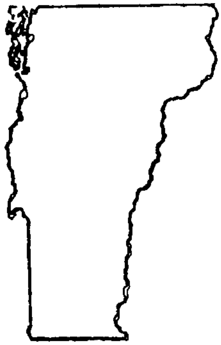
THE GREEN MOUNTAIN GEOLOGIST



QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

SUMMER 1992 VOLUME 19 NUMBER 2

Vermont Geological Society's
Summer Field Trip

Remediation of Contaminated Groundwater in Barre, Northfield, & Waitsfield

Saturday August 22, 1992, 9:30 AM

See inside for details!

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PRESIDENT'S LETTER

Dear Members,

It is with deep regret that we note the death of Brewster Baldwin early in July following a relatively short illness. Brew was a long-time faculty member of Middlebury College and an active member of the geologic community and of this Society. It was an honor to have known him and his absence will be difficult to get used to.

In April we had a fine group of speakers at our annual Symposium of Student Papers at UVM. Todd Kafka of Middlebury College received the Charles G. Doll Award for his paper of the geochemistry of sheared greenstone and Philip Royce of Union College took second place with a paper on the provenance of Taconic-age shales in Newfoundland. I would like to thank Stephen Wright making the arrangements with UVM and the caterers; our judges Larry Gatto, Shelley Snyder, and Dave Elbert, who had the especially difficult task of choosing among so many good papers; and especially the students themselves who put on some of the most well-rehearsed and sophisticated presentations I have seen.

I would like to note that we have awarded Mary Ann Schlegel and Jessica Falkenberg the first Student Grants-In-Aid (described elsewhere in this issue) and encourage members to attend next year's Spring Meeting to hear about their results.

This issue's guest editor is Ron Parker, who also put together the summer field trip. We thank Ron for the work he has put into organizing both and urge members to try to attend the field trip and learn about an important aspect of applied geology.

Sincerely,

Bruce Wilson
Brattleboro, VT

Brewster Baldwin (1919–1992)

Brewster Baldwin, 72, professor emeritus of geology at Middlebury College, died on Sunday, July 12, at the Medical Center Hospital in Burlington following a brief illness. He was born in Brooklyn, New York, on November 10, 1919, the son of William and Cecilia (Brewster) Baldwin.

A field geologist, Brew joined the Middlebury faculty in 1958 and retired from full-time teaching in 1986. A highly regarded faculty member, he was honored at his retirement by an unusual day-long symposium where 80 colleagues and current and former students came from far and wide to present papers on their current research. The papers presented at this meeting and three of Brew's papers were later published in a 400-page volume "A Collection of Papers Honoring Brewster Baldwin," edited by L.E. Harding and P.J. Coney and published by the Middlebury College Press. In October 1991, the R/V Baldwin, a 32-foot boat refitted with computers and other gear to facilitate its use for research on Lake Champlain, was dedicated in a ceremony at Basin Harbor Club in Vergennes.

A graduate of Williams College with M.A. and Ph.D. degrees from Columbia University, Brew taught field mapping, stratigraphy, environmental geology, and introductory geology. Brew's recent geologic activities focused on writing field guides to the geology of Crown Point, N.Y., Fair Haven, Vermont, and Thetford Mines, Quebec. These field guides appeared originally in Vermont Geology and more recently in the Geological Society of America's *Northeastern Section Field Trip Volume (part of the Decade of North American Geology—DNAG—series).*

A memorial service will be held in September at St. Mary's Church in Middlebury. In lieu of flowers, memorial contributions may be made to Vermont Catholics for Free Choice, P.O. Box 475, Middlebury, Vermont 05753 or to the Children's Trust Fund, State Office Complex, Waterbury, Vermont 05676.

This note was prepared by the Middlebury College Department of Public Affairs.

Guest Editor's Note

In this issue of the *GMG,* I have attempted to focus on selected topics concerned with environmental and groundwater geology. I selected this theme because of the significance of environmental work to geologists in Vermont. Virtually all of the geologists that have graduated from post-secondary schools in Vermont in the past ten years have (or will) work in environmentally related disciplines. This fact is a manifestation of the accelerated growth of hydrogeology and environmental geology. In the May 1991 *GSA Today* article entitled "Hydrogeology: It Is," Stephenson, Cutright, and Woessner state that "Hydrogeology is currently the fastest growing discipline in the geosciences." This accelerated growth is the result of a societal awakening to the limited nature and the value of uncontaminated ground and surface water. The trend of increasing opportunities for geologists in environmental fields is not likely to abate by the end of this millenia.

One concern in regard to the expanding need for hydrogeologists and environmental geologists is the paucity of educational opportunities that are available in Vermont. Few courses are available beyond the introductory level that focus on the more complex and interdisciplinary aspects of hydrogeology. This may stem from a perception by educators that these disciplines are best taught in an engineering format or that practical applications "cheapen" the science. It is certainly true that hydrogeology is an eclectic science (as is geology) that draws strength from many disciplines. Hydrogeologists today face problems that require some knowledge of chemistry, physics, mathematics, computer science, statistics, microbiology, soil science, and law as well as engineering principles. It is undeniable, however, that hydrogeology requires an understanding of the nature, fabric, structure, history, and origins of earth crustal materials: soils, sediments, and rocks. Hydrogeology requires trained geologists. As Stephenson, Cutright, and Woessner (1991) have observed, studies for hydrogeologists should "emphasize the processes that create the geologic framework through which fluid moves (e.g. depositional environments and structural character). Without such a basis, links between complex theory and application are poorly grounded."

In the July, 1992 issue of *Geology,* John Bredehoeft writes a letter that highlights the significance of fluids (dominantly water) in crustal processes. He points out the fact that fluid migration is the dominant process by which energy and mass are transported through the crust; that many ore deposits are the "products of extinct geothermal systems," and that pore fluids play a dominant role in the deformational and tectonic history of rock masses. Mr. Bredehoeft's purpose is to emphasize that hydrogeology is a rigorous and quantitative science that poses intellectual challenges to all geologists. Stephenson, Cutright, and Woessner (1991) add that there is a "paucity of bona fide hydrogeology candidates for employment at virtually all levels. Those employers facing staff shortages are turning to persons who have little or no actual hydrogeological education or training." In a water-rich state like Vermont, in which almost all geology graduates go on to professions in the environmental field, it is imperative that additional educational resources be allocated to buttress course offerings in hydrogeology.

The 1992 Summer VGS field trip is intended to provide an educational opportunity that will permit attendees to witness the processes and technologies involved with active groundwater remediation. The field trip will visit three sites that are contaminated by petroleum products. (A description of the nature and distribution of contaminants and the remedial strategies employed for clean-up at each site are presented as short articles in this issue of the *GMG).* The trip will conclude with a demonstration of the techniques that are employed in order to install an analytical quality groundwater monitoring well. This is sure to be an opportunity not soon repeated so please plan on attending.

Sincerely,

Ronald L. Parker

SUMMER FIELD TRIP

Hydrogeology and Remediation Technology at Three Hazardous Sites in Central Vermont

plus

A Groundwater Monitoring Well Installation Demonstration

This field trip is designed to illustrate three contaminated sites in the central Vermont region and to show how these sites are being cleaned up. The sites are located in the middle of downtown Barre, immediately south of the Norwich University campus in Northfield and in the village center in Waitsfield. The sites will progress from a relatively simple site to a relatively complex site in order that field trip participants can gain a better perspective of the range of groundwater contamination problems.

The field trip will start at 9:30 AM. on August 22, 1992 (rain or shine). The trip will meet at the Park & Ride parking lot on the north side of Route 62 at the Berlin-Barre exit (across from Town and Country Honda). From there the trip will proceed down the hill on Route 62 to the Barre City intersection of Route 14. At this intersection take a right. The site is a closed gas station on the left (northeast) side of the road next to Mr. Z's Pizza. Park in the shopping center parking lot adjacent to the site. The field trip will plan on being at this location for 30–45 minutes. A description of the site by Kent Koptiuch is included in this issue of the *GMG.*

From this site the trip will travel back up Route 62 and will get on interstate 89 heading south. The caravan will leave the interstate at the Northfield-

Williamstown exit (Exit 5) and will proceed west on Route 64 to Route 12 and thence, north on 12 to Northfield. The site is situated immediately to the south of the Cabot Science Annex (the building that houses the Norwich University Geology Department). The Cabot Science Annex is the southernmost building on the Norwich campus along Route 12. Estimated time of arrival at the second stop is 11:00 to 11:15 AM. The field trip will plan on being at the second stop for 45 minutes to an hour. Participants should plan on eating lunch at this stop. A description of this site by Ron Miller and Pete Murray appears in this issue of the *GMG.*

From this location the field trip will travel to Waitsfield via the Roxbury Gap passage over the mountains. From the second field trip stop, head south on Route 12. Almost immediately veer to the right (west) onto Route 12A. Follow Route 12A to Roxbury (the next town). In the center of Roxbury take a right and head west on Warren Road over Roxbury Gap through the Northfield mountains, pass through East Warren and onward to Warren. At Warren, get on Route 100 and proceed north through Irasville to Waitsfield. The Village Grocery is on the left (west) side of the road. The estimated time of arrival at this location is approximately 12:45 to 1:00 PM. The site will be visited for approximately one hour. Descriptions of the site by Haslam and Amadon appears in this issue of the *GMG.*

Immediately following the tour of the village grocery site, a demonstration of the methods and techniques used to install a groundwater sampling quality monitoring well will be given. This demonstration will be performed by Neal Faulkner of Tri-States Drilling and Boring of West Burke, Vermont. The estimated start time for the demonstration is 2:00 to 2:15 p.m. The demonstration should take 1 to 2 hours to complete.

In order to return to the starting point of the field trip, participants need only drive north on Route 100, veer right on Route 100B and then get on interstate 89 at the Middlesex-Moretown exit (Exit 9). Proceed south on the interstate highway to the Berlin-Barre exit (Exit 7) to the place of the field trip origin.

Stop 1: Application of Soil Vapor Extraction Techniques at a Site Contaminated by Gasoline, Barre Vermont

Kent S. Koptiuch, Senior Geologist
Matrix Environmental Technologies, Inc.
4 Kellogg Road, Essex Jct, Vermont, 05452
(802) 878-9310.

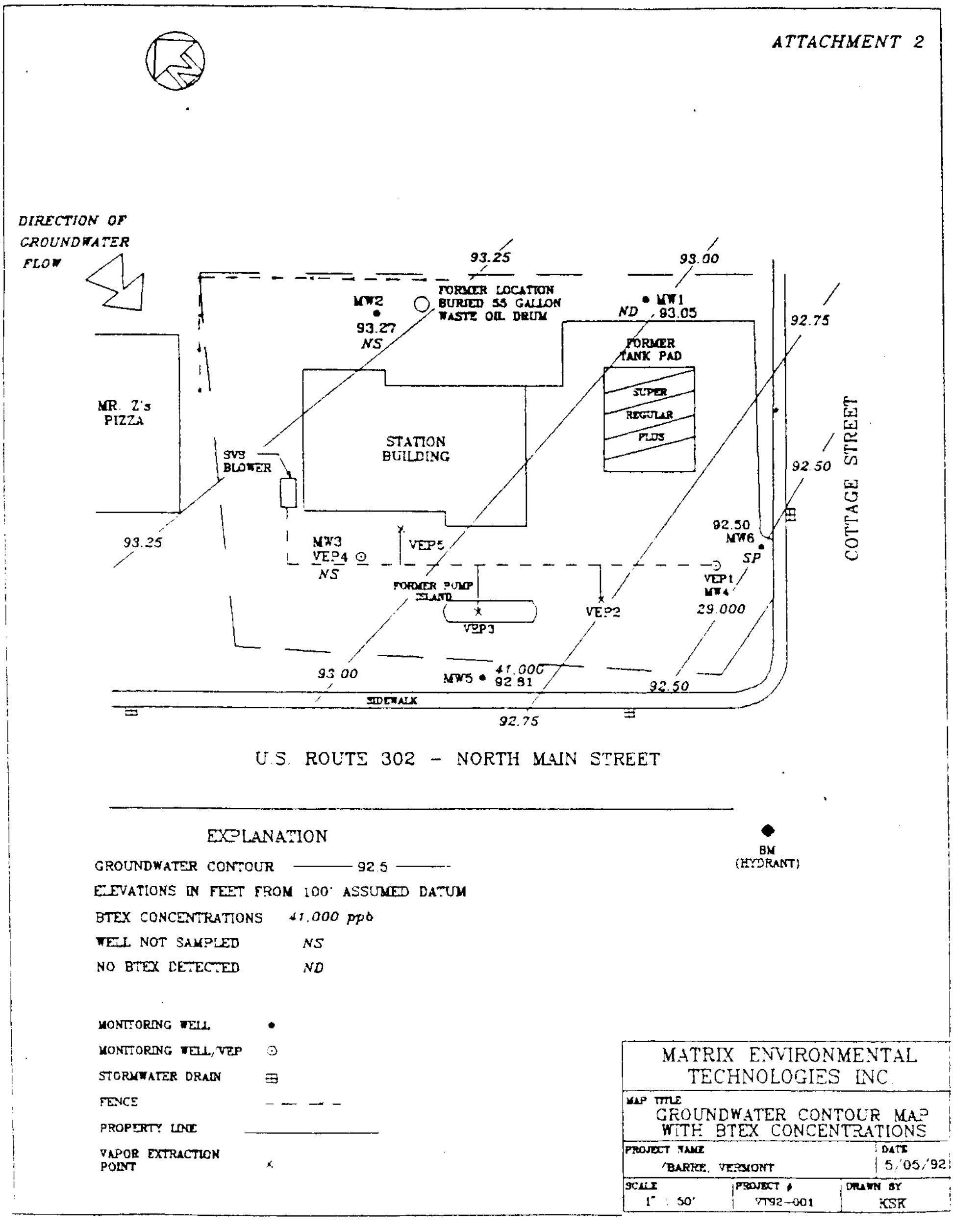
In November 1990 a phase II subsurface investigation at a former gas station in Barre Vermont confirmed that overburden soils and groundwater were affected, respectively, by adsorbed and dissolved petroleum hydrocarbons. In October 1991 a soil vapor survey and ancillary investigations revealed that hydrocarbon impact was limited to the perched, unconsolidated aquifer and its associated vadose zone. Groundwater flow in this aquifer trends to the south with a gradient of approximately 1%. The potentiometric surface fluctuates seasonally between four and seven feet below grade.

The bedrock underlying the site consists of highly metamorphosed Paleozoic metasedimentary rocks (the Barton River Member of the Waits River Formation) and granitic intrusive rocks. Overburden at the site consists of poorly sorted sands and gravels of deposited by the Stevens Branch River and well sorted glaciolacustrine silts and clays.

Potential receptors of subsurface hydrocarbons from the gas station include trenchlines containing underground utilities along Main Street (water, sewer, gas), down-gradient residences and businesses, and the Stevens Branch itself. In cooperation with the Petroleum Sites Management Section of the Vermont Department of Environmental Conservation (DEC), a Remedial Action Plan (RAP) was developed and approved in December, 1991 to mitigate environmental impacts.

The RAP called for the installation of a five (5) point soil vapor extraction system to address both the adsorbed and the dissolved petroleum hydrocarbon plumes. The locations of the vapor extraction points were chosen using computer models that were based on a soil vent test. Recovered vapors are treated through a series of two (2) granular activated carbon (GAC) vessels prior to atmospheric discharge. A maximum discharge threshold of 5 parts per million total volatiles was imposed by the DEC. When vapor emissions meet or exceed this level, rotation of the GAC vessels is required.

The remedial system installation was completed during the early Winter months of 1992 and system startup occurred on April 8, 1992. The system is monitored and balanced on a monthly basis. The vapor extraction system utilizes a two (2) horsepower vacuum blower pulling an average of 2,800 cfm. Current recovery rates, with a system influent of 214 parts per million total volatiles, have been calculated to yield 70.44 lbs./hr total gasoline vapors. With continuous operation at the current extraction rate, removal of 95% of the contaminant has been projected to take a period of one year from the date of system startup.


ATTACHMENT 2
DIRECTION OF GROUNDWATER FLOW
93.25
93.00
MW2
93.27
NS
FORMER LOCATION BURIED 55 GALLON WASTE OIL DRUM
MW1
ND
93.05
92.75
FORMER TANK PAD
SUPER
REGULAR
PLUS
MR. Z's PIZZA
STATION BUILDING
SVS BLOWER
92.50
COTTAGE STREET
93.25
MW3
VEP4
NS
VEP5
92.50
MW6
SP
FORMER PUMP ISLAND
VEP3
VEP2
VEP1
MW4
29,000
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MW5
41,000
92.81
92.50
SIDEWALK
92.75
U.S. ROUTE 302 - NORTH MAIN STREET
EXPLANATION
GROUNDWATER CONTOUR 92.5
ELEVATIONS IN FEET FROM 100' ASSUMED DATUM
BTEX CONCENTRATIONS 41,000 ppb
WELL NOT SAMPLED NS
NO BTEX DETECTED ND
BM (HYDRANT)
MONITORING WELL
MONITORING WELL/VEP
STORMWATER DRAIN
FENCE
PROPERTY LINE
VAPOR EXTRACTION POINT
MATRIX ENVIRONMENTAL TECHNOLOGIES INC.
MAP TITLE
GROUNDWATER CONTOUR MAP WITH BTEX CONCENTRATIONS
PROJECT NAME
BARRE, VERMONT
DATE
5/05/92
SCALE
1" : 50'
PROJECT #
VT92-001
DRAWN BY
KSK

Stop 2: Investigation and Remediation of Subsurface Petroleum Contamination at a Gasoline Station in Northfield, Vermont

Miller, Ronald W., Staff Geologist, and Peter M. Murray, Hydrogeologist
Griffin International, Inc.
2B Dorset Lane, Williston, VT 05495
(802) 879-7708

In July 1991, subsurface petroleum contamination was discovered at a gasoline station and convenience store located in Northfield, Vermont. Several feet of free-floating gasoline were detected in a monitoring well that had been installed to comply with Vermont Department of Environmental Conservation underground storage tank (UST) regulations.

The source, degree, and extent of contamination have been investigated by the installation of twenty soil borings and monitoring wells. Up to four feet of free-floating gasoline have been measured in several monitoring wells in the immediate vicinity of the station's gasoline USTs. The area of soil and groundwater contamination appears largely confined to the immediate vicinity of the gasoline station. The station's present or former tanks or piping are considered a probable source of soil and groundwater contamination in the vicinity of the site. Two gravel municipal supply wells are located along the Dog River approximately one half-mile southwest of the site.

Materials comprising the surficial aquifer in the vicinity of the site are predominantly silty sands, apparently deposited along the shores of a Pleistocene high-level glacial lake. The relatively low permeability of these materials has apparently helped to reduce contaminant migration from the site. Groundwater in the surficial aquifer at the site flows west-southwest. The Cram Hill member of the Ordovician Mississquoi Formation is mapped as underlying the site, but has not been encountered during subsurface explorations.

Because of the degree of contamination found at the site and the potential threat to the municipal water supply, four dual-pump recovery well systems were installed at the site in December 1991, to intercept contaminated groundwater and recover free-floating gasoline. Contaminated groundwater is pumped through granular activated carbon drums, then is discharged into a storm sewer. Recovered gasoline is pumped to an above-ground recovery tank. One horizontal and two vertical soil vapor extraction points were also installed in December 1991 to remove adsorbed contaminants from unsaturated soils adjacent to the gasoline UST's. Contaminated vapors currently pass through granular activated carbon drums prior to discharge to the atmosphere. During summer 1992, several additional soil vapor extraction points will be installed, and the carbon vapor treatment system will probably be replaced with a catalytic incinerator.

Stop 3: Early Site History of the Village Grocery Waitsfield, Vermont

Robert Haslam, Environmental Technician
Hazardous Materials Management Division
Vermont Department of Environmental Conservation
West Office Building, 103 South Main Street, Waterbury, Vermont, 05671

The Village Grocery site came under active management by the Department of Environmental Conservation (DEC) on November 2, 1988. DEC investigators responded to a complaint on that day by an adjacent resident of a petroleum odor in his home. Using photo-ionization devices, the investigators detected petroleum vapors in this residence and the residence of his neighbor. The source of this contamination was found to be leaking gasoline underground storage tanks (UST's) at the Village Grocery.

An emergency remedial effort began which involved installation of a soil vapor extraction (SVE) system to mitigate vapor impact to these homes. A series of screened vapor points were placed just above the groundwater table in the area surrounding the Bettis residence. These points were manifolded together and attached to a one-horsepower regenerative vacuum blower. The blower drew a vacuum through the soils to vaporize and extract the adsorbed volatile constituents of the gasoline in the subsurface. Extracted vapors were run through granular activated carbon (GAC) prior to discharge to the atmosphere.

Next, a series of monitoring wells were installed across the site. These wells were used to (1) determine the degree and extent of soil and groundwater contamination, (2) determine the direction and gradient of groundwater flow, and (3) further characterize the soils. Monitoring wells were installed simultaneously with the expansion of the SVE system to include the area surrounding another residence down-gradient. Frequent breakthrough of the GAC (resulting from extremely high vapor concentrations) necessitated replacing the drums with a catalytic oxidizer to incinerate the petroleum laden vapor extracted from the SVE system. Laboratory indoor air analyses were conducted in the surrounding homes to evaluate the effectiveness of the SVE system. Indoor air results indicated that the system was effective in quickly reducing indoor vapor concentrations to well below allowable standards.

Eventually soil vapor concentrations were sufficiently reduced to allow removal of the catalytic incineration unit to be replaced with the GAC filters. The incinerator was then used at another petroleum release site.

The Village Grocery site remained in active status although there was no longer actively on-going remediation. Monitoring wells were sampled and analyzed on a regular basis to track groundwater quality. The natural processes of dilution and degradation continued to improve groundwater quality across the site.

On December 2, 1991, the tank owner reported to the DEC a loss of product. A sudden release of 6,000 gallons of gasoline had occurred from a puncture in the UST. Repeated inventory readings in UST's can result in a weakening of the tank wall where the inventory stick strikes the bottom of the tank. Apparently, a stick reading on the morning of December 1, 1991 was the "final straw" for this tank, resulting in a puncture approximately 1/2 an inch in diameter. Through this hole poured approximately 6,000 gallons of gasoline. The tank owner contracted with Lincoln Applied Geology (LAG) for an emergency response to the release. DEC inspectors met on-site with LAG and the owner to formulate a response.

As a contingency measure, the subsurface components of the original SVE system had been left in place along with one vacuum blower. This system was reactivated along with free-product recovery from an existing monitoring well. In the days to follow a series of recovery wells were installed, marking the beginning of a massive remediation effort at this site.

Stop 3: Hydrology and Remediation of Contaminated Groundwater at the Waitsfield Village Grocery, Waitsfield, Vermont

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On December 2, 1991, an inadvertent puncture of an 8,000 gallon underground storage tank (UST) at the Village Grocery in Waitsfield, Vermont released approximately 6,000 gallons of gasoline to the subsurface. The potential for serious environmental impact to nearby residences, businesses, and water supplies within Waitsfield Village was great. In a joint emergency response with the Vermont Department of Environmental Conservation (VDEC), the Bradford Oil Company (the owner of the UST) and its consultant, Lincoln Applied Geology, Inc. (LAG), efforts were successfully initiated to contain, control, recover, and remediate the impacts of the gasoline release.

Emergency efforts performed within days of the release included the installation of basement fans to ventilate the migrating gasoline vapors, removal of the UST source and heavily contaminated soils, reactivation of an existing vapor extraction system,and the installation of several large diameter recovery wells. During this initial time frame, hundreds of gallons of free product were recovered.

Figure 1: Map of the Village showing monitoring wells.

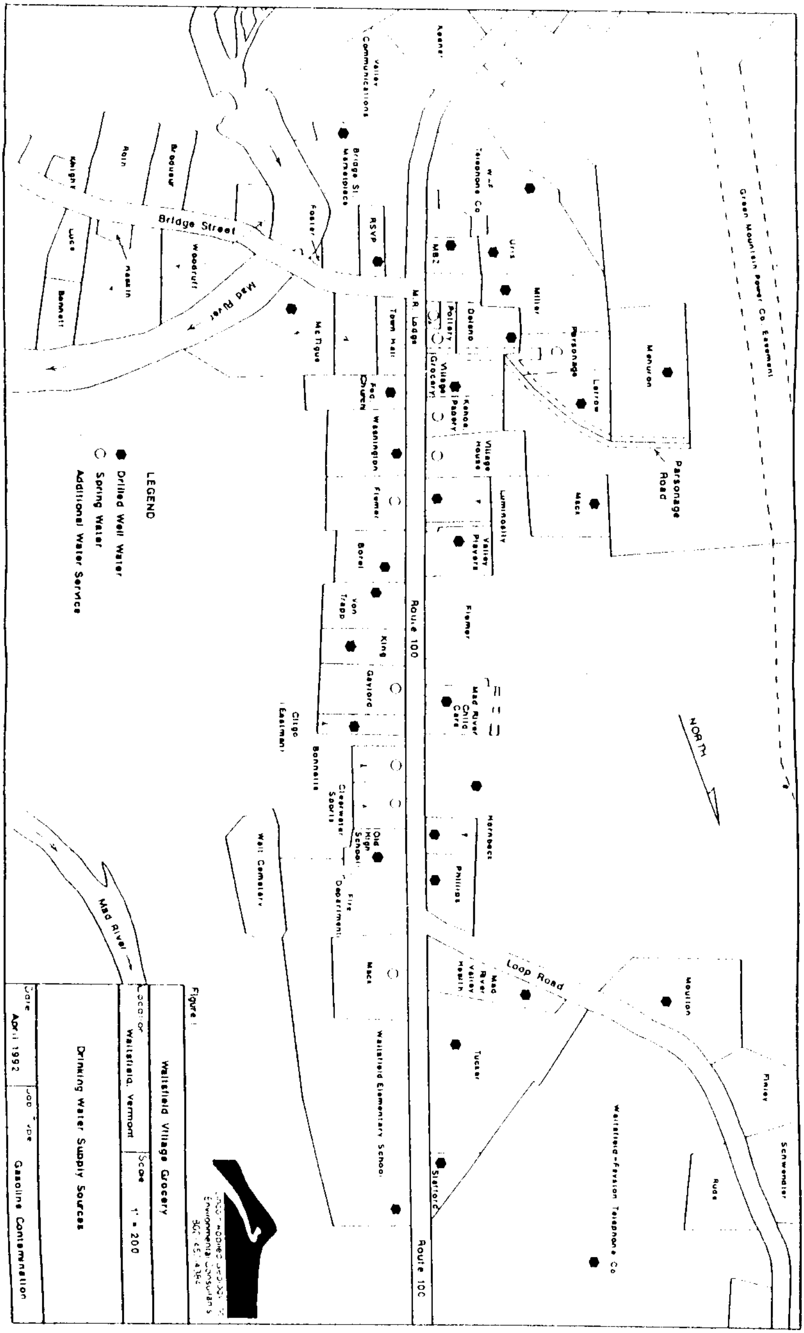
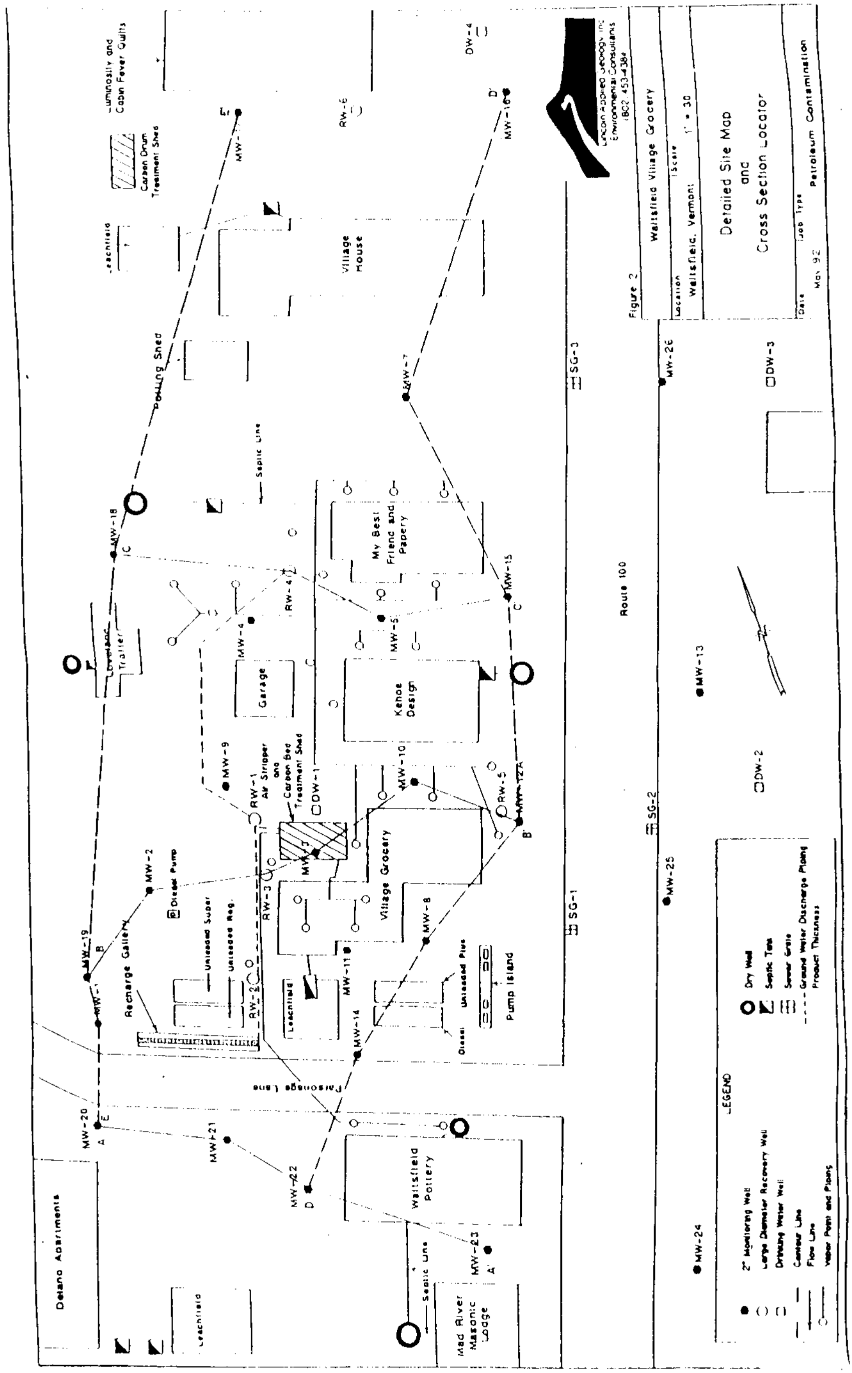


Figure 2: More detailed map of the area surrounding the grocery.



Emergency remedial efforts shifted during the first few weeks of December 1991 as progress was made and/or the contaminant migrated. Imminent threats were substantially decreased in a relatively short period of time. Significant elevated levels of vapors in the subsurface environment has necessitated the continued operation and maintenance of the vapor extraction and treatment system.

The glaciofluvial sand and gravel deposits present beneath the Village Grocery and nearby receptors include an unconfined groundwater aquifer that is highly conducive to petroleum contaminant transport in the vapor phase, soluble phase, and free product phase. Surficial geologic deposits present beneath the site and surrounding area include a thin layer of fill material above glaciofluvial outwash sands and gravel to a depth of 12 to 14 feet. Underlying the sands and gravel is a glaciolacustrine lake bottom clayey silt deposit of unknown thickness.

The sand and gravel outwash contains interbedded layers of silt and fine sand within coarser sand, gravel, and cobble layers. This heterogeneity within the sand and gravel aquifer allows ground water to flow at different rates and directions depending upon the ground water gradient, permeability, and areal extent of the individual beds. The underlying clayey silt deposit is a low permeability unit forming a lower confining layer that impedes the vertical migration of ground water and dissolved contaminants.

Although not encountered in any of the ground water monitoring wells or recovery wells installed on-site, the bedrock beneath the site and surrounding area has been mapped as the Lower Cambrian age Pinney Hollow formation of the Camels Hump Group. The bedrock is a complex, highly fractured, highly metamorphosed, undifferentiated phyllite and schist. Several drinking water wells in the vicinity obtain potable drinking water from this bedrock formation. Depth to bedrock in the area is estimated to be about 70 feet beneath ground surface.

Ground water is present in an unconfined sand and gravel aquifer at depths ranging from 10 to 14 feet beneath the ground surface. Private and community water supplies close to the Village Grocery are delineated on Figure 1. The natural ground water flow direction beneath the Village Grocery site is towards the northeast and east. With an average ground water gradient of 0.015 ft/ft and an estimated hydraulic conductivity as high as 425 feet per day, the travel time is estimated to be 4.7 days between the source area and MW-3 (Figure 2). This is a rapid contaminant transport rate. The presence of free gasoline product in MW-3 on the day the December 1991 spill was discovered, and in MW-10 several days later, indicated that the free product plume was migrating out of control and required immediate emergency action to contain and control the source prior to a complete site assessment.

Contamination of the sand and gravel subsurface environment by gasoline has resulted in distinct and measurable phase partitions. The partitioning has been dynamic over time and is strongly influenced by the various remedial methods employed for controlling, containing, and recovering the gasoline contaminants.

Free phase product (gasoline) floating on the ground water surface has been recovered by depressing the ground water surface and pumping off the gasoline. Through the spring of 1992 approximately 70 gallons of gasoline was recovered from MW-3 and 200 gallons from RW-4. During the initial stages of the emergency response effort, 193 gallons of gasoline product and about 1,250 gallons of contaminated water was vacuumed from recovery wells RW-2 and RW-3. Approximately 500 gallons of liquid-phase gasoline have been recovered from the subsurface by direct pumping to date.

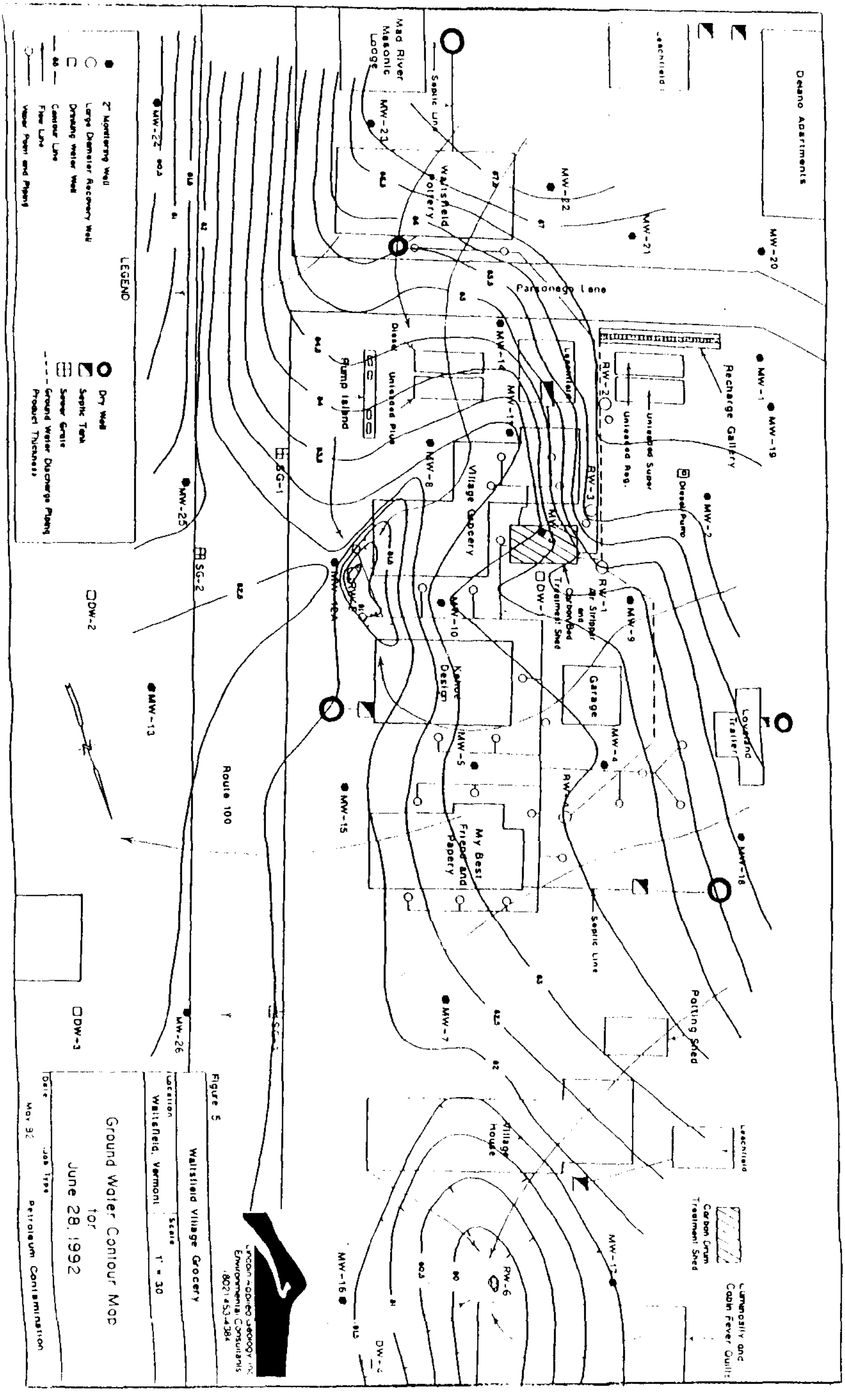
Vapor phase product consists of the lighter gasoline constituents that readily volatilize into the gaseous phase from the liquid, dissolved, or adsorbed phases. The volatile gasoline constituents benzene, toluene, ethylbenzene, and xylene (BTEX) are of primary concern regarding their impact to the public health. Once in the vapor phase, the volatiles readily migrate through the pore spaces of the coarser textured soils under the influence of pressure and temperature differentials. Volatiles may also redissolve as ground water levels fluctuate or surface water percolates downward through the soils. The vapor extraction system (VES) originally installed has been expanded and continues to operate effectively.

The soluble phase of contamination consists of those gasoline constituents that dissolve in ground water and migrate through the aquifer in the direction of ground water flow. Because of their solubility and effects on health, the BTEX constituents are of the greatest concern. The gasoline additive MTBE also readily dissolves in water and its presence in ground water serves as an indicator of the direction of ground water flow and sometimes the impending arrival of the BTEX constituents.

Ground water pumped for the purposes of depressing the ground water surface for free product recovery was being discharged into a 40 foot long recharge gallery constructed parallel to Parsonage Lane as shown on Figure 2. As the soluble phase contaminant plume migrated northerly and water supplies began to be affected in 1992, two new recovery wells (RW-5 and RW-6) were installed and ground water treatment was initiated. Figure 3 shows a recent ground water contour map and the influences of ground water pumping.

No free product is currently being recovered on-site. Ground water treatment, however, in conjunction with the VES currently continues to treat high levels of vapor and soluble phase gasoline constituents.

Figure 3: Map of groundwater contours beneath the Village Grocery.



Groundwater Illiteracy

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"Got any bites yet?" asked the car's driver as he waited in his car for the attendant to fill the fuel tank.

I recorded the depth to groundwater from the monitoring well I was gauging in my field log as I replied "Not today, the heat's keeping them from biting."

The driver chuckled and then asked if I was really looking for oil. In fact, I was "looking for" gasoline, but all he really needed to know was that I was monitoring the water level beneath the service station. This man's perception of groundwater was typical of that expressed by many lay-people; in other words, he had no idea what I was talking about.

Most people have only a rudimentary understanding of groundwater, it's properties and characteristics and the forces that act upon it. Yet a very significant majority of the water we, as a society, utilize on a daily basis originates from groundwater sources. This ignorance can be deemed the root cause of most groundwater contamination problems that we are faced with today.

Many sites that are currently featured on the Vermont Hazardous Sites list are the result of historical negligence; back when folks didn't know and better than to just "dump it out back by the woodshed." Just as many of the contamination problems we must face today are the result of much more recent negligence and the root cause is still ignorance.

The WORD regarding the nature and characteristics of groundwater needs to be broadcast. We, as representatives of the scientific community faced with the ponderous task of identifying and solving groundwater problems, must take up the challenge of providing better education for the public. Our everyday interaction with our community of interdisciplinary scientists, is not enough.

If we are to maintain the environment that we benefit so much from --not just for ourselves, but for our children and our grandchildren also--then we must take the initiative to speak out now! It is not enough to write papers on our research for professional journals. We must contribute in a more wide-reaching manner. Let's all make the commitment to send an easy-to- understand article to the local paper; to attend and speak up at public meetings and to go into our children's classrooms as a guest speaker. Most town planning commissions lack individuals who are trained and qualified to offer sound scientific evaluations. Offer your services, if not as a regular commission member, then as the expert consultant that you are. Your payment will be a better educated public—a public that will better understand the importance not only of groundwater, but of our environment as a whole.

There exist no better qualified people to undertake this task then ourselves. The alternative, if we do not step in, will be a void that continues to be filled only by misinformation and continued ignorance. I challenge every VGS member to take a stand today, so that we may all have somewhere clean to stand, and clean water to drink, tomorrow.

Polycyclic Aromatic Hydrocarbons as Environmental Contaminants

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Polycyclic (or polynuclear) Aromatic Hydrocarbons (PAH's) are a group of high molecular weight organic compounds that consist of two or more fused benzene rings oriented in linear, angular, or cluster arrangements (API, 1974). They have been termed the "semi- volatile cousins of the [more familiar] volatile aromatics" such as benzene, toluene, ethylbenzene and xylene (Brubaker, 1991). PAH's are created by the incomplete combustion of coal, oil, gas, or other organic substances (ATSDR, 1990). While the bulk of PAH's are created by human activities, natural sources (e.g volcanoes, forest fires, and lightning strikes) make a small but measurable contribution (Menzie, Potocki and Santodonato, 1992). Eighteen unsubstituted PAH's have been identified by the EPA as priority pollutants (EPA, 1985). These compounds are: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methyl naphthalene, naphthalene, phenanthrene and pyrene (ATSDR,1990).

As environmental contaminants, PAH's are ubiquitous, being found in air, water, soil and sediments, even in remote arctic regions. Large concentrations of PAH's are found in the immediate vicinity of former or existing coal gasification plants, coal-fired power plants, wood treatment plants, asphalt plants, and coking plants (ATSDR,1990). Wastes from these plants usually consist of a variety of PAH compounds that occur as a black, viscous and tarry liquid (Brubaker,1991). Many locations that have witnessed a prolonged history of PAH-laden waste disposal are currently on the National Priorities List (NPL) of hazardous waste sites to be addressed by CERCLA (the Comprehensive Environmental Responsibility, Compensation, and Liability Act of 1980, otherwise known as Superfund). Coal tar and wood preservative CERCLA sites are considered to be among the largest and most expensive sites to clean-up.

This is largely due to the fact that the chemical and physical properties of the PAH's result in contaminant distribution and transport that is substantially more complex than that for gasoline or solvent contaminated sites (Brubaker,1991). The Burlington Barge Canal, which was among the first 115 sites to be listed for superfund, (Villaume, Lowe, and Unites, 1983), is projected to cost in excess of 100 million dollars to remediate.

The environmental fate of PAH's is controlled by the chemical and physical properties of individual constituents (Quinn, Wasielewski and Conway, 1985). Table 1 presents information on the physical and chemical properties which control the partitioning behavior of the individual PAH compounds into air, water, and soil. PAH's have varying geochemical stabilities that are linked to the relative number of benzene rings in individual compounds (API, 1984). In a general sense, the solubility and the volatility of individual PAH constituents decreases exponentially as molecular weight increases (API, 1984; Hult and Stark, 1988). In opposition to this tendency, density, susceptibility to microbial degradation and tendency to adsorb onto aquifer materials increases with molecular weight (Ekambaram, 1986; Hult and Stark, 1988; Brubaker, 1991).

Even with solubilities that are generally low, PAH's are found to result in significant contamination of groundwater at hazardous waste sites (Yazicigil and Sendlein, 1981; Rosenfeld and Plumb, 1991). Because PAH's are usually more dense than water, separate phase and dissolved phase PAH's are often observed to sink in aquifer materials, resulting in areally extensive contamination (Franks, 1988; Hult and Stark, 1988; Yazicigil and Sendlein, 1981). The tendency of PAH's to sorb onto aquifer materials is another important characteristic. At the Burlington Barge Canal, a large deposit of humic substance—rich peat—has effectively adsorbed a large volume of the PAH-rich coal tar that is the dominant contaminant (Johnson, 1986). The strong sorptive capacity of the peat and the humic substances combine with the large organic-carbon partition coefficients (K_{oc}) of the PAH's to partially immobilize the coal tar. In contrast, dissolved humic substances have been shown to facilitate the transport of lighter molecular weight PAH's (Kan and Tomson, 1986).

The physical and chemical properties of the PAH compounds constrain the possible methodologies that can be used to remediate PAH sites. Pump and treat technologies are useful for capturing free-product coal tars and the lighter molecular weight PAH's (Villaume, lowe and Unites, 1983) but have virtually no impact on the concentration of the heavier PAH's (Brubaker, 1991). Other remediation technologies that have been proposed and implemented at highly PAH contaminated sites include: thermal desorption, soil washing, solvent extraction, incineration, and bioremediation (Sale and Piontek, 1988). Given the inherent difficulties with extracting and destroying these materials, bioremediation (destruction by the biochemical metabolism of contaminants by microbial organisms) is becoming a favored means of treatment (Mihelcic and

Table 1: Chemical Properties of Polycyclic Aromatic Hydrocarbons (PAH's)

Contaminant	Carcinogenicity[1]	Chemical Formula	Mol Wt.[2]	Volatility[3]	I.P.(eV)[4]	Log HC[5]	Log P_V[6]
naphthalene	N	$C_{10}H_8$	128.16	mod-high	8.14	-2.91 to -3.44	-1.27 to 1.30
2 methylnaphthalene	N	$C_{11}H_{10}$	142.19	--	8.48	--	--
dibenzofuran	--	$C_{12}H_8O$	168.20	--	8.59	--	--
phenanthrene	N	$C_{14}H_{10}$	178.22	slow-mod	8.22±	-3.88 to -4.60	-3.68
pyrene	N	$C_{16}H_{10}$	202.24	slow-mod	7.7±	-4.96 to -4.73	-5.60 to -6.16
fluorene	N	$C_{13}H_{10}$	166.22	mod	8.63	-3.68	-3.00 to -2.00
acenaphthene	N	$C_{12}H_{10}$	154.21	mod	--	-3.82 to -4.10	-3.00 to -2.00
acenaphthylene	N	$C_{12}H_8$	152.20	mod	8.73	-3.55 to -3.94	-1.54
anthracene	N	$C_{14}H_{10}$	178.22	mod-high	7.58	-2.85 to -4.75	-3.71
fluoranthene	N	$C_{16}H_{10}$	202.24	high	8.54	-1.77	-2.00
benzo(a)anthracene	Ca	$C_{18}H_{12}$	228.29	low	8.01	-5.07 to -6.18	-7.00 to -8.30
chrysene	Ca	$C_{18}H_{12}$	228.29	v. low	7.85±	-19.14	-6.20
benzo(b)fluoranthene	Ca	$C_{20}H_{12}$	252.32	slow	--	-4.92	-6.30
benzo(k)fluoranthene	Ca	$C_{20}H_{12}$	252.32	high	--	-2.98	-10.02
benzo(a)pyrene	Ca	$C_{20}H_{12}$	252.32	slow	--	<5.62	-6.30
indeno(1,2,3-cd)pyrene	Ca	$C_{22}H_{12}$	276.33	low	--	-19.5	-9.00
dibenzo(a,h)anthracene	Ca	$C_{22}H_{14}$	278.35	low	7.28±	-8.13	-9.00
benzo(g,h,i)perylene	Ca	$C_{22}H_{12}$	276.33	slow	7.24	-6.85	-9.99
bis(2-ethylhexyl)phthalate	--	$C_{24}H_{38}O_4$	390.56	mod	--	-4.96	-6.70

[1] = Carcinogenicity Ca = documented carcinogen P = potential carcinogen N = Not carcinogen-
[2] = Mol wt. = Molecular Weight in g/mole
[3] = Volatility is classified based upon Henry's Constant
= < -7 atm.m³/moL = low volatility = low
= -7 to -5 atm.m³/moL = will volatilize slowly = slow
= -5 to -3 atm.m³/moL = volatile = mod
= > -3 atm.m³/moL = highly volatile = high
[4] = I.P. = Ionization Potential measured in electron volts (eV)
[5] = Log HC = Log Henry's Constant
[6] = Log P_v - vapor pressure at 20° C (or lower if available) > 1.0 highly volatile
[7] = Laboratory solubility in distilled water at 25° C (unless otherwise specified) measured in ug/l (micrograms per liter or parts per billion).
[9] =
[10] =

Sources: Mon-

<u>Table 1: (Continued)</u>

Aqueous Solubility[7]	Specific Density[8]	Log K_{oc}[8]	Log K_{ow}[9]	Uses
20,300 to 40,000 21,600 @ 15.42°C	1.02 to 1.16	2.74 to 3.50	3.01 to 4.70	Mothballs, insecticides
24,600 to 25,400	1.0058	3.87 to 3.93	3.86 to 4.11	Insecticides
10,000	1.089	3.91 to 4.10	4.12 to 4.31	
710 to 1600 601 @ 15° C	0.98 to 1.18	3.72 to 4.59	4.16 to 4.57	Dyestuffs
13 to 175	1.273	4.66 to 5.13	4.88 to 5.32	
190,000 to 1,980,000	1.203	3.70	4.12 to 4.38	
3,470 to 3,930	1.0242	1.25	3.92 to 4.33	Dyestuffs, pesticides, plastics
3,930	.8988	3.68	4.07	
41,000 to 75,000 22,200 @ 14.1° C	1.240	4.20 to 4.40	4.34 to 4.54	Manufacture alizarin red dye
206 to 373 133 to 275 @ 15° C	1.252	4.62	5.22	
9.4 to 14	1.274	6.14	5.61 to 5.91	
1.8 to 6.0 1.5 @ 15° C	1.274	5.39	5.60 to 5.91	
1.2 to 14	--	5.74	6.57	
.55	--	6.64	6.85	
3.0 to 4.0	1.351	5.60 to 6.29	5.81 to 6.50	Potent carcinogen.
62.0	--	7.49	5.97 to 7.70	
.25 to .50	1.282	6.22	5.97 to 6.50	
.26 to .50	--	6.89	7.10	
285 to 400 41 at 20° C	.985	5.0	4.20 to 5.11	Plasticizers

ic [8] = Specific density in the temperature range from 20 to 4° C in g/cc.
= Log K_{oc} = Log organic carbon partition coefficient
= Log K_{ow} = Log octanol/water partition coefficient

-- = insufficient data

ıtgomery and Welkom (1990)

Luthy, 1987; Sims, 1989; Thomas et. al., 1989; Brubaker, 1991 and Godsy, Goerlitz and Grbic-Galic, 1992). A broad array of soil organisms including bacteria, fungi, cyanobacteria (blue-green algae) and eukaryotic algae have been shown to possess the ability to enzymatically oxidize PAH's (Mihelcic and Luthy, 1987; McGinnis et.al., 1989).

PAH's are literally everywhere in concentrations that are significantly below the gross contamination observed at hazardous waste sites. Because they are so widespread, they are a class of environmental contaminants that virtually every human being is routinely exposed to (Menzie, Potocki and Santodonato, 1992). PAH's are found in air, dust, soil, sediment, water and food. Sources of PAH's include: crude oils, various high-boiling point petroleum distillates, complex mixtures of petroleum products, coal tars, creosote, coal gasification wastes, heating furnaces, wood stoves, vehicle exhausts, asphalt roads, driveway sealer, roofing tar, treated-wood products (railroad ties and telephone poles), tobacco smoke, building and agricultural fires, a variety of foods, grilled or charred meats, and hazardous waste sites (ATSDR, 1990; Menzie, Potocki and Santodonato, 1992).

PAH's are significant because they are associated with well-documented adverse impacts to animal and human health. Eight of the 16 PAH's listed as priority pollutants are considered to be possible or probable human carcinogens (Menzie, Potocki and Santodonato, 1992). These are listed in the table that accompanies this article. Documented impacts to human health resulting from exposure to PAH's include skin disorders, lung cancer and other carcinomas. Unusually high lung cancer mortality among non-smoking women in Xuan Wei, China was attributed to PAH's resulting from the domestic use of smoky coal (Chuang et.al.1992). Many other studies have verified the carcinogenetic properties of PAH's—most notably the potent complete carcinogen benzo(a)pyrene (see for instance the references in Jones and Leber, 1979).

Most studies regarding the biological effects of PAH's have been conducted upon animal populations. Documented adverse health effects attributed to PAH's from animal studies include: death, decreased survivability, respiratory tract tumorigenesis, bone marrow depression (aplastic anemia), reduced fertility, reduced birth-weight and offspring viability, offspring sterility and gastrointestinal and pulmonary cancer (ATSDR,1990). At present, little data is available regarding the incidental environmental exposure of humans to PAH's via the routes of inhalation, ingestion, and dermal contact (ATSDR,1990).

Given the known results from animal studies and the documented carcinogenicity of some PAH's, it would be considered prudent to limit one's potential exposure to these substances (insofar as exposures are voluntary and controllable). Because PAH's are a class of environmental contaminants that few have heard of or recognize, limiting such exposure may be difficult. Some exposures, however, are obvious. Reducing these exposures could mean finally giving up that smoking habit, reducing the intake of grilled foods, fixing the car's exhaust system, ventilating the wood stove, moving away from the interstate highway or wearing an organic vapor respirator when sealing the driveway or patching the roof. In a world in which "everything gives you cancer," being aware of the things that "really do" may end up enhancing your life in ways that will never be apparent, but may make all the difference.

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Humic Substances in the Aqueous Environment: Implications for the Environmental Chemistry of Trace Metals

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Organic compounds are known to be widespread in the hydrosphere and, in many cases, are important contributors to the physical and chemical nature of ground and surface waters (Rashid, 1985). This abundance and importance are manifestations of the intricate inter-relationship between the hydrosphere and all living matter (Hem, 1989). Organic chemicals are introduced into the hydrosphere by natural interactions with the biosphere and the lithosphere and by non-natural, anthropogenic activities.

Since passage of the Safe Drinking Water Act by the U.S. Congress in 1974, a great deal of scientific research has focussed upon characterizing the nature and the distribution of synthetic organic chemicals. During the same time period a great deal of less "glamorous" research has been conducted in the field of naturally occurring water-borne organics. This is a departure from the historic treatment of organic geochemistry as the study of petroleum, coal, and oil shale (Thurman, 1985). Instead, the more recent research has revealed the relative significance of a certain category of aqueous-phase organic compounds collectively termed "dissolved organic carbon."

Dissolved organic carbon (DOC) is a term that describes an enormous library of organically-derived substances that are present in natural waters. An arbitrary definition places the maximum size of "dissolved" organic carbon at .45 microns (Thurman, 1985). DOC may include fatty acids, carbohydrates, hydrocarbons, viruses, hydrophilic acids polysaccharides, proteins, lignin, amino acids, alcohols, terpenes, sterols, heterocyclics, long-chain acids, and other derivatives of plant, animal, and micro-organism decomposition (Thurman, 1985; Dragun, 1988). Many of these substances are readily degraded by the enzyme systems of micro-organisms into simpler monomers that are then re-utilized by plants and other organisms for metabolic activity and growth. In many instances, however, these monomeric organics re-co-polymerize with each other to form humic substances such as humic and fulvic acids (Dragun, 1988). Humic substances represent the residuum of biological breakdown of organic matter (Rashid, 1985) and are widely recognized as significant controls on the chemistry of metals.

Humic substances are defined by Aiken, et. al.(1985) as "a general class of biogenic, refractory, yellow-black organic substances that are ubiquitous, occurring in all terrestrial and aquatic environments." Humic substances are literally everywhere. Longmire (Pers. Comm., 1989) characterizes humic substances as likely candidates for the most chemically active types of organic carbon and yet they remain the least understood. Because humic substances are the most abundant and geochemically reactive types of DOC (Rashid, 1985), they significantly influence the chemical makeup of ground and surface water.

Humic substances are known to be extremely stable at geological time scales (Dragun, 1988). This stability is one of the more important characteristics of humic substances and is the reason they form the dominant type of organic material in soil profiles (Stevenson, 1985). Humic substances comprise 50 to 70% of total DOC (Thurman, 1985; Longmire and others, 1989). In the absence of oxygen, humic substances can be preserved for 100's of millions of years (Longmire and others, 1989). For instance, humic coal deposits date back to the Carboniferous (Manskaya and Drozdova, 1968). Humic substances have also been isolated from the Archean Onverwacht Chert (Jackson, 1975). As ancient deposits, humic substances provide clues to the development of early life on earth (Rashid, 1985).

Humic substances are divided into three major fractions by Aiken et. al. (1985) based upon their relative aqueous solubilities after isolation. These fractions are: Humin, which is insoluble; Humic Acid, which is soluble above a pH value of 2 and insoluble below a pH of 2, and Fulvic Acid, which is soluble at all values of pH. From the standpoint of importance to aqueous systems, the solubility of humic and fulvic acids in waters of "normal" pH make them abundantly available for chemical interaction. Humic and fulvic acids are significant because they have a strong tendency to form complexes with metallic cations, they participate in weathering reactions for many minerals, they influence the environmental fate of synthetic organic compounds such as chlorinated solvents and pesticides and they react with disinfectant chemicals added to drinking water to form carcinogenic trihalomethanes (Aiken et. al, 1985; Thurman, 1985; Rashid, 1985; Langmuir, 1989).

The following discussion is divided into two major sections: the first is a review of general humic and fulvic acid geochemistry; the second is a scrutiny of the importance of these substances in the transport and deposition of certain metallic ore deposits.

Humic and fulvic acids are identified as the agents responsible for coloring natural waters (Hem,1989). Straw or tea colored waters are found to be associated with swamps, bogs, and wetlands (Thurman, 1985). The geochemistry of colored waters has always been associated with the chemistry of transition metals (Malcolm, 1985). One of the dominant geochemical characteristics of humic and fulvic acids dissolved in water is the capacity to form stable complexes with metal cations. This capacity is in large part a result of the large number of functional groups that inhabit various structural positions on the periphery of the humic substance (Perdue, 1985).

Thurman (1985) defines humic substances as "polyelectrolytes of carboxylic, hydroxyl, and phenolic functional groups." Other, less abundant, functional groups include enolic, carbonyl, quinone, and amino groups (Rashid, 1985) as well as ethers, ketones, aldehydes, lactone esters, amines, and amides (Thurman, 1985). The various functional groups are the reactive sites on the humic molecules (Rashid, 1985). Carboxylic functional groups are among the most important in humic substances because they are the most reactive (Rashid, 1985). The chemical properties of carboxylic functional groups are generally characteristic of the bulk of the other functional groups.

According to Thurman (1985), humic substances average 5 to 10 carboxylic functional groups per molecule. Fulvic acids characteristically have a larger number of carboxylic groups than do humic acids (Longmire and others, 1989). Carboxylic functional groups are important for several reasons. One of the more important of these is their contribution to aqueous acidity via the protonation reaction:

$$R\text{–}COOH = R\text{–}COO^- + H^+$$

Thus carboxylic functional groups dissociate to liberate a proton, thereby creating an anionic charge on the functional group (Longmire and others, 1989). According to Thurman (1985) the dissociation constant:

$$K_a = [R\text{–}COO^-]\,[H^+]$$
$$\log K_a = -4.8 = \text{a strong acid}$$
$$pK_a = -\log Ka = 4.8$$

(pK_a) is a relative measure of the dissociation strength of an acid. pK_a's for the functional groups associated with humic substances range from 4.8 to 13 (Thurman, 1985). As the strong pK_a suggests, carboxylic functional groups are considered to contribute substantial numbers of hydrogen ions to equilibrium waters. Antweiler and Drever (1983) studied soil weathering solutions in which organic carbon was the dominant control on solution pH. In fact, a major portion of the total acidity of humic substances is attributed to carboxylic groups (Perdue, 1985). This acidification is an important characteristic in the weathering behavior of humic substances (Thurman, 1985).

The loss of the hydrogen ion as the result of the dissociation leaves the remaining carboxylate with a negative net charge. This anionic charge, when multiplied by the number of dissociated functional groups, yields a large charge imbalance. This strongly ionic character enhances the aqueous solubility of the humic substance (Stevenson, 1985).

Dissociating a carboxylic group increases the solubility of that functional group by four orders of magnitude (Thurman, 1985). This is significant because the dominant chemical activity of humic substances occurs as dissolved substances. Another aspect of increased solubility is that it increases the effective residence time of the humic substance in the water column (Rashid, 1985). The increased occurrence of carboxylic functional groups within the fulvic acid structure is responsible for its increased solubility relative to humic acid (Longmire and others, 1989). As a result, fulvic acid is retained in solution more effectively than humic acid (Thruman, 1985). (Recall that solubility as a function of pH is used to define humic and fulvic acids).

Perhaps the most significant aspect of carboxylic dissociation and the attending anionic net charge is the affinity of humic substances for metallic cations. "Because of their high geochemical reactivity, all humic compounds absorb and accumulate large amounts of trace and transition metals" (Rashid, 1985, p. 109). Humic substances form metallo-organic complexes of ranging stability with a large number of metals. As a result, humic substances are significant controlling factors on the solution, precipitation, mobilization, migration, recycling, redistribution, and concentration of many chemical elements that form cations in aqueous solution (Rashid, 1985). A list of the chemical elements that have been implicated in complexation reactions with humic substances includes the following*:

Ac	Ag	Al	As	Au	B	Ba	Bi	Ca	Ce
Cd	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Gd
Ge	Ho	K	La	Lu	Mg	Mn	Mo	Na	Nd
Ni	Pb	Pm	Po	Pr	Ra	Rb	Sb	Sm	Sr
Tb	Th	Tm	U	V	Y	Yb	Zn	Zr	

*Sources: Malcolm, (1985); Stevenson, (1985); Raspor and others, (1984); Frimmel and others,(1984); Rashid, (1985); Drever, (1988); Langmuir and others, (1989); Cameron, Schruben & Boudette, (1986) and Szalay (1964).

The concentration mechanism of many of these elements have been the study of economic geologists for decades. Until the middle of the century these geologists focussed their attention upon the inorganic chemistry of metals (Rashid, 1985). Much work has been done since then on the association of trace, transition, and heavy metals in organically derived sedimentary materials such as crude oil, oil shales, coal, kerogen, etc. (Manskaya & Drozdova, 1968). It is now recognized that the occurrence of metals above crustal abundance in association with most carbonaceous material is the result of the action of humic substances (Rashid, 1985). Humic substances are responsible for many economically important mineral concentrations (Turner-Petersen,1985).

This action may be illustrated by comparing experimental solubility data against calculated solubility data for various metals. Since aqueous solubility is the dominant factor controlling metal mobility, migration and redistribution, changes in solubility must also change the geochemical behavior of the metal (Rashid 1985). Complexation with humic substances can often lead to unexpectedly high concentrations of metals in solution (Drever, 1988). According to Siever (1971), the calculated solubility of iron in most natural waters at "normal" pH values and redox conditions is 108 to 109 times less than observed concentrations. A plausible explanation for this increase is the presence of humic substances which react with iron to form soluble iron-humates (Rashid, 1985).

A positive linear correlation has been shown to exist between the humic substance content of soil and the concentration of the trace metals Cu, Co, Mn, Ni, and Zn (Manskaya & Drozdova, 1968). These same five trace metals have been found to be enriched in the burrow walls of polychaete worms in coastal marine waters by the action of humic substance deposition (Over, 1990). Humic peat deposits are known to geochemically enrich uranium by 4 orders of magnitude over abundances in water (Szalay, 1964). Enrichment coefficients for vanadium, nickel, lead, and silver exceed 103 (Rashid, 1985). Polyvalent cations have greater enrichment factors than do monovalent cations (Szalay, 1964).

Humic substance participation in metal complexation reactions is controlled by the ionization of functional groups. Functional group ionization is determined by the acid dissociation constant, K_a, of each functional group. As a result of functional group dissociation, humic substance solubility increases. Dissociation also creates a more acidified aqueous environment by liberating hydrogen ions. Increasing the hydrogen ion concentration (decreasing pH) also increases the inorganic solubility of most metals. Thus, at low pH's, humic acid carboxylic functional groups will be more completely dissociated, resulting in a larger net molecular charge imbalance. This charge imbalance is offset by a larger mass of metallic cations inorganically dissolved by the increased hydrogen ion concentration. Therefore, the humic substances set up a "positive feedback" for maximizing the geochemical concentration of metals via metallo-organic complexation.

The degree to which humic substances influence the geochemical behavior of other chemical species is disproportionate to their relative abundance in water (Rashid, 1985). One implication of the influence humic substances have upon metal chemistry is the concentration of these metals into economically significant ore deposits. In the past two decades geologists and geochemists have recognized numerous instances in which humic substances have been the critical environmental factor culminating in economic concentration of ore metal (Turner-Peterson 1985).

Perhaps the most well documented associated between humic substances and an economic ore is the example of uranium. Uranium is almost always found in concentrations associated with organic matter (Manskaya and Drozdova, 1968; Nakishima and others, 1984). In a general sense, the association of uranium with organic matter has traditionally been considered to be a result of the negative redox condition that attends partially decaying organic matter. An important aspect of humic complexation, however, is that uranium reduction is not necessary for complexation (Turner-Peterson, 1985; Cameron and others, 1986). In oxidizing fresh waters, uranium exists as the soluble hexavalent form.

At low pH's the uranyl cation $(UO_2)^{2+}$ predominates. At a pH above 5 the double uranyl dicarbonate complex $UO_2(CO_3)_2(2H_2O)^{2-}$ is dominant. With increasing pH the soluble uranyl tricarbonate complex $UO_2(CO_3)_3^{4-}$ increases in abundance (Langmuir, 1978). These dicarbonate and tricarbonate complexes are readily fixed by humic substances (Turner-Peterson, 1985).

Primary uranium ore deposits in the Grants Uranium Region of New Mexico are considered to be the direct result of humic acid uranium concentration (Turner-Peterson, 1985). These deposits accumulated in upper Jurassic sandstones along the southern margin of the San Juan Basin. The significance of the humate in the deposit is such that the ore-bodies should really be considered as humate masses with associated uranium (Squyres, 1970 in Turner-Peterson, 1985). The significance of metallo-organic concentration of uranium is brought into perspective when considering that the Grants uranium region has produced 50% of the uranium supply of the United States as of 1985 (Turner-Peterson, 1985).

In the Grants uranium region, the humate-uranium ore was formed by introduction of humic acid rich groundwaters into previously deposited sands. The source of humic acid was indigenous organic detritus deposited with fresh water mudflat sediments. During burial compaction, basinal fluids were expelled and flushed through the mudflat facies into the adjacent sands. Uranium complexed humic acids in the basinal fluids reacted with magnetite, ilmenite, and feldspar in the sands. This chemical weathering resulted in cation loading of the functional groups on the humic substances thereby decreasing solubility and resulting in precipitation of humate.

Peat deposits have been well documented to enrich a variety of metals. The "Flodelle Creek deposit" described by Johnson, Otton and Macke (1987), records the Holocene accumulation of uranium and a host of other metals by organic matter controlled adsorption and ion exchange. The Flodelle Creek deposit was discovered to contain a large concentration of precipitated uranium that was virtually non- radioactive because secular equilibrium with shorter half-lived progeny had not had time to develop.

Since the time of the Flodelle Creek discovery, peatland and wetland deposits have been subjected to more detailed scrutiny with regard to humic and metals chemistry (Otton, 1991; Owen, 1991). Cameron, Schruben and Boudette (1987) analyzed the contents of a peat deposit near Fern Lake in Leicester, Vermont and found unexpectedly elevated concentrations of metals and uranium. The uranium was found to be present at levels equivalent to the lowest ore grade of the Flodelle Creek deposit: some 467 parts per million. The uranium anomaly was surprising because of the absence of a logical bedrock source. Other wetland and peatland areas of New England were also shown by these workers to significantly enhance the concentration of metals. It is probable that many deposits of this type can be found in other areas of Vermont.

One aspect of the concentration of metals that is worthy of consideration is the potential liberation of metals when peatlands or wetlands are drained or otherwise disturbed. In Colorado, peat mining was found to allow oxidizing meteoric waters to penetrate the peat mass. Unlike other metals, uranium is soluble in oxidizing waters. The exposure of the peat led to the liberation of a large mass of uranium to the environment (Otton,1991).

To summarize, humic substances comprise the dominant form of dissolved organic matter in natural systems. There are few chemical reactions that take place in natural waters or soils that are not influenced by these substances. They play a significant role in the geochemical evolution of soils and sedimentary deposits and the fluids that flow through them. They are a dominant factor in the environmental fate of metallic cations and are responsible for the economic concentration of metallic ores. They influence the bioavailability of metals and may also alter metal toxicokinetics. In spite of their ubiquity and geochemical significance, humic substances remain poorly understood and little known to the geological community. Given the well documented importance of humic substances in many hydrogeochemical reactions, it is interesting that environmental sampling does not attempt to quantify humic substance activities, especially when the chemistry of metals is concerned. Perhaps as research continues, a greater understanding of humic substance interactions will be achieved by the geological community.

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Vermont Department of Health Lead Program

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In October of 1991 the Center for Disease Control (CDC) lowered the blood concentration at which an individual would be considered to lead poisoned. The level was reduced from 25 micrograms per deciliter (µg/dl) to 10 µg/dl. This change was based upon research indicating that a small amount of lead in a child's blood dramatically increases the risk of irreversible central nervous system damage leading to learning disabilities, behavioral disorders and impaired musculo-skeletal coordination. A child is more susceptible to lead poisoning because a child absorbs approximately 50% of the lead ingested (compared to 5% to 8% absorption for adults). A child's hand to mouth behavior also results in a greater ingestion of lead per unit bodyweight.

In response to the new standards from the CDC, the Vermont Department of Health lowered the blood lead level at which a child is considered to be poisoned to 10 µg/dl and required physicians to report incidences of poisoning to the Health Department. In addition, the Department directed the new Toxicology and Risk Assessment Program to work in developing a lead program. Currently the Lead Program is involved in:

- Lead inspection of homes with children having blood lead in excess of 20 µg/dl or greater
- Working with a group of State officials to draft legislation that would regulate lead abatement and establish a lead screening program.
- Public education regarding lead hazards and the development of informational materials.
- Working with the City of Burlington to address lead issues that affect Burlington residents.

Efforts to implement lead program initiatives are ongoing. Please call the Toxicology and Risk Assessment Program at 1-800-439-8550 or 863-7220 if you have any questions regarding lead issues.

Vermont Indoor Ambient Air Quality

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The Toxicology and Risk Assessment Program at the Vermont Department of Health recently received a grant from the U.S. Environmental Protection Agency to conduct an Indoor Ambient Air Quality study of rural Vermont dwellings. Sixty homes in Fairfax, Grand Isle, Huntington Stowe and Westford have been selected by a biased random method. In order to qualify for selection, target homes could not be inhabited by smokers, could not be "pre-fabricated" manufactured homes and could not be located within a 1.5 radius of a gasoline service station. These constraints assure that the chemicals detected will be the result of building materials, furnishings, or hobbies. Samples are collected for analyses of the 10 aldehydes and 15 volatile organic compounds (VOC's) listed below:

ALDEHYDES	VOLATILE ORGANICS
Formaldehyde	Methylene Chloride
Acetaldehyde	Chloroform
Acetone	1,1,1–Trichloroethane
Acrolein	Carbon Tetrachloride
Propionealdehyde	Benzene
Butyraldehyde	Trichloroethylene
Benzaldehyde	1,2 Dichloropropane
Valeraldehyde	Toluene
m-Tolualdehyde	Tetrachloroethylene
Hexaldehyde	Chlorobenzene
	Ethylbenzene
	ortho-Xylenes
	meta- and para-Xylenes
	Styrene
	Para-dichlorobenzene

Sample collection is conducted over an eight hour period four times a year. This corresponds with one sampling event per season. During each sampling event, one aldehyde and two VOC samples are collected. Three personal air sampling pumps are used to pull ambient air through the collection media. Aldehyde samples are trapped on Millipore Sep-pak collection media; VOC samples are trapped on Supelco Carbotrap collection media. Sample collection follows stringent Quality Assurance/Quality Control (QA/QC) protocols to ensure sample integrity and representativeness. Laboratory chemical analyses are conducted on the samples by the Vermont Department of Health Laboratory. The VDH lab uses High- Pressure Liquid Chromatography (HPLC) for aldehyde analyses and Gas Chromatography/Mass Spectrometry for VOC analyses.

Once data collection is complete, yearly average concentrations will be calculated. Statistical analyses will be performed to determine if the results can be attributed to home different environmental factors such as home design, heating source, building materials, building age or habits of the occupants. The overall objective of the investigation is to determine what constitutes a "clean home atmosphere." The results will provide a baseline for comparison during the clean-up of contaminated homes.

The New Water Supply Division

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Departmrent of Environment Conservation, Water Supply Division
The Old Pantry, 103 South Main Street
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For many years, the Department of Health was responsible for managing the State's public water systems. However in July of 1991, the State's General Assembly passed Act 71 which transferred responsibility for the management of public water systems from the Department of Health to the Department of Environmental Conservation. The transfer resulted in the Health Department's Drinking Water Program being combined with the Grants Management and Groundwater Management Programs from the Department of Environmental Conservation forming the new Water Supply Division.

In May of 1992, the Water Supply Division moved into its new digs in Waterbury. The building location is officially referred to as "The Old Pantry" although it was the former location of cold storage. The new Division consists of approximately 25 people organized into three sections: Water Systems Management, Resource Management, and Compliance and Licensing. The Water Systems Management section consists of four regional engineering teams and is responsible for the regulatory and financial oversight of all public water systems in Vermont (e.g. permitting, grants, surveys, etc.). The Resource Management section develops and maintains the division's rules and regulations, administers the well drillers licensing program, classifies State groundwaters, reviews Act 250 applications, and manages the Division's geographic information system. The Compliance and Licensing section tracks water quality monitoring results and is responsible for all enforcement activities. For more information about the Water Supply Division, please should contact us at 244-1562.

VERMONT GEOLOGICAL SOCIETY BUSINESS AND NEWS

Fall Field Trip Announcement

Tentative Date: Saturday October 17, 1992

Lance Meade and Eric Lapp are planning a fall field trip dedicated to Brew Baldwin. The focus of the trip will be the ever-changing role of the geologist in the mining and mineral processing industry. The trip route will be "C"-shaped in central and western Vermont and may include the following stops: Rochester verde antique quarry, historical kaolin pits and iron furnace sites, marble/limestone quarries in the Middlebury-Wallingford corridor, and the talc operations in Ludlow. In addition to the specific geology of the sites, our discussion will cover some of the historical changes in stone/mineral uses, technologies, environmental considerations, "every day" problems the geologist faces, and the current quest for quality assurance. Full details will follow in the Fall *Green Mountain Geologist.*

Eric Lapp & Lance Meade

Geological Education in Vermont
Fall Green Mountain Geologist

Shelley Snyder is the guest editor for the fall issue of the Green Mountain Geologist. This issue will focus on "Education" in the geological sciences. Shelly invites anyone with an interest in the subject or with something to contribute to contact her at the below address or phone number. Anyone contributing material for this issue should get a manuscript to Shelley by September 11, 1992.

Shelley Snyder
72 Black Lantern Lane
South Burlington, VT 05403
658-0575

Executive Committee Meeting Minutes

April 25, 1992; Kalkin Hall, University of Vermont, Burlington

Present

Shelley Snyder, Dave Westerman, Steve Howe, Steve Wright, Bruce Wilson, Larry Gatto, Lucie Harding and Ron Parker

The meeting convened at 2:20 p.m. immediately following the Student talks presented at the Spring meeting. Given the nature of the beautiful day, this committee meeting was uncharacteristically brief.

Secretary's Report

The secretary had no additional news to add to the information printed in the Winter GMG.

Treasurer's Report

The treasurer indicated that the VGS had welcomed 3 new members during the quarter. No other news to report.

Old Business

The guest editorship of the GMG, initiated by Larry Gatto in the Spring '92 edition was considered by all to be a success. Larry was commended for a fine effort. Recommendations for a Fall '92 guest editor were discussed. This was considered to be a good opportunity for a secondary school teacher to get involved.

A question regarding the status of the "Directory of Vermont Geologists" was raised. The directory was originally intended to provide a comprehensive listing of geologists residing or working within Vermont. In order to be finished, the compilation effort requires the attention of an interested member. Please contact Dave Westerman of Steve Wright if you would be interested in assisting with this project.

The Fall field trip was discussed and several possible options were tabled. Nothing concrete was determined, although the carbonate terrain of the Vermont valley was once again brought up as a potential topic of interest.

Bruce Wilson mentioned that he received a telephone call from Rachel Barker, a retired USGS geologist who lives in Arlington Vermont, regarding the donation of her extensive personal library of USGS publications. She wanted to give her collection to a worthy geology library. Since UVM and Middlebury are already US Government repositories, Norwich, Castleton and Johnson were considered to be appropriate recipients.

The meeting adjourned at 3:25 p.m.

Respectfully submitted,

Ronald L. Parker

Vermont Geological Society Student Research Grants Awarded

Two University of Vermont students have received the first two AWARDS under the new Vermont Geological Society Student Research Grant program.

Jessica Falkenberg will receive funding to aid in field work for her undergraduate thesis. She will be examining the lithology and fauna in outcrops of the Day Point Formation, located on Isle La Motte, to determine the depositional setting of the Bryozoan reefs found there. Jessica's advisor on this project is Char Mehrtens.

Mary Ann Schlegel will receive funding for laboratory expenses connected with her Master's thesis. Her research will apply oxygen isotope studies and Carbon-14 dating to refine the timing of changes in paleosalinity and paleotemperature in the Champlain Sea. Mary Ann's advisor is Allen Hunt.

SEMINARS, MEETINGS, AND FIELD TRIPS

September 11: University of Vermont Fall Seminar Series (3:30 P.M.): *"Introduction to fractal geometry and chaos theory and their application in the earth sciences"* Dr. Christopher Barton, U.S. Geological Survey, Denver.

September 18: University of Vermont Fall Seminar Series (4 P.M.): *"Kinematic evidence for extensional unroofing of the Franciscan Complex, California"* Dr. Tekla Harms, Amherst College.

September 18–20: *New York State Geological Association Fall Field Conference, Hamilton, New York;* Contact the Geology Department, Colgate University, Hamilton, New York 13346, for details.

October 9–11: *NEIGC Field Conference,* Contact the Geology Department at the University of Massachusetts, Amherst for details.

October 17: *Vermont Geological Society Fall Field Trip and Annual Meeting.* Details in this issue.

October 19: University of Vermont Fall Seminar Series (4 P.M.): *"Paddling through time: Swimming styles in extinct marine mammals"* Dr. Emily Giffen, Wellesly College.

November 9: University of Vermont Fall Seminar Series (4 P.M.): *"Tectonics and Igneous Activity: Examples from the Coast Mountains Orogen, British Columbia/Alaska"* Dr. Maria Crawford, Bryn Mawr College.

November 16: University of Vermont Fall Seminar Series (4 P.M.): *"Tectonics and stratigraphy in Northern Maine"* Dr. David Roy, Boston College.

November 30: University of Vermont Fall Seminar Series (4 P.M.): *"Nuclear Waste Disposal: Does Geology Matter?"* Dr. George Shaw, Union College.

December 7: University of Vermont Fall Seminar Series (4 P.M.): *"The dilemma of Lake Baikal: Geological treasures for extractive use in a time of political chaos. What role should the geologist play?"* Dr. Jean Richardson, University of Vermont.

THE GREEN MOUNTAIN GEOLOGIST

VERMONT GEOLOGICAL SOCIETY
P.O. BOX 304
MONTPELIER, VERMONT 05601

The *GREEN MOUNTAIN GEOLOGIST* is published quarterly by the Vermont Geological Society, a non-profit educational corporation.

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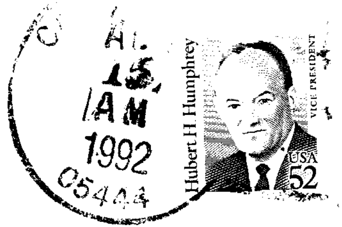

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THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

FALL 1992 | VOLUME 19 | NUMBER 3

Geologists' Roles in the Rock and Mineral Extraction and Processing Industries

A Field Trip with Lance Meade and Eric Lapp

dedicated to

Brewster Baldwin

&

Vermont Geological Society Annual Meeting and Banquet

Guest Speaker: John Williams

Director, Maine Low-Level Radioactive Waste Authority

Saturday October 17, 1992

9:30 AM Rochester Village Green: See inside for details!

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PRESIDENT'S LETTER

Dear Members,

It has been an honor to serve as VGS president this last year. The Society has started the Student Research Grants program, and I hope that continues to grow. We've also started a program of guest editors for the *Green Mountain Geologist* which has been very successful in providing interesting content while spreading around a lot of the work necessary to put the *GMG* together. This month's editor is Shelley Snyder and I'm sure you will all enjoy reading the articles concerning geologic education that she has collected. Both these programs started under Chris Stone last year, and I hope they continue to grow.

We had a very successful summer field trip, doing "gas station geology". Thanks are in order to Kent Koptiuch, Ron Miller, Bill Norland, and John Amadon who hosted the individual stops, to Neal Faulkner of Tri-States Drilling and Boring for donating his time and equipment to install a monitoring well at the Waitsfield site, and to Ron Parker who put the tour together.

This fall's field trip and meeting continues the theme of applied geology begun by Ron's summer trip. Eric Lapp and Lance Meade will be guiding us on a tour of various aspects of the building stone industry with emphasis on the geologist's role in this industry. Another application of geology which will be a growing topic in Vermont in the next year or so is the siting of a low-level radioactive waste facility. For our banquet speaker, John Williams will be coming over from the Maine Low-Level Radioactive Waste Authority to talk about Maine's experience applying geology to this process with some additional comments on the political aspects which can't be escaped.

I've received a lot of help negotiating my way through this last year from the officers and directors of the Society and from various members of our community. One more time, I'd like to express my deep appreciation for all that they have done. I would also like to single out Steve Wright for the large and constant effort he provides the VGS in putting this newsletter together four times a year (along with everything else he does).

We've got an exciting year coming up with the GSA meeting in Burlington, and I look forward to joining the ranks and providing our new president and the GSA committees the kind of help and support that I've had.

Sincerely,

Bruce Wilson
Brattleboro, VT

FALL FIELD TRIP

Geologists' Roles in the Rock and Mineral Extraction and Processing Industries (or, What Happens to Students Who Don't Go into Hydro?)

Eric Lapp & Lance Meade
OMYA, Inc.
61 Main Street
Proctor, VT 05765

Saturday Oct. 17, 1992

Introduction and Background:

Years ago, the public's common vision of a geologist may have been the classical idea of a field mapper or core and outcrop inspector, typical of the dimension stone industry. Technological changes, market demand, and developments in industries such as paper-making, paper-coating, plastics, and many other diverse areas, spawned advantages to using mineral fillers derived from crushed stone as functional and less expensive substitutes for other raw materials.

Similar to Ron Parker's commentary last issue, we find today's industrial geologist likely to gain knowledge of or interact with other professionals involved in fields such as: engineering (many subareas), chemistry, computers, finance, purchasing, regulatory/safety/legal, human resources, quality control, sales/customer service, transportation and delivery, marketing/advertising, international trade, and many more. Industry depends on forming critical partnerships between suppliers and customers to assure the quality of its product and services. In addition to the geology department, individuals with geology backgrounds can be found in areas as diverse as production and packaging supervisors, customer service, product handling, engineering, regulatory and quality assurance specialists, analytical chemistry, and even sales/marketing at vice-president levels.

With advancements in processing technology and expanding applications of raw materials for the finished products, the geologist has had to learn a great deal more about the engineering and manufacturing opportunities and limitations for refining the raw materials and how even subtle changes in ore qualities can dramatically affect various segments of the internal and external customer chain along the way. As a complement to the summer trip, we hope to show that there remains a need for high-quality basic education in the traditional geologic disciplines. Although we also recognize the need for multi-disciplinary background and skills, much of the "world of work" expertises can likely best be gained on the job.

Because of Brewster Baldwin's involvement with the dimension stone, talc, and other industries, he was very cognizant of the need for a broad-based education for the aspiring geologist. We dedicate this day's events to his memory and his high standards.

Trip Details:

Our discussion will include the geology and evolution of the individual field trip stops, changes in mining, milling, material uses, and environmental factors for the serpentine/talc and marble deposits. The stops are made available for this occasion by permission of the companies and owners involved. Details of the historical stops are still being arranged at press time and may be subject to change. It is our hope that these "bonus stops" may serve to inspire a future trip focused entirely on historical sites! Below is the current trip itinerary. The trip will take place regardless of the weather. Participants are asked to bring a bag lunch but may have the chance to purchase items at a store. Those wishing to join the trip mid-day can meet the group at the parking lot of the Smokerise Diner on Route 7 north of Brandon at 12:00 noon, where we will proceed to the quarry for the lunch stop/discussions.

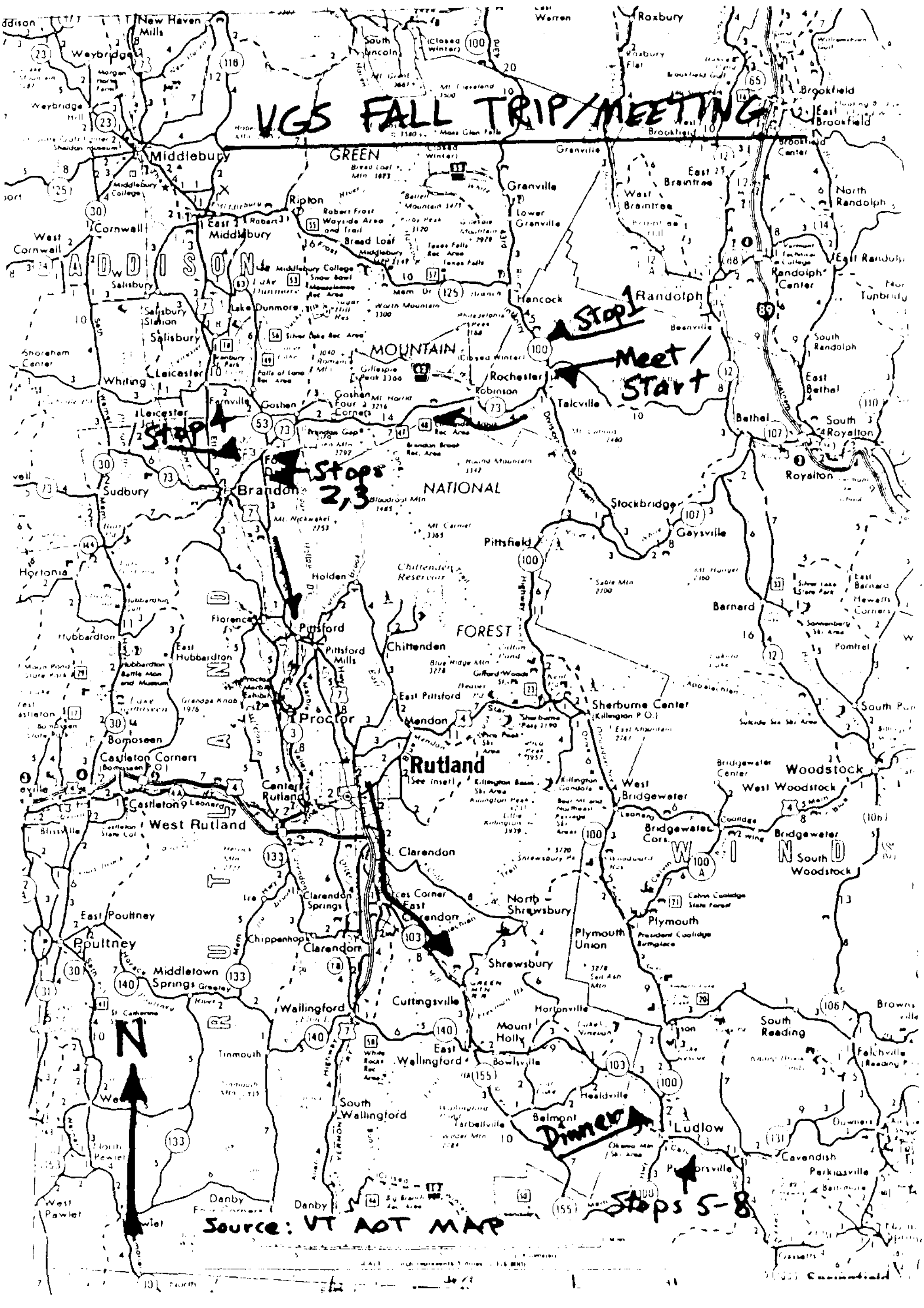
ASSEMBLY TIME & PLACE: 9:30 A.M. Rochester,VT village green

Those coming north on I-89: take the Bethel exit, Rt. 107 west to Rt. 100, N to Rochester.

TRIP LOG

Time	Stop:	Features/aspects
9:45–10:30	(1) Rochester Quarry	Verde Antique/Serpentinite dimension, stone, contacts, lithology and structures
	Travel west over Brandon Gap (Rte. 73).	
11:00–11:45	(2) Forestdale Iron Furnace historical site (3) Forestdale Kaolin/lignite/ochre site	Details for stops 2 and 3 are still being arranged.
12:15–1:15	(4) Smokerise quarry	Historical, changes, reclamation and structure (marble/limestone). (Brandon—see lunch above)
Travel Rte. 7 So. through Rutland, take 103 left (SE) to Ludlow; proceed SE through village to E. Hill Rd. right(SW) off 103 (see Luzenac America sign); cross bridge, assemble in truck staging area before RR tracks.		
2:30–4:45	(5–8) Luzenac Talc quarries and operations:	Stops at Argonaut, Black Bear and Rainbow mines and short tour at Colombia Mill and shipping center. NOTE: Bring hard hats and glasses if possible.

To dinner: Travel north on 103 through Ludlow village; Chuckles is uphill on the left (N), just past the fire station. (See maps on following pages.)


VGS FALL TRIP/MEETING
Stop 1
Meet/Start
Stops 2,3
Stop 4
Dinner
Stops 5-8
N
Source: VT AOT MAP
Middlebury
Rochester
Brandon
Pittsford
Proctor
Rutland
Ludlow
Woodstock
Randolph
GREEN MOUNTAIN NATIONAL FOREST

FALL BANQUET, ANNUAL MEETING, & KEYNOTE ADDRESS

Chuckles Restaurant
Ludlow, Vermont

This year's Annual Meeting and Banquet will be held at Chuckles Restaurant, Route 132, in Ludlow (see location map). We are fortunate to have, as our guest speaker, John Williams, Executive Director of the Maine Low-Level Radioactive Waste Authority and formerly head of the Hydrogeology Division of the Maine Geological Survey. He will outline Maine's efforts to site a Low-Level Radioactive Waste Facility, a topic of intimate concern to many Vermonters as we attempt to site a similar facility here.

5:00–6:00 PM: **Social Hour/Appetizers/Cash Bar**

6:00–7:00 PM: **Dinner**
See menu below. *Please* send your reservation and check to Bruce Wilson by October 9.

7:00–7:30 PM: **Business Meeting: Election of new officers**
Note: Members not attending the field trip or dinner *are welcome* to come late to hear John Williams' talk and to participate in the business meeting. A copy of the ballot appears on the same page as the restaurant reservation form. Members unable to attend the business meeting are urged to send their ballot to Bruce Wilson at the address listed below.

7:30–8:30 PM: **John Williams, Director of Maine's Low-Level Radioactive Waste Authority**
Geological and Political Considerations for Siting a Low-Level Radioactive Waste Facility in Maine

Menu
Choice of Entree:
Chicken Peppar —sauteed boneless breast breaded with ground unsalted peanuts and breadcrumbs, with shallots and Absolut Peppar vodka cream sauce over fresh sweet red pepper fettucine (baked potato or rice pilaf may be substituted) OR
Prime Rib - Banquet Cut —8 to 10 oz. boneless prime rib, with choice of baked potato or rice pilaf OR
Stuffed Sole - baked fresh filet of sole, with crab and yellow, red and green onion stuffing, with choice of baked potato or rice pilaf
All of the above include: Salad, Homemade Bread, Carrot Cake, Coffee or Tea.

The banquet will cost $16.00 per person. If you wish to attend please cut off this page and return with payment by October 9. For more information, call Bruce Wilson at 257-7757 (work) or 254-9409 (home).

Detach and return by October 9, 1992 to:

Bruce Wilson
Vt. LLRWA
P.O. Box 8234
N. Brattleboro, VT 05304-8234

Yes, I wish to attend the VGS Annual Meeting and Banquet.

Name____

Number of people attending________________

Choice of entree (indicate number of each choice)

Chicken Peppar________

Prime Rib____________

Stuffed Sole____________

Enclose $16.00 per person.

Make checks payable to Vermont Geological Society.

Note: If you are planning on attending the field trip, please contact Bruce Wilson (via this form) or Eric Lapp (1-800-451-4468) to give Eric and Lance an estimate of how many people they need to plan for.

ABSENTEE BALLOT: 1992
Vermont Geological Society

Officers:

President	Lucy Harding	_____
	_______________	_____
Vice-President	Larry Gatto	_____
	_______________	_____
Secretary	Sue Hadden	_____
	_______________	_____
Treasurer	Steve Howe	_____
	_______________	_____

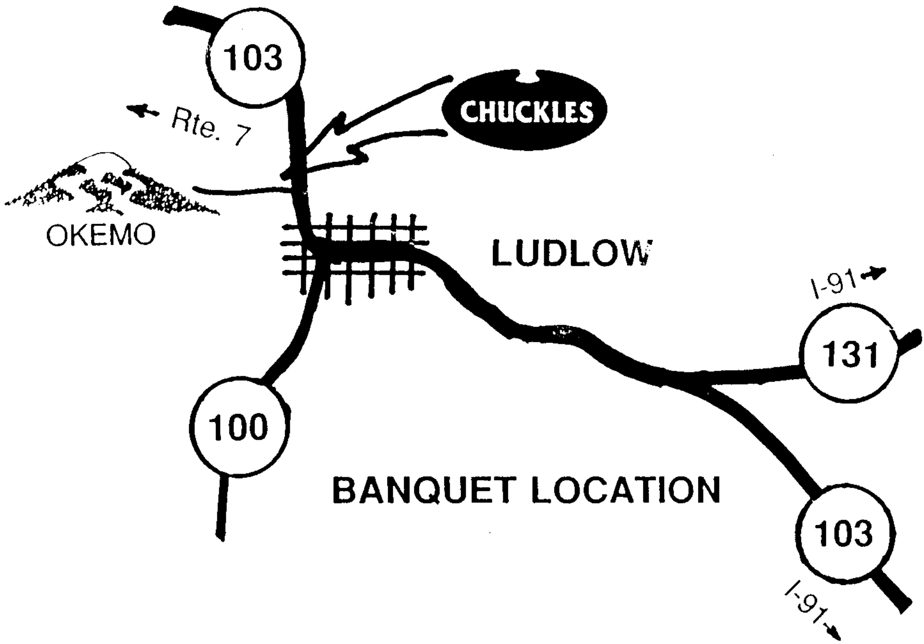
Board of Directors (2-year term):

	Ronald Parker	_____
	_______________	_____

If you will not be attending the VGS Annual Meeting in Ludlow, please complete this ballot and return it in an envelope marked with the word "BALLOT" in the lower left hand corner and your name and address in the upper left hand corner to:

Bruce Wilson
Vermont LLRWA
P.O. Box 8234
North Brattleboro, VT 05304

To be counted, this ballot must be received by October 16, 1992.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Rte. 7
OKEMO
LUDLOW
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131
100
BANQUET LOCATION
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I-91

Guest Editor's Note

Often as professionals, geologists find that they do not communicate effectively about topical issues with the average citizen. Conversely, what information does the citizen need to possess to be able to communicate in a meaningful way with the professional geologist? What does the professional geologist need to do to make it easier for him/her to communicate with the public sector? The communication key lies in public education. By becoming informed and involved in the education of the public at all levels, we as a professional society and as individual professionals can have a lasting impact on how the public views geologic issues such as ground water legislation and solid waste disposal. This is precisely what is happening in science education today through outreach programs and individual effort.

Under recent gubernatorial administrations, goals for education were written by Vermonters for Vermonters. Those goals include:

(1) Every child will become competent, responsible citizen;
(2) Schools will restructure to support high levels of performance;
(3) Vermont will support and develop effective teachers and school leaders; and
(4) Vermonters will create partnerships to support teaching and learning.

These goals and anticipated education reform were precipitated by our growing informational and technological society. The body of information that we have access to is growing much faster than our ability as individuals to assimilate it. Technology is advancing faster than we as a society can make ethical decisions about its use.

The American Association for the Advancement of Science has recommended a change in the way that science is taught. Rather than the traditional content approach, a more holistic approach is suggested. The normal subject boundaries will be softened and connections between disciplines will be encouraged. Rather than rote memorization, thinking skills and problem solving approaches are emphasized. Relationships between math, science, and technology are encouraged. For the average citizen, we need to begin to think of what information and skills will be needed to function in the twenty-first century. At the professional level, it is becoming necessary to become an expert in smaller and smaller areas of expertise.

This issue of the *Green Mountain Geologist* brings to your attention some of the activities and concerns in science education. Science education reform is occurring at many levels, from individual teachers to national movements (e.g. the recently publicized National Science Foundation grant). The articles in this issue are by no means a complete chronicle of the many exemplary activities and programs available in education today and many noteworthy programs and activities are not mentioned here. My sincere thanks to those who contributed to this effort.

Shelly Snyder
Mt. Abraham Union High School

Some New Trends in Science Education

John Vibber
Math/Science Coordinator
Mt. Abraham Union High School

Science education in the U.S. is about to begin a new era. The last major reform was the post-Sputnik development of such programs as BSCS, CHEM Study, etc. We invited new ways to educate our potential scientists and engineers. These programs and the inservice support that accompanied them, bloomed in the 1960's and went to seed in the 1970's. New ideas are now germinating in the name of "restructuring." The key goal to this reform will be to teach high skills to virtually all students.

We have heard a lot about the basic skills and low SAT scores. Many people judge and compare schools based solely on the percentage of graduates to enter college. By these standards, only the best traditional schools succeed. I feel that we need to disabuse ourselves of these ideas. Our goal should be to produce students who are world class in their ability to learn, solve problems and communicate, whether or not they are college bound.

I argue that the need for high-skills work force is the major reason for school restructuring. The argument goes as follows. The low-wage, interchangeable part (human or otherwise) economy common in the U. S. offers little competition abroad. It is of little comfort to its workers. Such jobs are readily lost to the Mexican labor force. In contrast, companies that maintain a corporate culture in which constant training occurs can be highly competitive. The high-skills work force (not the basic-competencies work force) is essential to the U. S. economy in years to come. As we reform science education, we need to keep this in mind. This time around we must raise the science literacy and skills of all students.

Restructuring is painful, worrisome, awkward, and uncertain. It can alienate the supportive parents we need the most. It asks us to disavow practices we have done for years. It seems counter-intuitive, and yet, WE KNOW HOW THE CURRENT SYSTEM PERFORMS. All too often in science education, the college prep kids get the extra lab time. Often they get the most experienced teachers and they surely get the more sophisticated knowledge. Only the students who go on to higher education get training in chemistry and physics which is the science most needed in manufacturing jobs. In essence, there is no core curriculum. In many schools the students that do not ago on to college are more likely funnelled into an earth science course.

The National Council of Research of the National Academy of Science is developing a national set of science standards. This will give a standard of comparison to judge each local curriculum. The document will be finished in

1993. We commonly compare what we see taught with what we were taught. This is true of content and of method. National standards allow us to compare what we see taught with what and how it should be taught. This is leverage for change for anyone interested in intelligent reform.

Many less inclusive sets of standards now exist and I believe they give insight into what the national standards will say. Here are the common themes. The first is the idea that 'less is more.' Science teachers should cover far fewer topics, but in greater detail. Greater emphasis should be placed on 'process skill.' Simply put; kids should learn science by doing science. We should develop assessment methods that honor many different talents and styles of learning. We need a core curriculum for all students. We need to integrate the sciences with each other, with math, with pertinent contemporary issues, and with other subjects students are learning. We should, in some ways, teach all the sciences each year. Science courses must reinforce students language and math development.

At Mt. Abraham our approach to this tall order has been to add equal lab time for all students to increase science from a two year to a three year requirement. We have heterogeneously grouped our students from grades 7 through grade 10 and we have began work on an integrated curriculum. We have extensive team teaching in grades seven through nine with an increasing interdisciplinary component. Our Chemistry course is based on CHEM Com which covers chemistry through expanding a few basic themes. Our Physics program is taught at two levels with a strong project/activity orientation. The score so far is that most of our students experience a common curriculum from grades seven through ten. Most students take Physics. Enrollment in upper level courses is increasing. Standardized testing and analysis of teacher grades show equal success in learning science regardless of gender. We still need to raise our quality standards and learn to be more skillful in teaching heterogeneous groups. Our curriculum needs more time and in-service support to evolve into an integrated model. Such support is on the way.

Vermont has recently received a N. S. F. grant for 10 million dollars over the next five years. The goal is to promote reform in the teaching of Math and Science. I believe that you will soon see some of the most exciting reform in the U. S. happening here in your neighborhood schools.

One of my favorite insights into the high-skills argument exposes my Vermont chauvinism. If there are regions (such as Vermont?) with the infrastructure to produce high-skilled workers, then such regions will attract and retain progressive businesses to employ those workers. With high-technology production and modern communications the quality of the work force becomes more important than the location of other resources. The work ethic is alive and well here and "Made in Vermont" is a mark of quality. Combine this with a high-skills work force and just imagine. I trust that reform in science education will play an important role in these developments.

Vermont Elementary School Teachers Become Rock Hounds!

Nancy Keller* and Mary Ann Schlegel**
*Winooski Educational Center, Winooski, VT
**Dept. of Geology, University of Vermont, Burlington, VT

Fifty two teachers from 21 primary schools across Vermont are participating in a "Teacher Enhancement Program in the Physical Sciences" at UVM, a program funded through the National Science Foundation. Over the course of three consecutive summers, beginning in 1991, elementary school teachers rotate through intensive three week courses in physics, geology, and chemistry taught from a constructivist perspective. For project organizers Drs. Russell Agne and Michael Strauss "...the constructivist approach encourages teachers to view science as an evolutionary developmental process which matches the learner's conceptual level." Rather than teaching science as a series of facts to be learned, teachers using a constructivist approach focus on how scientists reason, how knowledge is constructed, and how models are developed. Teachers expect their students to become active rather than passive learners—problem solvers rather than just fact finders.

To encourage this synthesis of science content and constructivist pedagogy in a course uniquely suited to the needs of elementary school teachers, the individual science disciplines are taught by combinations of university professors, graduate students and primary school teachers. UVM Professor Barry Doolan, UVM Graduate Student Mary Ann Schlegel and Winooski Educational Center teacher Nancy Keller comprise the geology teaching team. The merging of our related but different areas of expertise resulted in fundamentally redefining our approach to teaching geology: What are the essential concepts in geology and how can we help our students discover these concepts?

This past summer (1992) eighteen fifth and sixth grade teachers undertook an exploration of geology through a series of inquiry-driven, participant-guided discussions and activities. For example, a question such as "How does the inside of the Earth differ from the outside?" was posed. This led initially to a class discussion in which collective knowledge and perception was aired. Speculation followed and a research plan emerged. Observations on materials comprising the Earth's surface were garnered through field trips to the Salmon Hole in Burlington and Devil's Bowl in Bolton. Graphical analysis of changes in seismic wave velocities, density, and pressure from the Earth's surface to its core led to discoveries about the Earth's interior. Cooperative research teams reached conclusions. Results of group investigations were shared and summarized. Said one teacher "I love the discovery approach. I appreciated all of you [instructors] ...allowing me time to figure it out ... I grew to trust my opinions and knowledge." Another participant observed: "If the same information had been presented in a lecture form, it probably would not have been as meaningful."

In such a positive atmosphere of collective inquiry and brainstorming, data collecting and summarizing, participants gained ownership and confidence in additional topical areas including folding and faulting, sedimentation, paleoenvironmental interpretation, fossil and rock identification, stream processes, relative age determination, plate tectonics and glacial history. One teacher remarked that "I received the gift of knowledge. Not Diet Coke knowledge but the real thing. I liked being exposed to unadulterated geology and being treated as a capable learner." Another said, "I saw myself as a science teacher for the first time." In addition, by the end of the third week, teachers had an appreciation for the expanse of geologic time and the events through the periods that have brought Vermont to the present. Indeed, "learning about the mountains I have admired so many years and being able to take that knowledge and excitement back to my class" was a course highlight!

One of the challenges continually facing staff and teacher participants alike was the application of geologic concepts to the elementary classroom. In fact, development of an earth science curriculum and its incorporation into extant school curricula was a major project. We relied, in part, on the American Geological Institute's Content and Planning Guides for Earth Science Education in the 21st Century.[1] These useful documents propose both topics and pedagogy for Earth Science curricula using a constructivist approach in presentation for all grades, kindergarten through 12. With these publications as guides to curriculum development at age-appropriate levels, participating teachers created and tested a myriad of activities designed to bring geology to children in a fun, fresh manner. Activity development reinforced content for the participating teachers; as one articulated: "The hands-on really made it real—[made it] easier to fit it into my own frame of mind."

At the close of the summer session, classroom teachers submitted proposals outlining ways in which they intend to develop and implement Earth Science content in their curricula. Teachers are supported in their endeavors through the school year. This support includes the loan of materials and project supplies from UVM, classroom visitations and field trips by Barry and Mary Ann, and interim meetings of Program participants with NSF staff.

The 1992 Geology Strand participants are off to a strong start with "Project New Stonehenge" involving students in nine classrooms from Sheldon to Manchester to Barre in the telecommunicated exchange of geologic data collected in their respective locations. "Project New Stonehenge" founders

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[1]Available from: AGI Publications Center, P.O. Box 2010, Annapolis Junction, MD 20701, (301) 953-1744.

Marilyn Bish and Joan Lumbra discuss their collaboration in depth elsewhere in this publication. On a smaller scale, many teachers plan to approach earth science through study of local rivers and associated issues of water quality, or through a variety of interdisciplinary venues involving local history, environmental issues, mathematics, and geology.

For us, the Geology instructors involved in the Teacher Enhancement Program, there have been revelations and insights as well. Teaching geology from a constructivist perspective to elementary school teachers and supporting our teachers in the application of this content in their classrooms revealed that science learning is indeed a continuous process. As one teacher participant aptly commented: "Learning is never ending, it is ongoing." Furthermore, through our respective teaching roles as professor, graduate teaching assistant, and middle school science teacher, we can assert that constructivism applied at any level will enhance the learning process.

The NSF Teacher Enhancement Program is effectively reaching its stated goals. However, the real challenge remains. To ensure continued success in earth science education at all levels, educators and administrators must expand their commitment to develop and implement curriculum that allows the opportunity to problem solve rather than just fact find. To this end, we must continue to enhance our science teachers by providing opportunities for them to both experience and teach science in a constructivist manner.

Update on the Governor's Conference on Environmental Education

Steve Crowley

After decades of progress in environmental science and policy, many in Vermont are seeing that an important missing link is now being filled by Vermont Educators. Just as Vermont schools are addressing the needs of the 1990's and beyond, environmental education is rising to a more significant level in the curriculum.

Several years ago, a group of educators in the Vermont State-Wide Environment Education Programs (VT-SWEEP) began to address broad goals for environmental education in Vermont. In March of this year, the effort led to a Governors Conference attended by more than 200 people, sharing ideas, programs, and plans for the future.

Key themes of environmental education closely parallel the evolution of education generally and feature inter-disciplinary, exploratory programs and create bridges between school and community. An important component is the opportunity, even the necessity, for professionals in the field to lend their energy to building these bridges.

The effort continues, as educators, through VT-SWEEP, make their stamp on curriculum and program development. In early October, SWEEP plans to host the New England Environmental Education Associations' annual conference with a focus on "Painting the Town Green: Environment, Involvement, and Empowerment." Vermont Geological Society members who would like to build bridges of their own should contact their local schools. To find out more about VT-SWEEP, contact Steve Crowley at 658-5782.

The Value of Field Trips in the Study of Science

Shelley F. Snyder
Mount Abraham Union High School

Regrettably, the job of teaching earth science in our schools today often falls to an educator whose background and experience are centered in the general sciences, who believes that he has already learned all the earth science he needs to know, and whose field experience is limited. This is not intended to be a poor reflection on the earth science teacher or the school system. The science teacher may find himself in the position where necessity dictates teaching a subject that is not a first choice. As a consequence, the one activity that really engages kids, the field trip, is lost. This does not have to be the case.

The depth that an individual who is knowledgeable can add to a field trip is invaluable to the classroom teacher and the student. I will share three field trips that I have been on where students were involved with professionals.

The first is a field trip sponsored by the Vermont Geological Society. The trip was to the Ordovician Coral Reef on Isle La Motte with Chuck Ratté as trip leader. By accident there were four children on the field trip as well as a teacher who had not previously been on any VGS field trips. We all were locating fossils and marking them for later mapping. For the adults it was an enjoyable experience. The day was sunny, the weather was just right. The children and teacher were the last to leave the reef. They searched tirelessly for the finest examples of cephalopods, *Maclurites,* and became quite proficient at finding rugose corals. For the children, two things made the trip successful. They were finding fossils, which are usually a big draw for young people, and there was an expert to answer their questions. The children and teacher had connections made between fossils and living organisms, features in the rock, and modern beaches.

The second field trip example comes from the New Haven River Project, a junior high level stream study. The weeks of sampling were preceded and followed with special events such as guest speakers and media presentations. In classes where appropriate, background material was introduced. Each group's major problem was discussed and relative concepts were taught. Students were prepared for field work and data reporting through math and science class time. Lessons focused on the geography, natural history, and management of the aquatic habitats of Vermont with particular attention given to the New Haven River. Volunteers from the Vermont Agency of Natural Resources and Vermont Natural Resources Council as well as many private consultants gave field assistance.

The experiences of gathering data, analyzing it, and drawing conclusions are valid lessons. Also important were the lessons learned from lost or incorrect data. The most important lesson at this stage is the fact that students have been stimulated, excited, and riveted by their discoveries. Some students were virtually unaware of the opportunities in their own back yards. It was rewarding and stimulating to see them absorbed in a hunt for new aquatic insects or in complete concentration during measurements of stream cross sections. Students begin to take a proprietary interest in the river. Group presentations indicate obvious pride in their achievement, and confidence in the knowledge that they have generated.

Students "had a lot of fun and ... would like to visit the New Haven River again." Over and over the question was asked, "Can we do this for the rest of the year?" It was an educational experience with a lot of fun. The aesthetic value of the river was not lost to the students. Baldwin Creek "was truly breath taking," wrote one student, "the water seemed to just tumble over the rocks to a silent symphony" added another. "All together it would be a wonderful place to just lay around and watch the day go by."

Daily routine was changed. The project infused the school with an air of excitement and anticipation. Other students and teachers dropped by to see what was going on. The students use classroom writing, reading, science and math skills in a practical application to investigate community impact on the local environment. Most important, students have the opportunity to interact with professionals involved in environmental issues and to have hands-on research experience including gathering, organizing and analyzing real life data.

Faculty members benefited from the program as they were challenged to be creative and to explore new approaches to teaching and learning as well as new information. Teachers were brought into close association with community professionals where new information was introduced to students and teachers.

The willingness of volunteers from the community and the cooperation of many scientists were crucial to the management and success of the project.

The third field trip story involves a geologist we have all known and respected for many years. No *Green Mountain Geologist* edition on education would be complete without mention of Dr. Brewster Baldwin. Brew was a long time friend to many of us in VGS. He was always the quintessential teacher. Two months before his death he was with a group of students from Mt. Abraham Union High School. As part of the Annual Symposium at Mt. Abraham Union High School, a group of students proposed to write a self guided tour of Memorial Park on Route 17 in Bristol. For teachers involved it was a way to introduce some math, science, and writing skills to the students involved in a more palatable format. The Memorial Park was chosen because the students were familiar with it. For the students it began as a project that they chose and wanted to do. As part of the Memorial Park Project, the students needed to research the geologic history of the area. Brew was invited to talk about the geologic history of Vermont and relate it to what the students were seeing. As was his custom, Brew was charming and slightly irreverent. The students he was talking to were not an ordinary group of students. Most of these students were those at risk of dropping out of school. Many had a history of little success in the traditional classroom.

In the field, Brew talked to the students about the rocks they were sitting on as well as how, where, and when they fit into the big picture. With much arm waving and pointing the students' interest was held. His discussion, punctuated with "qu'est que le hell c'est?" gave the students a vision of the scientist as someone who knew what was going on as well as an individual with humor. Too often the scientist is portrayed as a strange individual in a white lab coat (a la Young Doctor Frankenstein). This scientist was not like that. We are saddened that he is no longer with us.

In Vermont we are concerned about ground water quality, where solid wastes are going, what is happening to our radioactive wastes, and surface water quality as well as a host of other items. The students of today are the voters of tomorrow. By relating lessons in classes with real world activities, the student will receive the benefits of broader based studies, encompassing a broader range of topics. Historically math has been separated from biology, separated from geology, and separated from chemistry. As one studies any one content area the student realizes that there is no definite line drawn between scientific disciplines. This is the underlying concept that we are trying to reinforce. In earth science when the water cycle is first studied in high school, pH of water can be studied, as well. Usually it is addressed as acid rain. When the student studies biology, pH of systems is addressed again. By the time chemistry is taken, pH has been introduced twice in high school, yet it is taught again. Sadly this does not happen with the geologic sciences. In many school systems earth science is taught only to those students who are not planning on going on to college. For some students, there is little study of the cycles that are so vital to understanding complex environmental issues.

What does this mean to us as professional geologist? It means volunteer to participate in local school activities. The experience for students is invaluable! More generally, geologists in the private sector need to step forward and make known what is important information for all students/citizens to possess. This can be accomplished by approaching school systems at many levels, specifically, talk to teachers, administrators and school boards. If we are concerned about developing an informed citizenry, expectations need to be raised for education outcomes.

Memorial for Brewster Baldwin (1919-1992)

September 12, 1992 - St. Mary's Church, Middlebury

Lucy Harding
Department of Geology, Middlebury College
Middlebury, Vermont

Today I want to talk about Brew Baldwin as a member of the Middlebury College community—how he came here, what he did here, and why he will always be remembered.

Brew was a 1941 graduate of Williams College and earned his Ph.D. in geology from Columbia University in 1951. His graduate school career was interrupted for a time by World War II. He liked to tell people that he spent the War on an island in the Pacific ... then he'd add that it was one and a half miles off the coast of California. He then taught for 2 years at the University of South Dakota and next worked as an economic geologist for the New Mexico Bureau of Mines and Mineral Resources. During his time in New Mexico he made a geologic map which covered one eighth of 1% of the entire contiguous United States. This is an impressive accomplishment considering that it encompasses an area of about 5000 squares miles! In 1958 Roland Illick hired Brew to teach geology at Middlebury College.

The 1960's mark the formation of the geology department as we who belong to it know it. Under President Armstrong Brew was given a charge of building the department. He hired Peter Coney and together they added Roger Laurent, Dave Folger, Dave Clague, and Tom Davies to the program. Brew concentrated on developing meaningful field and laboratory problems for the students, problems that, as Brew was apt to say, even he didn't always have all the answers. Most of these problems are still in our curriculum today and include famous localities like James Pasture, Huntington Falls, and Crown Point, where Brew pointed out to the students not only the fossils *Maclurites*, *Girvanella*, and *Lambeophylum*, but also the fossil bird and the fossil cannon, chiselled into the rock by the soldiers 200 years ago. Brew also developed our departmental philosophy that includes cooperation among students, going outdoors to see the rocks, an emphasis on concepts rather than memorization, letting students grope for reasonable interpretations rather than giving them answers, and going outdoors again to see the rocks.

In the early 1970's Brew and some colleagues including D.K. Smith, Louie Poole, and Howard Woodin founded one of the earliest programs in environmental studies. Brew applied his skills to finding local solutions to help alleviate the global energy crisis. For example he studied the feasibility of a pumped water storage project for the town of Middlebury. This involved diverting the flow of Otter Creek during the evening and pumping it up to a reservoir in New Haven, then letting the water generate electricity during the day by flowing back down into Otter Creek. Similarly, at faculty meetings Brew often reminded us to always turn off lights.

Then one day in 1975, as Brew put it, "all of my colleagues quit." He hired a new group which included Bill Glassley, Ray Coish, and Peter Goreau, and to Brew's delight and credit, the geology program kept right on going. Much of Brew's most scholarly work came from this time period, all the more impressive as he was approaching his sixtieth birthday.

I was hired, in 1984, as his replacement. He had intended on staying in the department for another year t mooth the transition, but ended up staying for eight years in many capacities including professor emeritus, lab instructor (he referred to himself as my TA) researcher, and author. More colleagues joined the department during this time and he welcomed them and their new ideas with great enthusiasm. They included Murray Journeay, Kathy Gingerich, David Elbert, Jack Schmidt, and Pat and Tom Manley. Brew's last project, nearly complete at the time of his death, was a book on all aspects of geology entitled "Rocks Make Sense." On a visit I made to Brew during his last illness, we talked excitedly about the course we were to have taught together this fall rather than focusing on his health.

During the time I knew Brew, he thrived on informality, refusing to wear the faculty name tag that said Brewster Baldwin, Chairman and Professor of Geology, in favor of the simpler Brew Baldwin, Geology. He delighted in being able to relate to students' grandparents as well as them and their parents. He served as a mentor to young faculty. He strongly advocated adding more women, minorities, and young people to the faculty. He became, in the words of many, many faculty colleagues, a role model of how to stay young and current throughout your career. He truly thrived on new ideas and change, as evidenced by a memorable Abernathy lecture he gave in 1984 entitled "Who likes new ideas?" This talk was inspired in part by having 3 manuscripts full of new ideas rejected in review, all of which were subsequently published. Brew asked simply "What got in the way of those reviewers who were negative?" In a similar vein he collected sayings entitled "Quelque Bon Mots" which wonderfully reflect his views and I will read you a sampling here:

> On why people resist new ideas: "The father of the last technological revolution is in the ideal position to stamp out the next one" and " age and treachery may not overcome youth and skill but they have a tendency to stand in their way"
>
> On science: "<u>The Gerber Model of Science</u>: One way to feed strained food to a baby is to use a baby spoon and get "the airplane to go into the hangar." This is very neat and precise. The other way is to use a butter

> knife to move the food from one cheek to the other; in each pass, some food gets into the mouth."
>
> On innovation a student says: "The most interesting thing about some professors is their (office) doors."

In the fall of 1985 about 50 of Brew's current and former colleagues and students met at Breadloaf to honor Brew on the occasion (so we thought) of his retirement by giving a day-long symposium of their research. These papers were subsequently published in a 392 page volume honoring Brew. In addition, we asked these people to write letters to Brew and I want to read you some of the things they wrote:

From students:

> ""We left." If any phrase brings you to mind, it is that one - uttered so often on departures to field labs. It signified to me that you were always ahead of yourself, if not literally, then at least figuratively in your thoughts and ideas" Deborah Hutchinson
>
> "You were the first to take my geology term paper and lovingly tear it to shreds so that I might learn to write effectively (nice try!)" Bill Hoyt
>
> "Before the first "Bedrock Geology of Vermont" field trip I asked you what the mirror on a Brunton (compass) was used for. You told me that it could be used while shaving. Or for signalling help when lost. Well, you were right, but, though I'm glad to know of these uses, I still haven't tried them in the field." Joseph Hedal
>
> "Perhaps someday the department will have a moon vehicle named the RV Brewster Baldwin" Silvio Calabi

And from a former colleague, Dave Clague:

> I learned a great deal of geology from you, but even more about what good science can be and should be. Your zest for life both in and out of the classroom taught me the balance needed to maintain a professional career and a happy and satisfying personal life. I suspect that Bill Glassley, Tom Davies, Rob Cocherham, and I all arrived at Middlebury expecting to teach and left realizing we had learned more than we had taught —you were our teacher. You clearly made a difference in many lives, including mine."

Which brings me to the next to the last thing I have to say and that's how will Brew's memory be honored? The answer in the broadest sense is by carrying on in the geology department as we best we can, following Brew's example. But also we will honor Brew's memory in two more tangible ways. The first is through the geology department's new boat on Lake Champlain. This boat, christened the R.V. Baldwin last fall, contains the latest in remote sensing equipment for studying the geology and human history of Lake Champlain. It is active 5 days a week taking students out to study the lake. The second is through the Coney-Baldwin Field Camp Scholarship Fund. The income from this fund will go to Middlebury geology majors who attend a geology field course, an experience Brew felt was very important.

In closing I want to tell you in the words of Peter Coney at Brew's retirement symposium why Brew will always be remembered:

> "There are only two things I would like to say about Brew... Firstly, in all the 22 years that I have known Brew I have never heard him say an unkind or hostile thing about anyone. This is not to say that he always agreed with or liked what people did or said, but he always gave people the benefit of the doubt, tried to reason with them, or tried to discover what honest motives they might have.... The other thing about Brew which is such a rare quality and so often misunderstood is the childlike exuberance with which he meets life. His first reaction is always positive, hopeful, full of anticipation and excitement and wonder. To those of us who know him well it is always infectious. To some it is always unnerving.... Most of us lose this precious quality of the child under the imagined pressures of career and life. Brew never has, and let him be a reminder of what we have lost and should regain."

Thank you Brew, for all you have given us. We will not forget.

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CURRENT PROGRESS ON THE RENOVATION OF THE PERKINS MUSEUM OF GEOLOGY UNIVERSITY OF VERMONT BURLINGTON, VERMONT

Jeff Howe
Curator
Perkins Museum of Geology

The Perkins Museum of Geology houses an important collection of rocks, minerals, fossils, and geologic oddities from Vermont, New England, and around the world. Located in Perkins Geology Hall on the campus of the University of Vermont since the early 1960's, the collections existed previously in the form of the 'State Cabinet' in Montpelier and as a portion of the 'Natural History collections' stored in the basement of the Fleming Museum at UVM. Until recently the museum exhibits have remained static and unchanged, and failed to reflect important recent advances in geology, most specifically those in plate tectonic theory. A generous grant from the Lintilhac Foundation however, allows us to now renovate the space into a modern teaching museum.

During the fall and winter of 1991–92, developmental work was undertaken with the aim of producing a museum that showcases the important specimens of the collection while promoting an understanding of modern geologic principles. Educators and museum professionals were consulted and Mission and Project Statements drawn up to reflect this goal of providing a first rate display museum that can also serve the varied needs of Vermont's educational community. In the spring of 1992, the entire museum was emptied in preparation for asbestos abatement and subsequent construction that has taken place over the summer. With the advent of the fall semester, the new museum is beginning to take shape. New walls are in place as is a new floor and ceiling. By mid-semester, the display cabinets should be installed and readied for the new exhibits.

Featured exhibits will include: Rocks, Minerals and Fossils of Vermont, Seismology, Structure of the Earth, Plate Tectonics, Tectonics of Vermont, Glacial Landforms and Processes, The Fossil Record (including the principles of Historical Geology and fossil formation), Rock Processes, Rock Forming Minerals, Mineral Characteristics, and Current Research in Geology. An added "dark room" will display fluorescent minerals under both long- and short-wavelength radiation, as well as back-lit transparencies of interesting petrographic thin sections.

The most notorious fossil specimen in the collection is the skeleton of a Pleistocene whale unearthed during railroad construction in Charlotte, Vermont in 1849. (This whale, an ancestor of modern Beluga whales that still inhabit the

Gulf of St. Lawrence, was originally described and reconstructed in the early 1850's by naturalist Zadock Thompson of *"Thompson's Vermont"* fame.) The Charlotte whale, along with some stunning new graphics, will occupy a prominent position near the main entrance. Returning also will be a completely restored ichthyosaur cast, a highlighted "Snowflake Bentley" exhibit, the dinosaur trackway, and an array of tactile specimens.

Our records indicate that the two largest user groups of the Perkins Museum are K–12 students on class field trips and Introductory Geology college students traversing the museum on their way to lab. It is the goal of the museum to present geologic topics in a way that will reach out to these groups. The exhibits and the labeling are being designed, however, to present concepts on a variety of levels, attempting to engage the casual visitor, while stimulating the active one as well. The Museum, along with the UVM Geology Department and the UVM Geology Club is also reaching out into the community, leading guided public geologic walks to areas of local interest and providing speakers to local schools and tour guides to the museum. Classes of public interest are occasionally offered through the Church Street Center.

The Museum is taking shape through the efforts of dedicated students, community members and volunteers. Generous donations of polished verde antique floor tile by Vermont Marble Co., polished granite benches by Densmore Stone Co. of South Burlington, and slate materials from R. W. Tatko Slate Co. will give the museum a natural stone interior. Rock of Ages Granite Co. is funding a new microscope exhibit and placing a large granite boulder and bench out in front of the building. A "Grand Re-opening" is being planned for March of 1993, scheduled to coincide with the regional Geological Society of America conference to be held in Burlington at that time. Exhibit installation will take place up until then however, and by mid-October, there should be things to see at the Perkins Museum.

We believe that the process is every bit as important as the product, and much remains to be done between now and next March. If you have questions or comments, or if you have useful skills that you would like to donate to the effort (especially art, display, and construction skills), please contact the museum curator at (802) 656-8694.

Geological Society of America Meeting Update

Stephen Wright

The Northeastern Section of the Geological Society of America will hold its annual meeting in Burlington, Vermont in March of 1993 at the Sheraton Hotel (near the intersection of Route 2 and I-89). Some activities will begin on Saturday March 20th and many of the short courses and field trips will take place on Sunday, March 21st. The main part of the meeting will take place Monday through Wednesday, March 22–24.

The organization committee has been busy with many facets of the upcoming meeting. The final announcement (to be published in *GSA Today* in December) must be submitted by October 2. The final announcement will include information on registration (fees, deadlines, etc.), transportation (how to get here—maps, where to park), housing (where to stay and room rates) and details regarding the technical program. The winter issue of the *GMG* will outline the meeting in considerable detail. We will also be able to describe the kinds of jobs that are available to VGS members willing to help out. For those of you who are interested in the content of the meeting, I have outlined below the symposia, theme sessions, short courses, and field trips that are tentatively scheduled.

Symposia:

Origin and Emplacement History of Allochthons in the Maritime, Northern, and Central Appalachians

Thermobarometric Studies and P–T Path Determinations in Mountain Belts

Advances in Graphic Correlation

Rivers and Lakes: A Tribute to Brian Rust

Mineralogy and Geochemistry of Precambrian Terranes

Advances in the Geology of Vermont and Adjacent Regions

Tectonics of the Appalachians, Cordillera, the Earth, Moon, Mars, and Other Celestial Bodies

Practical Methods for Evaluation of Groundwater in Fractured Bedrock

Glacial-Marine and Glacial-Lacustrine Environments

Plate Tectonics and Terrane Analysis—New Interpretations

Exceptional Fossil Assemblages of Eastern North America: Evolutionary and Ecological Significances

The Glacial, Lacustrine, and Marine Environment in the Lake Champlain Lowlands

Theme Sessions:

Applied Environmental Geology

Studies of Recent Lakes

The Use of Geochemistry in Understanding Tectonics of the Appalachians

Magma Genesis in the Appalachians

New Advances in Earth Science Education K–12

Northern Appalachian Ore Deposits

Short Courses:

Hydrogeochemistry — John Tewhey

Krieging in Geohydrology — William Parker

Cathodoluminescence in Sedimentary Petrology — Mike Owen

System Dynamics in Geology, Water Resources, and the Life Sciences
Rolfe Stanley, Jack Drake, E.A. Cassell, and Kenneth Williams

Field Trips:

The Crown Point Section — Lucy Harding

Early Cretaceous Igneous Features in the Northern Taconics: (A Field Trip to the Unknown) — Greg McHone

Fire and Ice: The Ecology of the Jack Pine Barrens at Altona Flat, Northeast New York — David Franzi and Kenneth Adams

Lone Rock Point, Salmon Hole, and Redstone Quarry
Short trips by UVM staff

Much of the information listed above appeared in the preliminary meeting announcement which was published in the September issue of GSA Today. VGS members wishing a copy of this preliminary announcement should write to: Stephen Wright, Dept. of Geology, UVM, Burlington, VT 05405.

VERMONT GEOLOGICAL SOCIETY BUSINESS AND NEWS

New Members

We want to welcome the following new members who have joined the Vermont Geological Society since the Spring *GMG* was published:

Francis X. Bellini	Bolton, MA	Engineering/Environmental Geologist Yankee Atomic Electric Company
Shelly Hight	Danby, VT	Archaeologist Green Mountain National Forest
Jeff Howe	Winooski, VT	Geologist, Curator Perkins Museum of Geology, UVM
William Norland	South Starksboro, VT	Geologist, Hydrogeologist Lincoln Applied Geology, Inc.
Mary Ann Schlegel	Colchester, VT	Graduate Student—Paleontology University of Vermont
Michael K. Sparks	South Burlington, VT	Hydrogeologist Wagner, Heindel, & Noyes, Inc.
Greg Walsh	Richmond, VT	Geologist U.S. Geological Survey, Reston, VA

Address Change

Our V.G.S. post office box in Montpelier was temporarily shut down this summer—we forgot to pay our box fee. We apologize and invite any of you who had mail returned to you to please try again. We will be acquiring a new post office box in Burlington this fall.

Proposed Schedule Change for V.G.S. Meetings in 1993

The coming winter will be a busy one for many V.G.S. members as we prepare for the Northeastern section meeting of the Geological Society of America in March (see the more detailed description of this meeting in the preceding pages). Because of this, the V.G.S. executive committee is proposing to forgo our Winter 1993 technical meeting and replace it with a social meeting (social hour plus dinner) at the G.S.A. meeting. People who were planning to give talks at the 1993 Winter V.G.S. meeting have two options: (1) they can

ubmit an abstract to give a talk at the G.S.A. meeti...
our Spring 1993 V.G.S. ...
inges, p...
4).

rmont Geology—Teacher's field Guide

A new issue of Vermont Geology is nearing comp... des to Lake Mansfield, Smugglers Notch, Sterli... nd Mos... guidebook has been largely written by 7 Junior and Senior Hig... chers and is intended for teachers and students at those grade lev... icipate that a draft will be completed and ready for outside review ... ober. If you are interested in reading and commenting on this manuscript ore it goes to press, please contact Stephen Wright (work: 656-3396 or home: -5031).

SEMINARS, MEETINGS, AND FIELD TRIPS

ober 9–11: *NEIGC Field Conference,* Contact the Geology Department at the University of Massachusetts, Amherst for details.

ober 17: *Vermont Geological Society Fall Field Trip and Annual Meeting.* Details n this issue.

ober 19: University of Vermont Fall Seminar Series (4 P.M.): *"Paddling through ime: Swimming styles in extinct marine mammals"* Dr. Emily Giffen, Wellesly College.

vember 9: University of Vermont Fall Seminar Series (4 P.M.): *"Tectonics and gneous Activity: Examples from the Coast Mountains Orogen, British Columbia/Alaska"* Dr. Maria Crawford, Bryn Mawr College.

vember 16: University of Vermont Fall Seminar Series (4 P.M.): *"Tectonics and stratigraphy in Northern Maine"* Dr. David Roy, Boston College.

vember 30: University of Vermont Fall Seminar Series (4 P.M.): *"Nuclear Waste Disposal: Does Geology Matter?"* Dr. George Shaw, Union College.

cember 7: University of Vermont Fall Seminar Series (4 P.M.): *"The dilemma of Lake Baikal: Geological treasures for extractive use in a time of political chaos. What role should the geologist play?"* Dr. Jean Richardson, University of Vermont.

arch 21–24: Geological Society of America Northeastern Section Meeting, Burlington, Vermont.

Contact Rolfe Stanley or Barry Doolan at the Geology Department at UVM for stract forms. Deadline for abstracts is November 24, 1992.

THE GR[illegible]N MOUNTAIN GEOLOGIST
VE[illegible]NT GEOLOGICAL SOCIETY
P.O. BOX 304
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The *GREEN M[illegible]AIN GEOLOGIST* is published quarterly by the [illegible] Geological Society, a non-profit educational cor[illegible]

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QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

WINTER 1992 VOLUME 18 NUMBER 4

Vermont Geological Society's 15th Annual Winter Meeting

Bedrock Geology of Vermont

A Symposium in Honor of Wallace M. Cady

Saturday February 29, 1992, 9:30 AM
Norwich University, Northfield, Vermont

Directions: The Winter meeting will take place in the Cabot Science Annex, which is the southernmost brick building at Norwich University. The building is on the west side of Rt. 12, 0.7 miles south of the Northfield post office. Park adjacent to the building or in the student parking lot to the south. Look for VGS signs at the south entrance.

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PRESIDENT'S LETTER

Dear Members,

This last year the geologic community lost two colleagues who made important contributions to our understanding of Vermont geology. In April we lost Wallace Cady of the U.S.G.S., a long-time member of this society and major contributor to the Centennial Geologic Map of Vermont (a brief biography and testimonials from Robert Cushman and James Thompson can be found in this issue). And just this last November another U.S.G.S. member, Norm Hatch, passed away. Norm worked for over a decade mapping the bedrock of New England and most recently was working at unraveling the Connecticut Valley Synclinorium in central Vermont. We are grateful for having known both these men and will miss them.

Wallace Cady was partial inspiration for our Winter Symposium, a symposium dedicated to synthesizing our knowledge of the bedrock geology of Vermont. It's been 30 years since Doll, Cady, Thompson, and Billings published that Centennial Geologic Map—named so because it was published 100 years after Hitchcock and Hager published the first state-wide report on the Geology of Vermont. There have been many changes in geologic interpretation and much new work since then. This symposium will summarize for much of Vermont the current thinking on rock units, their origin, and their subsequent history. We will also find out more about the joint U.S.G.S./Vermont Geological Survey CoGeoMap project designed to publish a new bedrock map in the near future. The Norwich University Geology Department will host the meeting at their Northfield campus. This promises to be an entertaining and edifying "tour" with knowledgeable tour guides. I urge you to mark your calendar and plan to attend.

Those of you fortunate enough to attend our Fall field trip and banquet were treated not only to some breezy yet balmy Lake Champlain weather, but some fascinating geology led by Char Mehrtens and Rolfe Stanley, with a guest appearance by Barry Doolan, freshly returned from the Soviet Union. After a fine meal at the Deja Vu Cafe, George Davis did a wonderful job transporting us to Bryce Canyon for some surprising evidence of compressional faulting on the Colorado Plateau. And Stephen Wright organized the afternoon and evening for us. On behalf of the Society I would like to thank these five people for an excellent Fall meeting.

I would also like to extend the Society's thanks to two people who are leaving us, in one way or another. Brad Jordan, our erstwhile treasurer, has accepted a position as Director of Laboratories at Bucknell University. As most of you know, Brad's job entailed far more than keeping track of our bank account. He was the contact person for anyone requesting information or publications from the Society, he maintained and printed the membership mailing lists, and he personally hosted (with high-test coffee!) many of the executive committee meetings in Northfield. We thank him for a job well done, wish him the best in his new position, and hope he can drop back in on us from time to time. Dave Westerman has agreed to reoccupy the office of Treasurer and the Society's records and publications will remain in Northfield. And Eric Lapp, long our Chairman of the Public Issues Committee, has resigned that post because of other commitments connected with being gainfully employed. He has kept us abreast of what has been going on about the State Capitol, and we thank him for it. Anyone who might be interested in taking over Eric's position should drop me a note or give me a call.

Lastly, I would like to call your attention to the membership information form attached to your dues announcement. Please fill it out and return it. And if you'd like to help out the Society by working on a committee or serving as an officer or committee head, or would like to help out the various people putting together the March 1993 regional GSA meeting, let us know.

This looks like a promising year for the Society, with our student grant-in-aid program beginning this spring and the regional GSA meeting coming up. I look forward to serving you.

Sincerely,

Bruce Wilson
West Brattleboro, VT

WINTER MEETING PROGRAM

February 29, 1992, Norwich University

9:00 **Coffee**

9:30 **Bruce Wilson:** *Introductory Remarks*

9:40 **Diane Conrad and Nicholas Ratcliffe:** *COGEOMAP—Where are we and where are we going*

10:10 **Charlotte Mehrtens:** *Evolution of the foreland basin in western Vermont*

10:40 **Barry Doolan:** *Evolution of the Vermont Appalachians: Evidence from the northern transect*

11:10 **Coffee**

11:30 **David S. Westerman and Wallace Bothner:** *The Connecticut Valley Trough in eastern Vermont: A review*

12:00 **Rolfe Stanley:** *Arc-continental collisions in Taiwan—A modern analogue to western New England*

12:30 **Barney Hodges:** *Fluid inclusion constraints on mylonitization in the Cobb Hill Thrust Zone, central Vermont*

12:45 **Lunch:**

VGS Executive Committee Meeting: *All members are invited to attend!*

WINTER MEETING ABSTRACTS

COGEOMAP—WHERE ARE WE AND WHERE ARE WE GOING

Conrad, Diane* and Ratcliffe, Nicholas M.**, Vermont Geological Survey, 103 South Main St.—Center Building, Waterbury, VT 05676, **U.S. Geological Survey, Reston, VA 22092

EVOLUTION OF THE VERMONT APPALACHIANS: EVIDENCE FROM THE NORTHERN TRANSECT

Doolan, Barry L., Department of Geology, University of Vermont, Burlington, VT 05405

The northern Vermont transect contains all the major stratigraphic and litho-tectonic units which characterize the Ordovician Taconian Orogeny of the Appalachian Orogen. These units include allochthonous and parallochthonous shelf-slope platform sediments and cover; a relatively complete clastic/volcanic section—a rift facies; a metamorphic complex with a discernable record of Taconian thermal and baric conditions; ophiolitic rocks with a record of Taconian emplacement structures; arc related igneous and sedimentary rocks which postdate emplacement of the ophiolites; and Siluro-Devonian metasediments which onlap deformed Taconian structures and record the metamorphic and igneous events associated with the Acadian orogeny of Devonian age.

Understanding the geologic history of mountain building in Vermont requires knowledge of (1) the processes involved in the opening of the ancient ocean as well as (2) the configuration of first-order tectonic elements (e.g. ancient margin shape, arcs, trench systems) and (3) relative plate rates and motions during the closing stages of that ocean. Although this information will never be fully known from the available data base, the following represents plausible conclusions which can be derived from the rock record:

1. Rifting of ancient North American basement and its associated volcanism occurred over a relatively short period of time in the early Cambrian.
2. A well developed triad of shelf–slope–rise facies sediments were deposited upon and over an architecture of variably thinned continental crust and rift related cover rocks from the lower Cambrian through the lower Ordovician.
3. Subduction of the eastern margin of the ancient North American plate began during the time of slow shelf subsidence on the platform (i.e., prior to any sedimentary record of subduction as recorded in either autochthonous or allochthonous rocks).
4. The period between ophiolite obduction (500 Ma) and platform response to subduction (ca. 450 Ma) was a period of deformation, metamorphism, and profound shortening which allowed the accretionary prism to diachronously build above wave base. Shortening involved at least two

distinct diachronous phases which progressed generally from deep eastern regions to more shallow western parts of the orogen (present coordinates).

5. Shortening culminated with the transport of a wide variety of allochthonous rocks which root back to significantly different root zones within the orogen. In Quebec, allocthonous rocks entirely root from locations either east of or stratigraphically above the presently exposed rocks of the hinterland In the Taconic rocks of Vermont, allochthons rooted primarily from rocks within the deformed hinterland.
6. Island arc development postdates, and therefore is not the cause of, most of the deformation, metamorphism, and shortening associated with the Taconic orogeny.
7. Oceanic lithosphere outboard of the deformed Taconic Orogen developed as the result of back arc spreading and/or are remnants of ancient Iapetus lithosphere. These intracratonic and/or intra-arc oceanic basins were sites of rapid sedimentary infill from middle Ordovician to Devonian times. Closure of these basins against the Taconian orogen culminated in the mid-Devonian with intense metamorphic and intrusive (granitic rock) phases associated with the Acadian orogeny.

FLUID INCLUSION CONSTRAINTS ON MYLONITIZATION IN THE COBB HILL THRUST ZONE, CENTRAL VERMONT

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Fluid inclusions were studied from a mylonitic gneiss in the Mount Holly Complex near Lincoln, Vermont to estimate the temperature(s) at the time of mylonitization. The studied samples are medium-grained, muscovite-perthite-microcline-quartz-plagioclase gneiss containing some garnet, biotite, chlorite, carbonate, zircon and magnetite. Shearing took place in the greenschist facies during the Taconian orogeny (DelloRusso and Stanley, 1986).

Samples were collected from four different areas, each displaying a distinct phase of shearing previously identified by DelloRusso and Stanley (1986). Sequentially these phases are: (1) gneiss fragmentation and development of mylonitic foliation; (2) development of a pervasive mylonitic foliation; (3) folding of mylonitic foliation; (4) fragmentation of the folded mylonitic foliation as a result of shear-band development. Fluid inclusions were found in porphyroclast grains and healed microfaults in quartz veins from each of these four phases.

Five inclusion types were identified, all of which are secondary inclusions. **Type-1:** Three-phase inclusions containing H_2O-rich liquid with a CO_2-liquid plus vapor (L+V) inner phase. **Type-2:** Two-phase, H_2O-rich inclusions with a low density, CO_2 inner phase. These inclusions are only found in unfractured quartz porphyroclasts. **Type-3:** Two-phase, H_2O-rich inclusions in quartz. **Type-4:** Three-phase, H_2O-rich inclusions with high density CO_2-L+V inner phases. **Type-5:** A four phase, H_2O-rich inclusion displaying CO_2-L+V inner phases and a CH_4 liquid that nucleates between -57° to -25°C when the samples are cooled.

Type-1 inclusions from DelloRusso and Stanley's third phase display the highest homogenization temperatures (400°–450°C). This indicates that at least part of mylonitization occurred above 450°C. Type-3 inclusions are present in all samples except those from phase one. Type-3 inclusions from phase two samples indicate shearing above 312°C. Homogenization temperatures found in Type-2 inclusions identify recrystallization conditions in the porphyroclast grains. Only one homogenization temperature was found for Type-4 and Type-5 inclusions; therefore, no interpretation relative to mylonitization can be made.

Decrepitation of most inclusions other than Type-3 presently precludes the possibility of extensive isochore analysis and P–T path determination. Rare homogenization temperature determinations in other inclusions are compromised by leakage. However, since decrepitation preceded homogenization, it is clear that $T_{homogenization}$ must exceed $T_{decrepitation}$ and, therefore, deformation occurred at temperatures above $T_{decrepitation}$.

EVOLUTION OF THE FORELAND BASIN IN WESTERN VERMONT

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This abstract summarizes our understanding of the sedimentologic and stratigraphic relationships of selected units in the Cambro-Ordovician sequence of western Vermont.

Cambrian through Lower Ordovician clastic and carbonate rocks in western Vermont were deposited as sediments of shallow water affinity on a passive, thermally-subsiding continental margin following late Precambrian rifting of the North American continent. The rock units comprising the Cambrian to Lower Ordovician sequence can be divided into two groups, termed the Western Shelf and Eastern Basinal Sequences (Dorsey, et al., 1983). The Western Shelf Sequence is comprised of alternating siliciclastic (Cheshire, Monkton, Danby) and carbonate (Dunham, Winooski, Clarendon Springs) rock units recording deposition in tidally-influenced, shallow-water environments characterized by cyclic deposition. The Lower Cambrian Cheshire Quartzite records tidally-influenced coarsening-upward shoreline sedimentation. The Lower Cambrian Dunham Dolomite and Upper Cambrian Danby Quartzite are generally transgressive in nature, recording an overall intertidal to subtidal trend up section, however the bulk of both units is characterized by multiple shallowing-up sequences. Work is currently in progress on the lower Middle Cambrian Monkton Quartzite, which appears to record cyclic inter- to shallow subtidal shoreline sedimentation. The Middle Cambrian Winooski Dolomite has not been studied in detail, however, all observations suggest that the unit contains features of a shallow water origin. Regardless of siliciclastic or carbonate composition, the depositional environments of the Cambrian units are remarkably similar. Comparing the Cambrian sequence in western Vermont to those of Newfoundland and northwestern Scotland shows that the alternating siliciclastic and carbonate pattern seen in Vermont is not present elsewhere around the western margin of the Iapetus Ocean. For example, the Middle Cambrian Monkton Quartzite, a regressive sandstone unit in Vermont, is absent in Scotland where it is represented by a karstified unconformity within a coeval carbonate unit (Palmer, et al., 1980). This suggests that the siliciclastic sediment comprising the Monkton Quartzite represents localized sediment production and distribution coincident with eustatic sea level fall. Studies of the timing of emplacement of the units which comprise the Eastern Basinal Sequence have also shed light on the sea level history of the Cambrian platform.

The Eastern Basinal Sequence consists of Cambrian through Lower Ordovician slate units which accumulated in deeper water adjacent to the carbonate platform. Occurring throughout this shallow basin are horizons of limestone, dolomite, and sandstone breccias. Earlier stratigraphic studies of the basinal sequence described each breccia horizon and intervening shale unit as formations (Rugg Brook Conglomerate, St. Albans Slate, Mill River Conglomerate, Skeels Corners Slate, Rockledge Breccia, Saxe Brook Dolomite, Hungerford Slate) comprising the Woods Corners Group (Shaw, 1951). Detailed mapping and sedimentology studies have redefined the stratigraphy of these rocks and have shown that the different breccia units are sediment gravity flow deposits shed off the adjacent platform in two major periods of off-bank sedimentation. The first of these coincides with syn-to late Monkton deposition on the shelf (Rugg Brook and Rockledge Formations) and the second with Danby and Clarendon Springs deposition (Gorge and Highgate Formations). These two periods of sediment gravity flow emplacement are thought to be triggered by the initial stages of sea level change on the adjacent platform.

Detailed sedimentologic studies have also been completed on Middle Ordovician foreland basin limestones and shales. Studies have focused on documenting the extent and timing of bathymetric changes within the foreland basin. Syn-depositional block faults have been recognized in the Champlain Islands and adjacent southern Quebec and petrographic analysis of clasts within fault-scarp breccias (Lacolle Formation) constrained the times of movement to syn-Chazy and Black River times. Both the Black River and Trenton Groups are characterized by north-south facies and thickness changes within the Champlain Valley, possible influenced by fault-controlled bathymetry within the foreland basin. For example, current work on the Black River Group has documented the existence of multiple karst horizons, as well as rapid, non-gradational deepening sequences. Study of the sedimentology of the Trenton Group has documented the transition from wave-reworked to low density bioclastic turbidite deposition within the Champlain Valley, with deeper water facies restricted to the northern part of the basin. Work is just beginning on a project to document the degree to which syn-depositional block faults may have influenced Chazy deposition, specifically the location of reef facies.

The ultimate drowning of the fragmented foreland shelf is recognized by the mantling of transgressive Middle Ordovician limestones with Middle and Upper Ordovician shales (Cumberland Head Formation, Stony Point Shale) which are interpreted as low density turbidity current deposits derived from the foundered shelf to the west. These shales are succeeded by Upper Ordovician shales (Iberville Shale) whose source lay to the east.

An obvious gap in our studies is description of the Lower Ordovician stratigraphic sequence in the Champlain Valley, however earlier workers in southern Vermont have described the lithofacies of the Beekmantown Group (Mazzullo and Friedman, 1975). Also, conodont biostratigraphy currently in progress at the U.S. Geological Survey is attempting to document the frequency and extent of unconformities within the Lower Ordovician sequence and between the Lower and Middle Ordovician. These studies will help us to complete a more refined picture of the evolution of the foreland basin in western Vermont.

ARC-CONTINENTAL COLLISIONS IN TAIWAN—A MODERN ANALOGUE TO WESTERN NEW ENGLAND

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THE CONNECTICUT VALLEY TROUGH IN EASTERN VERMONT: A REVIEW

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Reconstructions of the geologic conditions of eastern Vermont from the late Ordovician to middle Devonian are chiefly constrained by the character of the rocks in the Connecticut Valley trough (CVT). Following the emplacement of Ordovician ophiolites along the central axis of Vermont and formation of the Bronson Hill–Boundary Mountains Volcanic Arc of adjacent New Hampshire and nearby Maine during the Taconic Orogeny, successor basins opened to accept sediments that later formed the rocks of the CVT and the Central Maine trough (CMT). In Vermont these are dominated by a turbiditic flysch sequence—an early calcareous facies (Waits River Formation) grading upward to a finer, "wackier" and muddier facies (Gile Mountain Formation and its pelitic members). An episode of mafic volcanism (Standing Pond Volcanics) flooded the basin at about the time the character of the sediments was changing.

The extension responsible for basin development gave way to compressional tectonics during the Devonian. The spatial correlation of low-pressure facies metamorphic isograds and centers of intrusion in northeastern Vermont suggests that the sedimentary sequence underwent regional metamorphism concurrently with partial melting. Contact aureoles as well as domal structures are a result of the emplacement of these S-type granites. Acadian magmatism is less pronounced in southern Vermont, although the temporal and spatial relations of magmatism, deformation, and metamorphism are consistent throughout the State. Large nappes are interpreted to have formed early in the Acadian, and, with continuing viscous deformation during that event, produced the structures now exhibiting exquisite map patterns so prevalent near the Massachusetts border.

Steeply dipping fault zones (Monroe and Dog River, respectively) mark the eastern and western margins of the CVT in Vermont and isolate the rocks between them. No confident correlations of pre-Silurian rock have been made across the CVT; the only rocks common to both the CVT and its neighboring terranes are of Mesozoic age. To the north the bounding fault zones appear to lose significance as the youngest units of the CVT have been tentatively traced into those in the adjacent CMT. Crustal stability, probably much like we now experience, was the rule from the close of the Acadian Orogeny to the initiation of rifting in the Mesozoic. Reactivation of north-south trending fractures systems may have occurred at that time accompanied by the intrusion of basaltic and lamprophyric dikes as well as scattered stock-like plutons with alkalic compositions characteristic of a failed rift.

Thoughts on the Underhill Formation in Central Vermont

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(Author's note: I am unable to attend the 1992 winter meeting honoring Wallace Cady, but wanted to share a few thoughts on the Underhill. This letter will be more meaningful with the Centennial Geologic Map of Vermont in hand.)

One of the frustrations of mapping within the Camels Hump Group in central Vermont is the uncertainty of age relations among units within the group. One solution may be to start with a thorough understanding of Tauver's (1982) section, which is constrained between basement and the Cheshire Quartzite, and then seek correlations in rocks to the east and north. I have long been puzzled by the fact that the east-west extent of the Camels Hump Group widens northward from about 44°10' N (Doll *et al.*, 1961). Field work in 1991 towards reconciliation of mapping by Tauvers (1982), DiPietro (1983), Walsh (in press) and Thompson and Thompson (in press), is leading to the conclusion that at least three faults, all within the Camels Hump Group, converge near Buels Gore, the southern-most tip of Chittenden County.

The Underhill fault, originally defined by Tauvers (1982) near Jerusalem and traced NNW by DiPietro (1983), probably continues north along the Pinnacle/Underhill contact through Richmond village and eventually toward the West Fletcher fault mapped by Doolan *et al.*, (1987). Walsh (in press) has found that quartz-laminated schist typical of the Underhill fault extends not only NNW from Jerusalem, but also NNE toward Hanksville. I hypothesize that this second fault continues north along the valley of the Huntington River, along the east contact of a quartz-muscovite-chlorite schist with distinctive brown carbonate mottling. The fault's position relative to the mass of Pinnacle north of Jonesville, and to the Cambridge-Richford syncline, remains unknown. A third fault, the Honey Hollow fault (Thompson and Thompson, in press), trends SSW from the Winooski Valley east of Jonesville toward Buels Gore. East of this fault the Underhill (roughly equivalent to Walsh's Fayston Formation) is associated with the Hazens Notch and Mt. Abraham Formations. The belt of rocks immediately west of the Honey Hollow fault in Buels Gore may correlate with rocks mapped as Monastery Formation by Osberg (1952) and shown as Underhill by Doll *et al.*, (1961). The Honey Hollow fault's continuation to the south may line up with faults along the Prospect Rock belt west of Mt.Abraham (O'Laughlin and Stanley, 1986).

Thus the Underhill Formation along the Winooski River between Richmond and North Duxbury does not all belong to one tectonic level, but represents the juxtaposition by faults of similar, probably once contiguous, depositional facies. Within the region cut by these faults, the Underhill Formation ranges from phyllite to schist to albitic gneiss, and locally it contains layers of greenstone, metagraywacke, and quartzite. Greenstones are more abundant west of the Honey Hollow fault. However, everywhere the unit is characterized by a silver-green color, dominated by quartz, muscovite, and chlorite. It commonly contains magnetite, and very little graphite.

In closing, I would like to argue in favor of keeping the Underhill's formational status, and retaining its usage across all the tectonic levels outlined above, despite the variation in depositional facies and metamorphic grade within the area shown as Underhill by Doll, *et al.* (1961). However, slices or infolds of other units, such as graphitic rocks of the Hazens Notch, should be mapped separately. This approach proved very workable in the Camels Hump quadrangle (Thompson and Thompson, in press).

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Stratigraphy of the Cambro-Ordovician Shelf in Western Vermont: the legacy of Keith, Bain, and Cady

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Up to about 1910, the stratigraphy of the Cambro-Ordovician shelf strata in western Vermont was known locally, but little had been done to enlarge this localized knowledge to a regional view. Over the following 35 years, Arthur Keith, George Bain, and Wallace Cady developed the regional picture from which most modern geologic work begins.

The regional view of Cambro-Ordovician stratigraphy prior to the work of Keith, Bain, and Cady was best expressed in maps by Perkins (1910), Seely (1910), and Dale (1913). Each of these early workers distinguished some stratigraphic units based on age, but lumped most of the eastern strata together based on very basic lithologic similarity. There was virtually no attempt to take structure into account except on the very largest scale. The basic limitation to their work was that they made no attempt to identify stratigraphic subunits of regional extent (our modern formations).

It was at this point that Keith arrived on the scene. With his appointment as chief of the Areal and Structural Geology Section of the U.S.G.S. in 1907, he inherited the job of reviewing and approving geologic folios prior to publication. One of the first he saw was T. N. Dale's Fort Ticonderoga Folio; he was bothered by several aspects of this work so he began his own mapping program focusing on the north end of the Taconics. Using the approach he had applied so successfully in the Southern Appalachians, he proceeded to map much of the Champlain Valley over the next 30 years. Unfortunately, he never published his maps (see Washington, 1988), but he did lay out the stratigraphy, as he saw it, in three separate publications (Keith 1923, 1932, 1933). In these publications, he tied together the Cambro–Ordovician shelf stratigraphy for the entire Champlain Valley. Many of our modern stratigraphic names come from his work.

Bain began his work in Vermont in the mid-1920's, first working with the Vermont Geological Survey and later with the marble companies. He concentrated on the Vermont Valley, especially the marbles. Although he did not publish heavily, his presence kept the other workers who entered that area "honest" and shaped their thinking. He did not generate much new nomenclature, preferring to use established nomenclature from nearby areas (especially the Champlain Valley) or local quarrymen's terms. His insistence on the continuity of the stratigraphy between the Champlain Valley and the Vermont Valley encouraged future workers to integrate the structural and stratigraphic history of the former with the later. In addition to his other achievements, it should be noted that his bound 1938 NEIGC guidebook for the marble belt of the Vermont Valley served as the model for the modern published NEIGC field guides (beginning with the 1959 guidebook edited by Zen).

Most modern geologists in the Champlain Valley begin their work using Cady's dissertation work as a starting point. Cady actually began this work in the 1930's, first as a Middlebury College student, then with his M.S. thesis at Northwestern University (Cady, 1936), culminating in his dissertation work which appeared as an article in the Bulletin of the Geological Society of America (Cady, 1945). By the time he finished his dissertation, Cady was working for the U.S.G.S. and had seen Keith's maps and field notes before Keith's death in 1944. He relied, however, much more heavily on Augustus Wing's work, having rediscovered Wing's notebooks in Middlebury College's collections (the originals of these notebooks disappeared in the early 1940's, about the time that Brainerd and Seely's fossil collection disappeared; the only records of what was in these notebooks are a typescript made by Cady's father [Dr. Frank Cady, an English Professor at Middlebury] and the sketch map included in Cady's 1945 article [p. 520]). He did incorporate much of Keith's stratigraphic nomenclature into his work, though he used many of the terms slightly differently than Keith.

Cady's main contribution was the publication of a detailed map that both synthesized all of the earlier stratigraphic work into a unified regional scheme and filled in most of the gaps left by earlier workers. From a modern perspective, we may complain that he ignored certain structures, but he was a product of a line of thought which preferred folds to faults unless the evidence was irrefutable. As a result, he did not accept many of the thrust faults mapped by Keith. His work in western Vermont continued into the 1960's, including helping compile the Centennial Geologic Map of the state (Doll et al., 1961).

Although time, new ideas, and more detailed mapping have made much of Keith's, Bain's, and Cady's work obsolete, we should remember their contributions. Their work was at the cutting edge of the science for its day, and it provided the regional perspectives on the geology of the Cambro-Ordovician shelf that make our present work possible. Despite the deaths of George W. Bain and Wallace M. Cady last spring, their legacy will endure for future generations of Vermont geologists.

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Wallace Martin Cady, Vermont Geologist

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Wally Cady's Vermont roots ran deep. He was born January 29, 1912 in Middlebury, where his father was a professor of English at Middlebury College. Both parents were descended from early settlers of the area, and Wally was familiar from childhood with the ways of Vermonters—ways that Wally later carried with him when living in "exile" in other states.

As an undergraduate at Middlebury College Wally was an active hiker and outdoorsman and developed a deep appreciation of Vermont's natural beauties. He was introduced to geology at Middlebury by Professor Bruno Schmidt, and through Schmidt became familiar with many aspects of Vermont Geology. Although Wally went afield for his graduate study (Northwestern and then Columbia) his love of Vermont came to the fore in his selection of the subject of his doctoral thesis, a study of the rocks (mainly carbonates) of the Champlain Valley, under the direction of Marshall Kay. This was later published in the G.S.A. Bulletin as "Stratigraphy and structure of west-central Vermont" (1945). Few doctoral theses have involved as much work. The detailed mapping extended from the latitude of Orwell and Brandon north to Georgia, and from the Green Mountain front west to the shore of Lake Champlain. This covered, at 1:62,500, an area equivalent to about four and one half fifteen minute quadrangles. Not shown was a considerable amount of detailed reconnaissance in surrounding areas! Wally's map and his interpretation of it marked a major advance in our understanding of the geology of western Vermont, and still stands, in its essentials, as the basis for most of the more recent reconstructions.

After his graduate study Wally taught briefly at Brooklyn College, working summers for the U.S.G.S. on the Olympic Peninsula in Washington. During the early forties Wally worked full time with the U.S.G.S. in Alaska. The opportunity to return to Vermont came at the end of World War II when Wally was assigned (or managed to become assigned!) to the U.S.G.S. project to study the talc and asbestos deposits of the eastern Green Mountain region, and their geologic setting.

By the summer of 1946 Wally was mapping in the Montpelier Quadrangle. A small branch office of the U.S.G.S. was soon set up in Montpelier, with Wally and Helen, and their son John, in residence nearby. Other geologists soon joined the project, John Murphy during the early years of the study, Al Chidester and Arden Albee for much of its duration. The Montpelier office lasted for nearly a decade and a half, the scene of both serious geology and good-natured fellowship, a scene punctuated by Wally's ready laugh and dry, earthy humor. The Montpelier Office, however, was not looked upon with great approval by the higher-ups at the U.S.G.S. in Washington. Bureaucrats like to have everything in sight and clearly under proper control. There were therefore several attempts to discontinue the office and have the members of the project winter in Washington under the watchful eyes of their bosses. Wally would have none of it. He regarded Montpelier as a vastly better place to live and raise children. Worse yet if he were in Washington he would have to attend "stand-up cocktail parties," a fate he dreaded. Wally managed, somehow, to resist the tide. Other small Survey offices fell like dominoes in the fifties, until the Montpelier Office stood alone as the last of its kind.

During its heyday the Montpelier Office served informally as the focal point for all of the geologists then working in Vermont, whatever their formal affiliations. It was a period of free and uninhibited exchange of ideas, and of frequent field trips to see each others latest results. Wally was acknowledged as the dean of the group, and his thoughts about new discoveries and new ideas were valued by us all. His standard response when deeply impressed by an especially revealing outcrop, or by someone's brainchild, was to announce: "I'll be a stud buzzard!" Wally's "stud buzzard" awards, however, were not given lightly. When one was extracted it was an encouraging sign that we were onto something really good. They therefore became cherished accolades.

Although Wally compiled a lion's share of the 1961 Vermont map it was, for a while, nip and tuck whether his name would appear as one of the authors. The reasons are complex. Charlie Doll, then Vermont State Geologist, had managed to accumulate an ample sum to finance the geologic map of the state. This was thanks to an interested governor (Johnson) and an unusually cooperative state legislature! The new map was therefore to be a publication solely of the Vermont Geological Survey, with no federal strings attached. Vermont, after all, had once, briefly, been an independent republic, beholden to no other temporal authority. Charlie felt strongly that Vermont, in this spirit, should be able to produce and publish its own geologic map without outside interference. The United States Geological Survey, on the other hand, had (and has) a firm policy that all publications having a Survey author or co-author would have to go through the full U.S.G.S. editorial and review process. Charlie would have none of *that!* After a rather stiff exchange of Survey-to-Survey correspondence it became apparent that negotiations had reached a deadlock. Wally, generously, had even volunteered to be a silent contributor with his name deleted from the masthead, but this was clearly an injustice. It was therefore agreed that I, as a more nearly neutral party, would go to Washington to see what could be done, one-on-one. Luckily I was soon ushered into the office of Charlie Anderson, then Chief Geologist. Anderson, fortunately, knew Wally well and Charlie Doll well enough. When filled in on the details he was more amused than dismayed, and granted the sought-after dispensation. So far as I know the Centennial Geologic Map of Vermont is the *only* publication, having a U.S.G.S. author, that never went through the U.S.G.S. "mill." As a result, and to Wally's delight, we were able to try out some cartographic innovations that were *not* in accord with the U.S.G.S. policies of that time.

Wally was dedicated to field geology and approached it in the manner of a Yankee craftsman. What he saw is faithfully recorded and he saw much of what was there to be seen. One can quibble about interpretation but Wally's maps can often be used to support *both* sides of an argument. He also knew that what one sees is often conditioned by ones state of mind, and he at times fell victim to it. He was conditioned by his graduate training to think in stratigraphic and sedimentological terms, and therefore tended to seek his explanations there rather than in later tectonic or metamorphic processes. This was probably a good influence on the rest of us even though we might not always agree with him. Trained as "hard-rock" geologists we were often too likely to overlook a primary explanation in favor of a secondary one.

Wally left Vermont in 1960 to continue his earlier work in the Pacific Northwest, but he never lost his interest in Vermont geology and continued to make contributions to it until illness intervened. Plate tectonics came in just as his Vermont work was coming to a close and did not seriously influence his large-scale thinking about it. His later work on the Olympic Peninsula, however, is strongly influenced by plate tectonic thinking. One wonders how he might have responded had the timing been different. Wally died in Denver on April 4, 1991. Helen (Raitanen) Cady had died there in 1986. They are survived by two daughters, Nancy and Norma, and by a son, John, a geophysicist with strong tectonic interests.

Works by W.M. Cady dealing wholly or in part with Vermont Geology

Compiled by J.B. Thompson, Jr.

1936 Areal and structural geology of the north end of the Taconic Syncline: Masters Thesis, Northwestern University.

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1950 Fossil cup corals from the metamorphic rocks of central Vermont: *American Journal of Science,* v. 248, p. 488–497.

____ Classification of geotectonic elements: *American Geophysical Union Transactions,* v. 31, p. 780–785.

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1957 (with Chidester, A.H.) Magmatic relationships in northern Vermont and southern Quebec (abst.): *Geological Society of America Bulletin,* v. 68, p. 1705.

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____ Excursion across the Green Mountains—Hinesburg to Montpelier, Trip A-1: in Vermont Geologic Map Centennial, *New England Intercollegiate Geological Conference, 53rd Annual Meeting Guidebook,* New Haven, Connecticut, Yale University, Department of Geology.

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A Tribute to Wally Cady

Robert V. Cushman
Middlebury, Vermont
Retired District Chief
U. S. Geological Survey, Water Resources Division

Most of us can name one or more persons who have had a profound influence on the selection and/or enhancement of our careers in Geology. For me, the name of Wallace M. Cady heads the list. The following words focus on the impact that Wally had on me personally. They are apart from the innumerable ways he guided so many others into the profession and made his presence felt in many parts of this and other countries.

Wally, first of all, was a good friend. I had known him and his family all my life, we both having grown up in Middlebury. Although he preceded me in school by 5 years we had many contacts through family and especially through the Boy Scout movement. Our scoutmaster was Bruno Schmidt, Professor of Geology at Middlebury College. I chose to major in Geology at Middlebury partly because of Bruno and Wally, but once that decision was made Wally saw to it, through correspondence and personal contact, that I did not deviate from that choice. By the time I entered Middlebury College he had moved on to graduate work at Northwestern University and then to Columbia for a Doctorate. During part of his summers field work on his Doctoral thesis in west-central Vermont, I accompanied him on numerous occasions, at his request. He loved to talk—about geology—so it wasn't long before this young student was thoroughly familiar with the literature, the problems of mapping in folded areas, and Wally's interpretation of the local stratigraphy and structure.

Midway in my senior year Wally convinced me to apply for a two-year fellowship at the Geology Department at Northwestern University, as he had done, even writing a recommendation for me which I had not bothered him to do. His record at Northwestern, plus the recommendation, was helpful in my receiving the fellowship, I am sure. Wally helped me to select the area for my Masters thesis, part of the Champlain Lowland, accompanying me in the field for several days to visit important outcrops and critical formational contacts. At other times we conferred by letter when I had problems, or thought I did.

Perhaps of most importance, Wally gave me my first job in geology, as his field assistant in the Sleetmute area, Alaska. He had been appointed by the U. S. Geological Survey's Alaskan Branch as Party Chief to begin the investigation of the Alaskan mercury deposits in the summer of 1941. He needed a field assistant which the Survey said he was to hire in Alaska, to save on travel expenses. Wally knew I was about to complete my Masters work at Northwestern and offered me the job—providing I would get myself to Alaska and back. He had it all worked out to hire me as we left the ship at Seward, which is exactly as it happened. At that time the Survey used land and water transportation wherever possible, being less costly than air. This was most fortunate for me as I could travel as a steerage passenger at a minimum cost. It was even more fortunate for Wally because he met his wife-to-be on the voyage north to Alaska and neither of them ever looked back!

That summer was an instructional, rewarding, and an idyllic experience for me. The Sleetmute area was about as primitive as you would find, complete with a horde of mosquitoes. But Wally was an enjoyable field companion, a great teacher, and a most resourceful boss. I recall especially his invention of a plane table, that he had been advised he would have no need for that first summer. Only a Brunton would be needed, Washington said! When we found there were several mine adits that should be surveyed in detail he made his own plane table by nailing three short legs to a Dupont powder box (an empty one), inverting a second box over it so that it could be adjusted horizontally, and then used the Brunton as an alidade. It worked quite well and the field season was a productive one. Wally returned to Alaska many summers after that but I did not accompany him.

Upon return to the States in the Fall of 1941 Wally, through Washington contacts, lined up a job for me with the Survey's Topographic Branch for the winter. However, I had accepted a job as mining geologist at a gold mine in Colorado so we pursued our separate careers after that. We kept in touch with each other down through the years, here in Vermont and in Colorado. Looking back now at a lifetime—for the interest in me by you, the advice given, and the immeasurable help along the way, I am deeply grateful to you, Wally, wherever you are.

Wallace M. Cady (1912-1991)

by Bruce Wilson

Wallace M. Cady passed away this last April, 1991, at the age of 79, after a period of failing health. With his death we have lost a longstanding member of this Society (joining soon after its inception in 1974). We have also lost a respected regional and field geologist who has contributed much to our understanding of the geology of Vermont, as well as to the geology of the Olympic Peninsula of Washington and of parts of Alaska and the Montana-Idaho border region. And we have lost a friend and colleague who has touched the lives of many.

Born into one of the original families that settled Middlebury, Vermont, Wallace was the oldest of three children of Frank and Marian Cady. His interest in geology, especially field geology, may well have started in his youth. He liked the outdoors and was an active Boy Scout. His scoutmaster was a geologist, as was his uncle, the eminent geologist Gilbert Cady. After growing up in Middlebury, he attended Middlebury College where his father was an English professor. He graduated with a B.S. in 1930, strangely enough majoring in biology with geology as a minor (according to his U.S.G.S. Personnel Record). By then his interest was obviously geology; he obtained a master's degree in geology from Northwestern University in 1936 and a doctorate in geology from Columbia University in 1944.

In 1939 and 1940, while still pursuing his doctorate, he worked for two summers for the U.S.G.S. on the Olympic Peninsula of Washington. After a year teaching at Brooklyn College, in 1941 Wallace went to work full time for the U.S.G.S. and remained with that organization until his retirement. His first five years with them was spent mapping and studying quicksilver deposits in southwestern Alaska. In 1946 he returned to Vermont, this time stationed in the U.S.G.S. branch office in Montpelier. There he began studying the asbestos deposits of northern Vermont. With his interest in and knowledge of regional geology in Vermont, he expanded his activities and was soon working on quadrangle bedrock mapping and stratigraphic, magmatic, and geotectonic relationships from the Taconics north to Quebec. Numerous publications culminated in his G.S.A. Memoir 120, "*Regional Tectonic Synthesis of Northwestern New England and Adjacent Quebec*". He compiled the northwestern portion of the Centennial Geologic Map of Vermont, turning the work of many geologists into a seamless map.

In 1961, as the Centennial Geologic Map was being published, he was transferred to the Pacific Coast Branch of the U.S.G.S., returning to the Cenozoic rocks of the Olympic Peninsula. Mapping this area involved much of the rest of his career; he continued to do field work in this rugged terrain into his 60's. From 1977 on he was also involved in mapping Archean rocks of the Montana-Idaho border. He continued to publish, many of the articles addressing geotectonic mechanisms based on his field experiences, until shortly before his retirement in 1985.

Wallace Cady was a member of several scientific and professional societies, including serving as associate editor for eight years with the Geological Society of America, as a councilor of the Geological Society of Washington, and as president of the Colorado Scientific Society. In 1975 he was a Fulbright-Hays Visiting Lecturer on 'Problems of Modern Tectonics' at Voronezh State University, USSR, and received the Meritorious Service Award from the U.S. Department of Interior in 1983.

Early in his geologic career Wallace met and married Helen Raitanen, a teacher from Astoria, Oregon. They had two daughters, Nancy and Norma, and a son John. Helen died in 1986. They are survived by their children, six grandchildren and Wallace's sister Frances Grauman.

(Author's note: in compiling this biographical sketch I am indebted to information provided by Robert Cushman, John Cady, and Brewster Baldwin, a biography by Bruce Bryant of the U.S.G.S., an obituary by Frances Grauman in the Middlebury Magazine of Autumn, 1991, and Wallace Cady's Professional Personnel Record from the U.S.G.S. I apologize for any errors or inaccuracies, which are my own.)

Norman L. Hatch, Jr. (1932- 1991)

Norman L. Hatch, Jr., 59, a geologist with the U. S. Geological Survey in Reston, Va., and a member of the Vermont Geological Society, died Saturday, November 30, 1991 from complications of primary lymphoma.

He was stationed in the Washington, D. C. area for most of his 30-year career with the U.S.G.S., but worked extensively in central New England. Since 1975 Norm has been an Adjunct Professor of Geology at the University of Vermont and has had a long association with members of geology department there. Norm was very active in his studies of the Silurian-Devonian rocks of eastern Vermont and his presence in the professional geologic community in Vermont will be missed.

Norman Hatch, Jr. joined the USGS in June 1961 at Corbin Ky., and spent the next year and a half studying and mapping the geology of southeastern Kentucky. From 1973 to the present he worked on many geoscience projects in central New England, and also held a number of managerial posts, including Chief of the Branch of Eastern Environmental Geology and the Washington Technical Reports Unit.

Some of Norm's most recent scientific work involved major contributions to the bedrock geology map of Massachusetts and its accompanying professional paper, and numerous reports and maps on the geology of the northern Connecticut Valley.

Norman L. Hatch, Jr. was born May 27, 1932, in Boston and attended Exeter Academy from 1945 to 1949. His undergraduate studies, which began in 1949, were interrupted by several years overseas in the U. S. Army. After returning to school, he received a bachelor's degree (1956), master's degree (1958) and Ph. D (1961) in geology from Harvard University. His doctoral dissertation involved studies of intricately folded and metamorphosed stratified rocks intruded by granite in the Dixville area of northern New Hampshire.

Norm was elected a Fellow of the Geological Society of America in 1967, and chaired its northeast section from 1975 to 1976. Along with being a member of the Vermont Geological Society, he was also a member of the Mineralogical Society of America and the Geological Society of Maine. In 1985, he served as president of the Geological Society of Washington.

In 1989, he was awarded the Meritorious Service Award, the second highest honor of the Department of the Interior, in recognition of his outstanding scientific leadership and contributions to the regional geology and tectonics of the northeastern United States.

A memorial service was held Monday, December 16 in Washington D. C.

–compiled using material from the Public Affairs Office, U. S. Department of the Interior.

VERMONT GEOLOGICAL SOCIETY BUSINESS AND NEWS

New Members

We want to welcome the following new members who have joined the Vermont Geological Society since the Fall *GMG* was published:

George H. Davis	Burlington, VT	Structural Geologist
Helen Mango	Castleton, VT	Assistant Professor Castleton State College
Ron Miller	Underhill, VT	Staff Geologist, Griffin International, Inc.
Peter Murray	Burlington, VT	Hydrogeologist, Griffin International, Inc.

Treasurer's Report

As of September 1st, the VGS is 190 members strong. A "breakdown" of the membership reveals: 158 full members, 7 associate members, 10 student members and 15 institutional members (mostly U.S. and foreign libraries). As of this late date, 83% of the membership have paid their dues, contributing to our current holdings of $2,627.63.

Biographical Sketches of New Officers

Lucy Harding (Vice President) grew up in California and received her B.S. in geology from Stanford University in 1975. She then attended the University of Arizona in Tucson and received her M.S. and Ph.D. degrees in Geosciences. Her research centered on the study of the McCoy Mountains Formation in SE California and SW Arizona. Next stop was a two year stint in the oil industry working for Conoco in Houston and New Orleans. In 1984 she moved to Vermont where she is an Assistant Professor of Geology at Middlebury College. Her research involves stratigraphy, sedimentary petrology and structure of the rocks along the Green Mountain Front and she teaches courses on environmental geology, the bedrock geology of Vermont, and sedimentary rocks. She lives in Middlebury with her husband, Peter Schumer, and two young daughters, Laura and Amy.

Leslie Kanat (Board of Directors) received his Ph.D. from the University of Cambridge in England. His research interests involve unravelling the complex geologic history of western Spitsbergen, Svalbard (an archipelago located in the Norwegian Artic). He has spent three summers developing geological maps in Spitsbergen. Leslie has been teaching geology since he was an undergraduate at Wayne State University in Detroit, Michigan. He was a graduate teaching assistant at the University of Cambridge, a lecturer at the University of Texas (San Antonio) and is currently Assistant Professor of Geology at Johnson State College where he has been for the past two years. In addition to his college duties, Leslie has been teaching geology to fourth, fifth, and sixth graders, and their teachers, in northern Vermont. This role is part of a teacher enhancement project funded by the National Science Foundation, entitled Project GEO.

Nominating Committee

The nominating committee nominates members for positions on the executive committee for the year following the annual meeting. The following members have agreed to serve on the nominating committee for the coming year:

Jim Ashley	244-1562
Eric Lapp	459-3311 x219
Dave Westerman	485-2337

Annual Meeting Minutes

October 5, 1991, Deja Vu Cafe, Burlington, Vermont

Present:

General membership meeting

Outgoing president Chris Stone called the meeting to order at approximately 7:45 PM. Stephen Wright agreed to serve as Secretary in Ron's absence.

Meeting Summary:

The meeting opened with Chris thanking the field trip leaders for an excellent trip. The nominees for open positions on the executive committee were introduced. Stephen Wright informed the members that Ron Parker had agreed to accept the nomination for secretary for a second year. There being no other nominees for the Society offices, a motion was put forth by Dave Westerman that the acting secretary cast one vote for the proposed slate of officers. The motion passed unanimously. This year's president is Bruce Wilson, the new vice president is Lucy Harding, the secretary is Ron Parker, the treasurer is Brad Jordan, and the board of directors includes Chris Stone, Larry Gatto, and Leslie Kanat.

The other item on the agenda was a change in the bylaws whereby dues would be increased to fund a new student research grant. The proposed bylaw change was read and passed by unanimous voice vote. Article II, the 'Dues' section of the bylaws, now reads as follows:

A. Dues for members and associate members shall be *$15.00* for each fiscal year *of which $5 shall be devoted to the Vermont Geological Society Student Research Grant.*

B. Dues for student members shall be *$8.00* for each fiscal year *of which $3 shall be devoted to the Vermont Geological Society Student Research Grant.*

The meeting was opened for general comments. Bruce Wilson invited members to bring suggestions concerning the Society and its activities to his attention and asked members to submit black and white photographs for future issues of the *GMG.*

The meeting adjourned at 8:15 PM for George Davis's talk which began after a quick dash back to George's house for an additional slide tray.

Respectfully Submitted
Stephen Wright

Executive Committee Meeting Minutes

Minutes of the November meeting will be published in Spring issue of the *GMG.*

Proposal to the Vermont State Legislature to Name a State Gem, Rock, and Mineral

Sue Hadden
RR 3, Box 303,Grafton, VT 05146
875-3562

A large measure of Vermont's economic growth has been provided by its rocks and minerals. From the famous Bristol iron beds that supplied McDunough's fleet in the War of 1812 to the soapstone from the Vermont hills that warmed the toes in "one horse open sleighs," and the marble that graces some of the world's finest buildings and monuments, rocks and minerals from Vermont have played an important part in our state and national history.

Just as the state has honored the hermit thrush, red clover, and sugar maple, it should honor its unique geologic heritage by naming a state gem, rock, and mineral and join the 95% of the other 50 states to have done so. The consensus of Vermont mineralogical societies, geologists (including recently retired State Geologist Charles Ratté), geology teachers, and industrialists within the mining industry is to choose grossular garnet as the state gem, talc as the state mineral, and marble the state rock.

The three candidates—garnet, talc, and marble—are found throughout our state. The rarity of gems in Vermont coupled with the fact that the finest example of grossular garnet in the world was found at the Belvidere Mine in Eden Mills *(World's Finest Minerals and Crystals,* Bancroft) makes grossular garnet a prime candidate. As for talc, 20% of the combined United States–Canadian output is produced in Vermont, ranking the state second only to Montana. Soapstone, so important historically to Vermont's growth (and comfort!) is composed primarily of talc. The third candidate, marble, brings world-wide attention to our state. The stunning white, crystalline marble of the Imperial vein in Danby graces the Jefferson Memorial and Old Senate Office Building in Washington, New York City's Public Library, and the Chiang Kai-Shek Memorial in Taiwan, to name but a few of the buildings where Vermont marble has been used.

Slate and granite are important to the economy of Vermont, but have drawbacks as candidates. Some of the slate finished by the Vermont Structural Slate Company is imported from other states, thereby diminishing its candidacy, and our neighbor, New Hampshire, is known as the "Granite State," thus diluting the candidacy of granite. Vesuvianite has been mentioned as a possibility for State Mineral, but it is only found in one locality, and pyrite, which is found in abundance, is not unique to Vermont. Green schist was proposed in the 1950's as a state rock, but was voted down because the legislature thought it would become the brunt of too many jokes (they were proved correct).

A hearing was held on January 30th in Montpelier to discuss this proposal. Any members interested in the bill are encouraged to contact Sue at the address or phone number listed above.

SEMINARS, MEETINGS, AND FIELD TRIPS

February 10: University of Vermont Geology Seminar Series (200 Perkins, 4 P.M.): *"Tectonics and Stratigraphy in Northern Maine"* Dr. David Roy, Boston College.

February 24–25: University of Vermont Geology Department Short Course: *"Sedimentology and Geochemistry of Dolomite"* Dr. John Humphrey, Colorado School of Mines, call 656-0243 for further information.

February 29: Vermont Geological Society Winter Meeting, Northfield, Vermont.

March 23: University of Vermont Geology Seminar Series (200 Perkins, 4 P.M.): *"Evolution of the Taconian Orogen as seen in the Québec Appalachians"* Dr. Alain Tremblay, INRS-Georessources.

March 26–28: Geological Society of America Northeastern Section Meeting, Harrisburg, PA.

April 3: University of Vermont Geology Seminar Series (200 Perkins, 4 P.M.):*"Tectonic Influences on Drainage Patterns and the Origin of Thick, Widespread Coal Beds in the Williston and Appalachian Basins"* Dr. Ed Belt, Amherst College.

April 6: University of Vermont Geology Seminar Series (200. Perkins, 4 P.M.):*"Water, Energy, and Biogeochemical Budgets Research at the Sleepers River Watershed, Danville, Vermont"* Dr. Jamie Shanley, U.S. Geological Survey.

April 13: University of Vermont Geology Seminar Series (200 Perkins, 4 P.M.): *"New Sedimentary Facies and Quaternary Stratigraphy of New Jersey"* Dr. Bryon Stone, U.S. Geological Survey.

April ???: Vermont Geological Society Spring Meeting, Presentation of Student Papers, University of Vermont, Burlington, VT.

June 20–21: *Geology of the Taconic Orogen: A Sesquicentennial Field Conference,* Shoreham, Vermont, Contact Paul A. Washington, 919-733-1330.

THE GREEN MOUNTAIN GEOLOGIST
VERMONT GEOLOGICAL SOCIETY
P.O. BOX 304
MONTPELIER, VERMONT 05601

The *GREEN MOUNTAIN GEOLOGIST* is published quarterly by the Vermont Geological Society, a non-profit educational corporation.

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