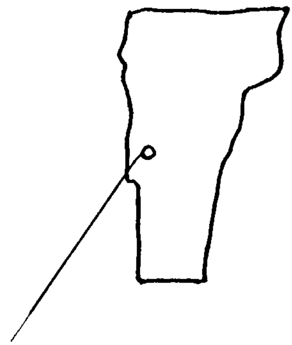
THE GREEN MOUNTAIN GEOLOGIST



QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

SPRING 1987 VOLUME 14 NUMBER 1

You won't want to miss

VGS' FOURTEENTH ANNUAL

PRESENTATION OF STUDENT PAPERS

SATURDAY, MAY 2, 1987 9:00 A.M.

WARNER BUILDING in the HEMICYCLE
MIDDLEBURY COLLEGE

Directions: From the center of Middlebury village, drive west on Vt 125. The Science Center is the first large college building on the left. Use the large parking area east of the building by the loading dock. Warner Building is a short walk northwest of the Science Center.

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PRESIDENT'S LETTER

Dear Members,

It has been suggested that the format for the fall 1987 annual meeting be changed from a fieldtrip and business meeting to having a speaker and meeting. This anticipated change was stimulated by the low attendance at our last annual meeting. We hope to have a speaker who will be of interest to all. Many good names have been suggested. If you have any thoughts on the change of format please feel free to make your feelings known at the spring meeting or by letter.

A summer fieldtrip is being planned, more information will be coming in the next GMG.

As you know I am concentrating on teachers in Vermont and what we have to offer. This is one of our reasons for being. One purpose of the society is to contribute to public education and promote the proper use and protection of natural resources. What better place than through a classroom teacher? There are two ways we can be of assistance to teachers. First develop a list of geologists who would be willing, on a limited basis, to talk to teachers, classes or lead a field trip. I see this as an activity that would take place close to home for the geologist. Please let me know if you are interested. The second service we can provide is a bank of fieldtrips. At this point we are collecting copies of Vermont fieldtrips. These fieldtrips can be simple. The idea is to have an activity that will last between 45 minutes and 2 hours. The field is wide open as they say. Please mail your fieldtrip guides to me or bring them to a meeting. We are always glad to see you.

Shelley F. Snyder

VGS BUSINESS & NEWS

NEW MEMBERS

The following are new members, accepted by the Executive Committee since the Winter Meeting:

Eric Hansen	Huntington Center, VT
John Hollman	Newtonville, MA
Ron Parker	Burlington, VT
Nicholas Ratcliffe	Reston, VA
British Library Documents Supply Center	

GRANT-IN-AID

As of April 15th, two applications for the grant-in-aid of research have been submitted. The award announcement will be made at the Spring Meeting, May 2nd.

[VGS Business & News continued on page 8.]

I wish I were an Ammonite
With sutures rather goniatite
Then as I floated on my way
An index fossil all would say.

JRock

SPRING MEETING PROGRAM

May 2, 1987
Warner Building in the Hemicycle
Middlebury College, Middlebury, VT

COFFEE 8:30

MORNING SESSION: Ray Coish, Presiding

1. David Case: Geothermobarometry and petrology of high grade metamorphic rocks, Witherbee Quadrangle,Northeastern Adirondacks. 9:00
2. Rebecca Clough: Geochemistry of anorthosite of the Marcy massif and olivine metagabbro body in Moriah, N.Y. 9:20
3. Ebbe Hartz: Structure and stratigraphy of the Green Mountain Front at East Middlebury, VT . . . 9:40
4. Jonathan Doolittle: A geochemical and structural analysis of greenstone and serpentinite in the Ottaquechee Formation 10:00

BREAK

5. J.B. Colton: Structure, metamorphism and petrography of the South Lincoln Gap region, central Vermont 10:30
6. Thomas Armstrong: Tectono-stratigraphic geology of the Granville-Hancock area, central Vermont . . 10:50
7. Flenner Linn and Keith Klepeis: A quantitative determination of strain and percent volume loss in slates of the Taconic allochthon 11:10
8. Diane Abendroth: Glacial lake-shore levels in the Lamoille Valley, Vermont 11:30

ANNOUNCEMENT OF GRANT-IN-AID OF RESEARCH AWARD 12:00
AWARD OF PRIZES AND TROPHY

VGS EXECUTIVE COMMITTEE will meet following the awards.

ABSTRACTS

GLACIAL LAKE-SHORE LEVELS IN THE LAMOILLE VALLEY, VERMONT

Abendroth, Diane C., Department of Geology,
Middlebury College, Middlebury, VT 05753

This abstract will appear in the 1987 Summer Issue of the Green Mountain Geologist.

TECTONO-STRATIGRAPHIC GEOLOGY OF THE GRANVILLE-HANCOCK AREA, CENTRAL VERMONT

Armstrong, Thomas R., Department of Geology
University of Vermont, Burlington, VT 05405-0122

1:12000 mapping within the pre-Silurian sequence of the Granville-Hancock area, central Vermont, has demonstrated the tectonic nature of contacts between the various units. Taconian pre-peak metamorphic faults (Tn-1) juxtapose discreet lithologies representative of the Pinney Hollow, Mt. Abraham, Hazens Notch, and Ottaquechee formations. Tn-1 faults are

believed to have large westward displacements which bring together thrust-bound lithologies from differing depositional environments. Kinematic evidence for this displacement is absent due to the obliteration of thrust related fabric by subsequent peak-phase metamorphism. Tn-1 faults are deformed by pre-peak folds (Fn-1) with an associated axial-plane schistosity (Sn-1). Later syn-metamorphic folding (Fn) deformed the Tn-1 thrust slices into large sheath-like, isoclinal, inclined, west-verging structures. Fn has an associated pervasive axial plane schistosity (Sn) which is the dominant fabric within the region. Numerous syn-metamorphic ductile thrusts (Tn) truncate the overturned limbs of Fn folds and are recognized as contacts between similar and dissimilar lithologies. Kinematic indicators display westward displacement of Tn thrust slices, the magnitude of which is much less than displacement along Tn-1 faults. Subsequent upright to overturned, west-verging minor folds (Fn+1) with an axial plane slip cleavage (Sn+1) fold the dominant schistosity (Sn) in the western part of the study area. Fn+1 appears to be related to continued flattening after Fn development, shown by the presence of conjugate shear bands which develop in the short limbs of Fn+1. Tight, upright minor folds (Fn+2), present in the eastern part of the study area, increase in frequency to the east and may be related to Acadian deformation. Late, post-peak metamorphic faults have been observed as superposing brittle to ductile fabric along Tn faults. Motion sense and age of development for the late faults has yet to be determined.

A current working hypothesis depicts the formations within the study area as having been deformed within an accretionary wedge situated above an eastward dipping subduction zone during the Taconic orogeny. Correlation of rift-clastic sequences of the Pinney Hollow and Mt. Abraham formations with similar sequences in the Nassau Formation of the Taconic allochthons places part of the Taconian root zone of Stanley and Ratcliffe (1985) along the tectonic contact between Pinney Hollow/Underhill lithologies and the Hoosac Formation in central Vermont.

GEOTHERMOBAROMETRY AND PETROLOGY OF HIGH GRADE METAMORPHIC ROCKS, WHITHERBEE QUADRANGLE, NORTHEASTERN ADIRONDACKS

Case, David J., Department of Geology,
Middlebury College, Middlebury, VT 05753

An area containing pyroxene gneiss, biotite gneiss, charnockite gneiss, meta-anorthosite, meta-amphibolite and meta-gabbro west of Moriah Center has been mapped and studied. Electron microprobe and petrographic analyses of minerals were performed to determine temperature and pressure conditions of metamorphism, and to compare the results of various geothermometers and barometers.

Temperatures derived from garnet- clinopyroxene, garnet-biotite and clinopyroxene- orthopyroxene range from 709 C to 828 C at 8kb. These results are consistent with Bohlene and Essene's (1985) estimated value of 750 C for this part of the Adirondacks. Temperature estimates based on 2-feldspar geothermometry are 480 and 520 C. Pressures of 6 to 12.5 bars

were acquired using garnet- clinopyroxene- plagioclase- quartz and garnet- orthopyroxene- plagioclase- quartz assemblages respectively. An anomalous value of 21kb was also obtained using the latter assemblage. Wide ranges and error in pressure and temperature estimates are attributed to retrograde exsolution, incorrect calibration assumptions, and the application of ideal solution models to natural systems.

The assemblages of the rock types studied were determined to be in the upper amphibolite to granulite facies, corresponding to the above pressure and temperature conditions. Field relations suggest that the igneous components were intruded prior to or early during the Grenville event.

GEOCHEMISTRY OF ANORTHOSITE OF THE MARCY MASSIF AND OLIVINE METAGABBRO BODY IN MORIAH N.Y.

Clough, Rebecca, Department of Geology,
Middlebury College, Middlebury VT 05753

This study involves the genetic relationship between Marcy anorthosite and a metagabbro body, located in Moriah N.Y.. The three rock types studied were anorthosite, olivine metagabbro and associated amphibolite. Grenville metamorphism has imprinted granular textures of granulite to amphibolite facies on all three rock types. The metagabbro body contains pyroxene-garnet and amphibole-biotite coronas and spinel-clouded plagioclase.

Major and trace-element concentrations reveal a complicated history of accumulation and fractionation among the three rock types. Due to the linear trends in incompatible elements (SiO_2 vs FeO, MnO and MgO), fractionation is thought to have occurred. In the more compatible elements there are also linear trends (SiO_2 vs Na_2O, Al_2O_3 and K_2O) that are due to the accumulation of plagioclase in both the metagabbro and the anorthosite. In several plots (SiO_2 vs FeO, Zr vs Y), there is no separation between the metagabbro and the anorthosite, which may be showing that the liquid was fractionating during the accumulation of plagioclase. The definite separation in other plots (SiO_2 vs Cr, SiO_2 vs MgO) suggests that the anorthosite differs mainly by a larger accumulation of plagioclase and a more fractionated liquid.

REE patterns show positive Eu anomalies in some anorthosite and metagabbro samples, indicating they are cumulate in nature. One gabbro sample shows a negative Eu anomaly, reflecting a substantial fractionated interstitial liquid. The amphibolite shows a depletion in the LREE and an enrichment in the HREE and is thought to be a model for a primitive magma.

The metagabbro samples are compared to other metagabbros in the Elizabethtown-Moriah area and found to be similar in composition. Other researchers have shown that the Marcy massif and associated metagabbros predated the Grenville orogeny and are thought to be a part of an ancient rift system in the ancient North American Continent.

STRUCTURE, METAMORPHISM AND PETROGRAPHY OF THE SOUTH LINCOLN GAP REGION, CENTRAL VERMONT:

Colton, J.B., Department of Geology,
Middlebury College, Middlebury, VT 05753

Cambrian Schist of the Hazens Notch and Mt. Abraham Formations occur within fault-bounded tectonic slivers along the east-dipping flank of the Green Mountain Anticlinorium in north-central Vermont. Field and petrographic studies of these rocks were undertaken in the Lincoln Gap region in order to determine their histories of deformation and metamorphism.

The Hazens Notch Formation comprises two mappable members: a carbonaceous schist and an albitic schist. The Mt. Abraham Schist can regionally be subdivided into four mappable units (O'Loughlin, 1986). Only one of these units, a fine grained white-mica schist, was mapped in this study.

There are 3 major episodes of deformation and 2 episodes of prograde metamorphic mineral growth. Four planar fabrics are present. The dominant schistosity S1, is associated with an early F1 folding event. The major deformation event, D2, produced tight to isoclinally folded F2 folds which are seen in map scale and outcrop scale; S2 crenulation cleavage is axial planar to the F2 folds. Late-stage brittle faulting occurred after the F2 event within the Carbonaceous Hazens Notch: a kinematic study of asymmetric shear zone fabrics indicates west-over east movement. The final deformation is an F3 folding event that developed a weak S3 cleavage.

The Carbonaceous Hazens Notch is a dark black schist with an early stage (M1) assemblage of qtz-mag-mus-chl-alb. The Albitic Hazens Notch is a dark green to grey schist with abundant albite porphyroblasts 1-3mm in size. It is characterized by the early (M1) mineral assemblage of qtz-mag-mus-chl-bt-gt-alb. The Mt. Abraham is a fine-grained white-mica schist, which is pearly grey in outcrop. It is characterized by an (M1) mineral assemblage of qtz-alb-mus-chl-mag.

Late-stage mineral growth (M2) is documented in the Hazens Notch by white mica overgrowing the S2 cleavage and by the development of zoned albite porphyroblasts, with a higher anorthite content on the rims. This mineral growth post-dates the S3 cleavage and may be part of a continuous metamorphic event or the product of a separate thermal pulse.

A GEOCHEMICAL AND STRUCTURAL ANALYSIS OF GREENSTONE AND SERPENTINITE IN THE OTTAUQUECHEE FORMATION

Doolittle, Jonathan, Department of Geology,
Middlebury College, Middlebury, Vt 05753

Whole rock and trace element analyses have been performed on two greenstone bodies and associated serpentinite in the Ottauquechee Formation. Field and structural relationships of the separate greenstone bodies were studied. Greenschist facies metamorphism has eliminated the original fabric of the rocks. The greenstones contain a chlorite-epidote-albite assemblage with minor amounts of biotite, calcite, and quartz. The calcite, quartz, biotite, and albite are associated with shear-related patches and veins in the greenstone.

TiO_2, P_2O_5, Zr, Y, and Nb are considered to be immobile during metamorphism and are used as petrologic discriminants. FeO, MgO, and Al_2O_3 are slighty mobile and are noted as such when used as petrologic discriminants. Major element anaylses and Y/Nb variations allow both greenstone bodies to be classified as tholeiitic basalts. Major element analyses of the serpentinite suggest that the serpentinite is a cumulate part of an ophiolite. Ti-Zr-Y, TiO_2-MnO-P_2O_5, and FeO-MgO-Al_2O_3 ternary plots show that the greenstones are like mid-ocean ridge basalts. A flat to slightly LREE depleted trend is consistent with this interpretation. Furthermore, the greenstones can be classified as transitional between type 1 and type 2 ocean-floor basalts as defined by the Basaltic Volcanism Study Project (1981) and Bryan and others (1976). In summary, the greenstones were probably ocean-floor basalts which were incorporated into their present position by the closing of the proto-Atlantic.

STRUCTURE AND STRATIGRAPHY OF THE GREEN MOUNTAIN FRONT AT EAST MIDDLEBURY, VERMONT

Hartz, Ebbe H., Department of Geology,
Middlebury College, Middlebury, VT 05753

The area studied is the Green Mountain Front, in the vicinity of East Middlebury, Vermont. Structural work along the Green Mountain Front showed there to be several N-S trending, east dipping faults. The Cheshire Quartzite is deformed into an almost overturned fold. The hinges in the fold are cut by faults, with minor displacement. The western section consists of horizontally to gently folded upper Cheshire. The Dunham Dolomite is depositional on the Cheshire. The next section to the east consists of west to vertical dipping upper to lower Cheshire Quartzite. This is the vertical limb of the fold. The eastern-most Cheshire is from the lower part of the formation. The attitude of bedding in this section is again close to horizontal.

The Cheshire Quartzite appears to grade down into the Moosalamoo phyllite. The phyllite appears to be a distant equivalent of the Cheshire Quartzite, as suggested by Myrow (1983).

The contact between the Cheshire and the Moosalamoo phyllite is faulted. The phyllite, which is structurally above the Cheshire, shows increasing shear to the east. The contact between the Moosalamoo and the Pinnacle is also a fault. The Pinnacle is heavily folded but appears to be facing up to the east near the contact with the phyllite.

In thin sections the Cheshire Quartzite and the phyllite have similar mineralogy, but with some variation in composition. The rocks are of greenschist facies, and the metamorphism generally increases to the east, with no sharp discontinuities.

Two tectonic models are proposed in order to explain the structure of the Green Mountain Front. One model suggests that the Pinnacle has arrived as a terrane onto the margin of the proto North America, deforming the quartzites and phyllites on the continental slope and shelf. The second follows Stanley and Ratcliffe's (1985) tectonic model for New England. This model proposes that the Pinnacle formed on the Mount Holly Complex during rifting that preceded the opening of Iapetus ocean. The formations were later faulted back in place by the closing of the same ocean.

A QUANTITATIVE DETERMINATION OF STRAIN AND PERCENT VOLUME LOSS IN SLATES OF THE TACONIC ALLOCHTHON

Linn, Flenner and Keith Klepeis, Department of Geology, Colgate University, Hamilton, NY 13346

This abstract will appear in the 1987 Summer issue of the Green Mountain Geologist.

[VGS Business & News continued]

COMMITTMENT TO TEACHER EDUCATION

The following letter was sent to Margaret Ottum at Johnson State indicating VGS' committment to support geology teacher education in Vermont:

February 1, 1987

To Whom It May Concern:

The Geological Society of Vermont is very pleased to lend its support to the proposed NSF Project titled "GEO" with principle investigators Dr. Margaret G. Ottum and Dr. Andrea Barlett. There are currently over 150 members in the Society and the interests and expertise of the membership covers the full spectrum of geology.

The primary way in which the Society sees itself assisting in this project is by compiling a directory of professional geologists who have stated a willingness to help teachers develop local field trips. The development of this directory is already underway and will soon be available to Earth Science teachers throughout the state of Vermont.

In addition to assisting as indicated above, the Society also sees itself serving the needs of those involved in this proposal in another way. The Society publishes a quarterly newsletter, The Green Mountain Geologist. This newsletter contains short articles on a wide range of topics and can provide teachers involved in the GEO project with current information about activities of geologists throughout the state. The GMG can also serve as a vehicle through which teachers can get direct published answers to their questions by submitting them to the editor.

(Signed)
Shelley Snyder, President

MEET THE OFFICERS

In the Winter 1986 GMG, we introduced the members of the Executive Committee to the Society at large. There are new faces among the officers this year, so the following information is provided, to let you get to know them.

David Butterfield, a charter member of VGS, is the new Secretary, but not new to the workings of the Society, having served on the Board of Directors in the early years. David was born in Paterson, New Jersey and received his early education in NJ and at the Vermont Academy. A B.A. in geology was earned at the University of Maine in Orono. He has worked for the Vermont Highway Department, the Magma Copper Company in Superior, Arizona, and most recently has worked for the Vermont Department of Water Resources as a geologist, planner, hydrologist and Chief of Ground Water Management. His other interests are the Guardianship Trust of Vermont and the National Water Well Association.

Stan Corneille, another charter member, is serving a one-year term as a Director. Stan comes from Crown Point, New York and received his education at Ithaca College, American University in Washington, D.C. and University of Vermont where he received an M.S. in geology. He currently works as a hydrologist for the Waste Management Division of the Vermont Agency of Environmental Conservation. His geologic interests are hydrogeology and application of geology and geologic principles to environmental concerns and problems. He practices these interests as a member of the Randolph, VT, Conservation Committee with which he is working toward preservation of agricultural land in town and a member of the Planning Commission which is in the process of revising the town plan. His outside interests are water sports, especially canoeing and sailing, and cross-country skiing and playing banjo.

Donald Wernecke is serving a two-year term on the Board of Directors. Although born in Bavaria, he has lived most of his life in Vermont, growing up in Groton and attending UVM and Lyndon State where he earned his B.S. in Environmental Science under Bud Ebbett. He also did graduate work at U. of Maine. He has taught elementary school at U-36, served as a naturalist at Groton State Park, worked at Space Research Corporation, as a real estate broker and on bridge construction, but since 1978 he has been permanently employed by the state, first in engineering geology under Frank Lanza and since 1983 as Assistant Regional Engineer in Barre for the AEC in Environmental Protection.

Donald lives in a home he built in Barnet with his wife and two young children.

WINTER MEETING REPORT

The winter meeting was a big success again, with a full day of talks and with an audience of about 50 persons both morning and afternoon. The guest speaker, James McLelland, left us well-informed about current knowledge of Adirondack geologic history as determined from igneous rocks.

The Executive Committee meeting at noon was devoted mostly to the discussion of how VGS can be involved in helping teachers with geology education. Several items related to suggestions for VGS teacher-related activities were suggested. Included were notification of our functions in the Vermont Science Teachers' Association Newsletter, development of a speakers bureau, workshop for teacher certification, and a slide show which is in place with Chuck Ratte the State Geologist. Margaret Ottum, a professor from Johnson State, asked for support of the Society for a National Science Foundation Project titled "GEO". A letter was sent (subsequently) indicating the philosophical support of VGS. It was indicated that a directory of professional geologists who have stated a willingness to help teachers develop local fieldtrips will be developed. The GMG is to serve as a vehicle through which teachers can get direct published answers to questions by submitting their questions to the editor.

The problem of dwindling attendance at the Fall annual meeting and banquet was mulled over. It was resolved that, in view of the many field trips available this fall at NEIGC, the VGS fall meeting be kept to a banquet with a speaker or discussion of general interest with the business meeting following.

EXECUTIVE COMMITTEE MINUTES - February 25, 1987

The meeting was called to order at 7:20 PM at John Malter's in Montpelier. Present were Shelley Snyder, Jeanne Detenbeck, Jeff Pelton and John Malter.

Minutes from the previous meeting were unavailable.

The treasurer reported in absentia. Previous balance \$2786.76 which includes \$1500 grant-in-aid money. Income = \$1251.06, expenses = \$329.85. Current balance (2/25/87) \$3607.97. New members accepted for membership are: British Library Documents Supply Center; Eric Hansen, hydrologist; John Hollman, student member; Ron Parker, hydrologist. Three members dropped at their own request: Mary Lou Curran, William Lynch and Jack Rand. Two members whose mail has been returned: Dale Mento Sheehy and Phil Wagner. 20 members will get second notice on dues and be dropped before the next newsletter if no response. Robert Snyder will audit the books for 1986 as he did last year.

A letter has been sent to Margaret Ottum of Johnson State concerning offer of a list of members who would volunteer to assist her in a special teaching project which was discussed at the last Executive Comm. meeting at the Winter Meeting. This letter should be published in the next newsletter and a request included to members to volunteer.

Suggestions for a fall meeting were discussed. In a vote at the Exec. Comm. mtg. at the Winter Meeting, it was decided to have a speaker at the 1987 Annual Meeting banquet instead of the day-long field trip (noting that in 1987 there will be many field trips at NEIGC at Norwich University in October). Dave Westerman has suggested a panel discussion about "How do we know what we know about geologic time?" with Brew Baldwin as coordinator and member. Also suggested was a single speaker with public appeal - ideas were: Steven J. Gould (Harvard), Robert Jastrow (Dartmouth), Robert Ballard (Woods Hole), Carl Sagan (Cornell), John McPhee (writer). October 24, 1987 was set as the tentative date and John Malter will look into the possibility of having the banquet at the New England Cullinary Institute in Montpelier. We might try to have teachers pre-register for this meeting. The secretary can write letters to these speakers to find out the possibility of their attending. It was decided that more discussion was needed about this annual meeting with more members of the committee present. Therefore, March 11 at 7PM at John Malter's was set as the next meeting.

Shelley reported that Brew Baldwin had accepted appointment to the Nominating Committee.

Shelley reported that Chuck Ratté is going to coordinate summer field trips with emphasis on geology for the nonspecialist (no F3's!) - geology for the technophobe.

Jeff reported that we have been invited to submit articles to the newsletter of the Vt. Science Teacher's Association. Their spring meeting will be April 4 and we are invited to submit info. about VGS.

Our spring meeting will be held May 2 at Middlebury College. Ray Coish is the coordinator.

Items for the GMG: solicitation of field trip education articles and solicitation for volunteers on a limited basis to provide geologic information on appropriate topics.

Dave Westerman reported that possible applications for the Grant-in-Aid will be coming from 2 Norwich U. studetns, 1 UVM student and Nancy Williams. Deadline is April 15, 1987.

Shelley and Jeff are working on a white paper in support of a more formal Vermont Geological Survey.

Jeff will submit a letter for the GMG about our potential VSTA involvement.

Jeann reported that field trip guides are trickling in for Vol. 5.

The student trophy should be located for the spring meeting. Also 3 judges need to be appointed.

Adjourned at 9:09 PM.

Respectfully submitted,
John Malter

EXECUTIVE COMMITTEE MINUTES - March 11, 1987

Meeting held at John Malter's at 7PM. Present were Shelley Snyder, Jeanne Detenbeck, Jeff Pelton, John Malter and David Butterfield.

Minutes from the 2-25-87 meeting were read and approved. The dates for the NEIGC field trips are Oct. 15-18, 1987.

Finances: It was reported that Treasurer Dave Westerman would like to change the present checking account system which seems to be too costly. Several options were discussed. Issue tabled until Westerman can be present.

ANNUAL MEETING: Malter reported that the New England Culinary Institute, 250 Main St. Montpelier, has a banquet hall which can handle up to 96 people. They have a "fantastic" menu with costs in the $15-20 range, including appetizer, main course and dessert. A cash bar is available. The room is free if we have a large enough group. A 2 to 3 week notice is required and ahead count a few days prior to the meeting date. A number of speakers were suggested and topics discussed. The committee wants a high powered speaker with an intersting topic in order to generate a large turn out of the members. Secretary to write letters of inquiry to NASA and USGS. Malter and Pelton to write to their "big name" connections. The date for the Annual meeting is: October 24, 1987. Mark your calendars.

The date for the spring meeting is May 2nd, 1987.

Members are encouraged to supply J. Detenbeck with news and poems for the GMG. Watch for J.Rocky Recycle's latest epic.

Snyder and Pelton will contact C.A. Ratté, State Geologist as to a society "white paper" supporting a more formal Geological Survey.

Meeting adjourned at 8:55 PM

Respectfully submitted,
D. Butterfield, Secretary

BELOW THE SURFACE

THE THICKNESS OF THE MIDDLEBURY LIMESTONE

Paul A. Washington

Cady (1945) estimated the thickness of the Middlebury Limestone near Middlebury to be about 600 feet (183 m) thick. When added to his estimates for the thicknesses of the Orwell and Glens Falls limestones in the same area, his estimate for the total thickness of strata lying between the Providence Island Formation (top of the Beekmantown Group) and the Hortonville Slate is over 750 feet (206 m). This thickness has been accepted by most subsequent workers (e.g. Welby, 1961; Coney and others, 1972).

Washington (1981a, 1982) found that the Orwell and Glens Falls are not discernible units in the Middlebury area and resurrected the original name (Sparry [Dana, 1877]) for the entire sequence (I now return to a modification of Cady's terminology, applying Middlebury to the entire sequence in the Middlebury area; this follows present informal usage). Instead, the limestone sequence is quite monotonous with only subtle variations in color and clastic content indicating stratigraphic horizons. The thickness of the entire limestone was estimated to be about 80 m (less than half Cady's estimate), but this was based on a structural-stratigraphic synthesis, not on any measured sections.

The basic problem with deriving a true thickness of the limestone sequence around Middlebury is the combination of extreme structural complexity and stratigraphic subtlety. Extending from Otter Creek west to The Ledges (Fig. 1), the Providence Island Formation (Cady and Zen's [1960] Chipman Formation) and overlying strata (Middlebury Limestone and Hortonville Slate) are involved in a duplex (Washington, 1981a,b: Washington and Chisick, 1987). Thrust traces are encountered every 50 to 500 m across strike. Although outcrops are generally plentiful, the paucity and obscurity of stratigraphic markers make determination of stratigraphic position adjacent to these thrusts nearly impossible.

To get around these problems, I have started logging water wells as they are drilled. Fortunately, cuttings from the Middlebury Limestone can generally be distinguished from the overlying Hortonville Slate and underlying Providence Island Formation. Recently, a couple of wells in Weybridge (Fig. 1, pts. A and B) fortuitously passed through entire sections of Middlebury. Both of these wells started in overlying thrust sheets, reaching the complete section of Middlebury by crossing the fault plane and passing through a section of Hortonville Slate. In one well (A) a sufficient thickness of Hortonville Slate (45 m) was encountered that it could not be mistaken for the slate lying along the Middlebury-Providence Island contact (.5 m thick at James Pasture - Fig. 1, pt. JP) or for a previously-unnoticed layer within the Middlebury (less than 10 m of Hortonville was penetrated in well B). The color change from the medium to dark blue limestones of the Middlebury to the blue-gray limestones and blue-black dolostones of the Providence Island is somewhat gradational

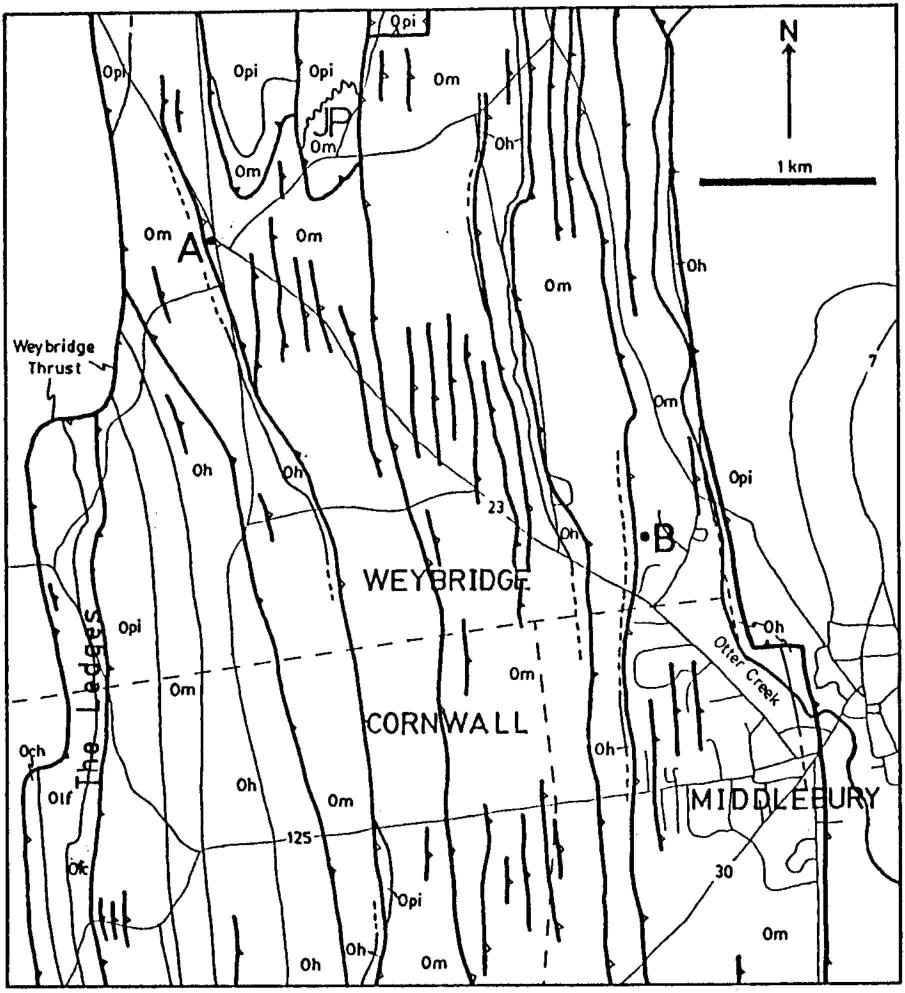

Figure 1. Geology of the area from Middlebury to The Ledges, showing the location of the two wells (A and B). The Weybridge thrust (Keith, 1932) structurally separates this area from the Snake Mountain massif just to the west. Oh - Hortonville Slate; Om - Middlebury Limestone; Opi - Providence Island Formation; Ofc - Fort Cassin Formation; Olf - Lemon Fair Formation.

(the basal Middlebury is color banded [Crosby, 1963; Washington, 1982]), making the contact difficult to precisely determine.

The thickness of the Middlebury Limestone encountered in these wells is 80 to 90m (Fig. 2). The paucity of nearby outcrop of the penetrated section below the upper thrusts makes correction for dip uncertain, but correlation of depth of water between well A and nearby wells suggests that there is only a slight (<5°) eastward dip. Thus, an upward bound for the true thickness of the Middlebury Limestone can be set at 90 m.

Well B (total depth 900 ft. [275 m]) was dry (<1/4 gpm), whereas well A (t.d. 677 ft. [206 m]) produces 20 gpm (all obtained at the bottom of the well). The lack of ground water encountered within the Middlebury suggests (Washington, 1981c, 1986) that there are no thrusts crossing the wells below the Hortonville. The lack of water along the penetrated thrusts is caused by the presence of Hortonville, which acts as a seal.

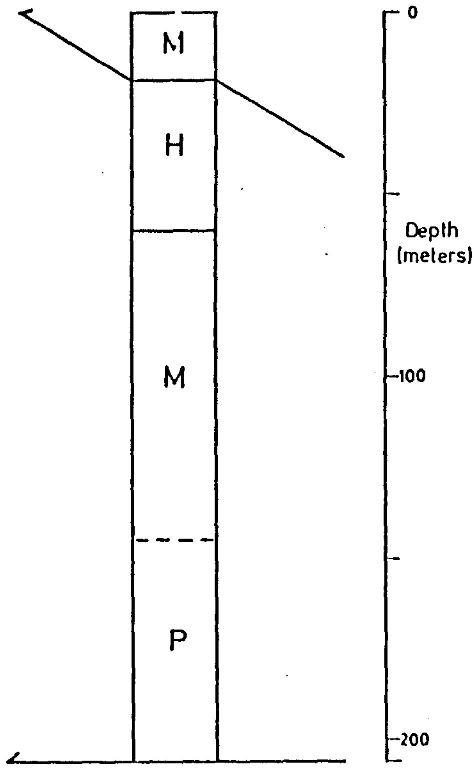

Figure 2. Summary of strata encountered in well A. H - Hortonville Slate; M - Middlebury Limestone; P - Providence Island Formation.

In conclusion, analysis of cuttings from two water wells that penetrate the Middlebury Limestone find that the thickness of the Middlebury is between 80 and 90 m thick. This is much less than Cady's (1945) estimate, but is quite close to Washington's (1982) estimate.

ACKNOWLEDGMENTS

This analysis would not have been possible without the cooperation of the drilling crew of Spafford & Sons and of the home owners, Lawrence and Ida Washington (well A) and Ashley and Louise Cadwell (well B).

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WATER QUALITY LEGISLATION - PART II

This is the continuation of an article written by Jonathan Lash, Commissioner of the Department of Water Resources and Environmental Engineering, and published in the Winter 1986 issue of the Conservation Quarterly. (Part I appeared in the Winter 1987 GMG). A summary of Vermont environmental legislation in 1986 and 1987 has been provided by Chris White to bring the story up to date.

A Confused Situation

In 1979 the Mt. Mansfield Corporation applied for a Certificate of Compliance for a 290,000 gallon per day tertiary treatment plant and high rate on-site disposal system next to Ranch Brook in Stowe. The Department of Water Resources concluded that the system would be a "discharge" and would require not only a Certificate of Compliance showing that the system would meet the requirements of the Environmental Protection Rules, but also a discharge permit. There were angry protests from the development community asking on what basis the Department had reached the conclusion that the proposed system would be a discharge and how such decisions would be made in the future.

As a result in September 1982, the Department amended the Environmental Protection Rules to state that any system exceeding 40,000 gallons per day would be treated as a discharge and would require a discharge permit unless it met four strict criteria:

1. The effluent flow cannot exceed 10 percent of the average flow of the affected stream in any month.
2. Effluent has to remain in the ground for at least 25 days before reaching surface waters.
3. The effluent flow should not disrupt existing ground water flow patterns or cause a normally dry area to become saturated.
4. The waste system should use the natural capabilities of the site to treat the wastes.

The new provision of the rules came to be known as the "threshold criteria". It was intended to be a clear simple statement of when a discharge permit would be required. But since the rule was adopted three and a half years ago, no applicant has ever met its requirements. Large scale developers have increasingly run up against the 40,000 gallon threshold. One recent case illustrates the bind in which the State found itself.

The Sunrise Group proposed to build 550 condominium units in the Town of Mendon near the north branch of Madden Brook. The project required a sewage treatment and disposal system in excess of 100,000 gallons per day, but the spray disposal site did not meet the "threshold criteria". Sunrise argued that since they had initiated discussions with the Department of Water Resources before the adoption of the "threshold criteria" in September 1982 the project should be reviewed and approved under the rules in effect at the time. In the fall of 1984, the Department rejected this claim and issued Sunrise a Certificate of Compliance for a spray system with a capacity of 40,000 gallons per day, the maximum allowed without obtaining a discharge permit. Sunrise appealed that decision to the Water Resources Board contending the project should have been grandfathered under the "old rules". At the same time, two environmental groups, the Connecticut River Watershed Council and the Vermont Natural Resources Council appealed the decision arguing that the Department should have required Sunrise to obtain a discharge permit.

CLASSIFICATION OF STATE SURFACE WATERS

Under present law (Title 10 V.S.A. Section 1252), state waters are classified in one of three categories.

Class A. Suitable for public water supply with disinfection when necessary. Character uniformily excellent.

Class B. Suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good asthetic value; acceptable for public water supply with filtration and disinfection.

Class C. Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and for common food and game fishes indigenous to the region; and such industrial uses as are consistent with Class 'C' uses.

The Water Resources Board has established, in its Water Quality Standards, specific water quality criteria to protect the uses of each class. The Water Quality Standards prohibit discharges of treated domestic wastes into Class B waters. The board also established special protection for what are commonly called "upland streams" (Class A and B waters upstream of existing Class C zones where no discharges are permitted except for non-polluting wastes and stormwater.) Discharges of treated domestic wastes are permissible in Class C waters if the water quality criteria are not violated.

The Board may reclassify state waters if it finds that the current classification is contrary to the public interest and that a higher or lower reclassification would be in the public interest. The classification process may be initiated by the Board itself or by a petition to the Board by a municipality, a state agency or 30 or more persons in interest. The Board holds a hearing in the area of the waters under consideration and makes its judgment on reclassification based on a number of criteria, including existing and obtainable water qualities, existing and potential water uses, fish habitat and municipal, regional and state plans. A change in classification is adopted as a rule by the Board.

At the present time about 95 percent of Vermont's waters are Class B, 3 percent Class C and 2 percent Class A. Classifications do not necessarily describe the actual water quality of a particular stream or pond. When actual water quality is lower than the criteria for the class, those criteria serve as goals to be achieved through water resource management. Many of our waters are of higher quality than the criteria established for their Class. The anti-degradation section of the Water Quality Standards requires protection of the high quality of these waters in the public interest to the fullest extent possible.

In April 1985, the Water Resources Board ruled that the Department was wrong to apply the "threshold criteria" to Sunrise and ordered the Department to issue a Certificate of Compliance for a 100,000 gallon per day system. Six months later the Board ruled that the Department was also wrong not to require a discharge permit and Sunrise could not proceed to build a 100,000 gallon per day system unless it obtained a discharge permit. Since the north branch of Madden Brook is an upland stream, Sunrise could not obtain a discharge permit unless the stream was first reclassified as a Class "C" stream.

The reasoning of the Board's decision was simple and direct. The experts agreed that the effluent from the Sunrise spray system would eventually reach Madden Brook and that when it reached Madden Brook it would be "measurably different from the naturally occurring water" of the Brook. As long as it was "measurably different", the Board concluded, the effluent was a "waste" under Act 252. If it was a waste, then it was a discharge, and if it was a discharge, it required a discharge permit.

The ruling was not based on the size of the system, nor was it based on the impact that the effluent would have on Madden Brook. Indeed, the Board refused to hear evidence relating to the effects of the discharge on Madden Brook. The sole question was whether the effluent was "measureably different" from the naturally occurring waters when it reached Madden Brook. Since virtually all effluent placed in the ground in Vermont will eventually reach surface water, the reasoning of the decision applies not only to upland resort development but to all on-site sewage treatment, even single family homes.

In response to a query from Water Resources Commissioner Lash, the Attorney General advised the Department that, pending action by the General Assembly, or further decisions by the Water Resources Board, it should continue to issue Certificates of Compliance under the Environmental Protection Rules. Neverthless, the implications of the Sunrise decision (which has been appealed to Superior Court) are clear. Potential applicants do not know whether any Certificate of Compliance they receive from the Department will be valid or whether they may be required to obtain a discharge permit as well.

In the days following the Sunrise decision controversy, environmentalists and developers wrangled over its future implications. Former Governor F. Ray Keyser, who had represented the Sunrise Group in their appeal to the Water Resources Board, said that the law as interpreted by the Board had "no relation to protecting the environment". Joe Parkinson, Executive Director of the Vermont Ski Area Association charged that the groups that had appealed the Sunrise Certificate to the Board "were trying to stop resort growth by plugging up the sewer pipes". Eric Palola of the Vermont Natural Resources Council responded that the decision simply acknowledged "the concern of a broad number of Vermonters who have witnessed a steady decline in the quality of certain headwater areas of the state " and recognized "the laws of the state of Vermont were fundamentally wronged" by the proposed Sunrise system.

Where Can We Go From Here?

Beneath this controversy lie several very real problems. The fact that the legislature has never considered the question of upland streams is one. The words "upland stream" do not appear in the water quality law. The very broad definition of upland streams adopted by the Water Resources Board, which includes over 90 percent of the flowing waters of the state, has not proven to be an effective tool for managing and protecting the quality of Vermont's waters. Providing a special level of protection to 90 percent of the state's waters is unrealistic, particularly when many of the waters included are already far from pristine. Over the past decade and a half we have not had to confront this because the procedure for approving on-site sewage treatment has not been based on water quality, thus whether or not adjoining streams were upland streams has had no impact on permitting decisions for on-site systems.

What level of protection is enough? The question is fundamentally one of values. There are hundreds of streams flowing out of our mountains. They are the root systems of our rivers, a critical part of our upland ecology. Most are small; many virtually disappear during dry summers. The classic Vermont mountain stream has a special clarity. Few natural nutrients flow into them from the mountains that give them life. They are shaded and cold. As a result they support limited populations of plant and insect life. They are fragile and vulnerable to change. Human activity can affect them profoundly. Sewage disposal, construction, logging, and agriculture can all create risks to upland streams.

Should we seek to manage and minimize those risks or simply to eliminate some of them? Should the legislature set a strict standard permanently protecting upland streams, or should it tell state government to proceed case by case, balancing the risks created by an activity against the benefits arising from it? If as Governor Kunin, and Governor Davis before her, have urged there is to be blanket protection for all streams over 1500 feet in elevation, what about fairness to those who own land above 1500 feet? Although a substantial portion of the land in the state above 1500 feet is publicly owned state and national forest land, the majority is not.

[Here we shift authors and consider the whole spectrum of water quality legislative action in the past two years.]

THE CONTINUING SAGA OF VERMONT'S ENVIRONMENTAL LEGISLATION

Christopher White
White Hydrogeology, Inc.
52 Seymour Street
Middlebury, VT 05753

Much has happened on the legislative front in terms of environmental issues since Commissioner Lash wrote his article in the Winter, 1986 Conservation Quarterly. Numerous water-related bills were introduced into the 1986 legislative session to deal with specific issues troubling the State. Many of these initiatives were combined and refined by the end of the session. The legislative work responded to some issues, and in doing so, created new questions.

This spirit of heated debates, high-profile legislation and attention-getting bills was evident last year. In contrast, this year's legislature seems much quieter environmentally. Conflicts which arose in the 1986 session appear to be near resolution in the 1987 session. The business community will possibly receive assistance with the persistent and expensive problem of leaking underground storage tanks. Municipalities stand to benefit financially from state-supported planning for solid waste disposal. In a general way, 1986 may have been devoted to redefining a person's right to conduct polluting activities. This year addresses the State's obligation to help share the cost of these newly defined responsibilities.

The 1986 Session

There were five general areas of water quality legislation passed in 1986. They are organized in various chapters in Title 10 of the Vermont Statutes Annotated (V.S.A.). These areas were: wetlands protection, water pollution control, groundwater protection, underground liquid storage tanks and waste management. The last topic covers both radioactive and solid waste. The licensing procedure for water well drillers, which was updated and refined, became part of the groundwater protection statute.

The wetlands legislation (Chapter 37) recognized the value of wetland areas for flood control, water quality enhancement, wildlife and fish habitats, vegetation, recreation and aesthetics. The law empowers the State to classify, protect and manage the wetland areas in order to maintain the value of the areas. While other states have similar statutes and our own Act 250 begged the question of wetland protection, this law further develops a wetlands protection policy for Vermont. The policy may have widespread economic ramifications. The Department of Water Resources has not yet written the rules for this chapter. The specific guidelines which will give this law regulatory life will further flesh out the State's wetland protection policies.

Chapter 47, which is devoted to water pollution control, has accomplished several important steps. Firstly, it recognized the existence of "indirect discharges" of sewage to a stream. Such indirect discharges are defined as any discharges of sewage to groundwater. It also reclassified stream waters so that any streams above 2500 feet in elevation were Class A and meritorious of the highest level of protection. The law also prohibits direct discharges of pathogen-laden waters to streams. Finally, it sought to clarify the issue of when a sewage disposal system might present a significant risk to a nearby stream or lake.

This last point is complex. It involves the legislative recognition of probability, levels of significance and groundwater flow prediction in forecasting a public health risk from sewage disposal. It stipulates that disposal fields of less than 6500 gallons per day (gpd) do not ordinarily pose a sufficient enough hazard to be considered. It admits to possible grey areas regarding the significance of a direct or indirect discharge. And it brings up the question of what are a current user's rights to the existing and potential beneficial uses of the stream or lake as weighed against the discharger's right to use the stream for dilution of his waste. In regard to this last point, Vermont's regulators seem to subscribe to the right of prior appropriation viz. surface waters.

If embodying these issues in legislation was challenging, the development of companion regulations has been even more demanding. The Vermont Department of Water Resources, the Vermont Water Resources Board and the Legislature continued to discuss the formulation of regulations on this statute throughout this past winter. Finally, in the 1987 session, a compromise appears to have evolved on the rulemaking for this statute so that final regulations may be forthcoming soon.

Chapter 48, Groundwater Protection, is another regulatory challenge, In Chapter 48, the legislature empowered the Department of Water Resources to classify all the groundwaters in the State. The classification system depends upon the degree to which the groundwater is already compromised, the risks for future compromise and the current potability of the water. There is a list of 9 or 10 factors to be considered in assessing the degree of compromise.

The Department is also charged with developing a management strategy for groundwater. Presumably, the strategy should consider what sort of activities should be permitted in certain areas, what to do with already heavily compromised areas and how to determine the likelihood of groundwater contamination given certain activities in different environmental settings. The classification system and management strategy will have wide-ranging implications for land values and land use planning on a State-wide basis.

Well driller licensing used to stand separately as Chapter 51, but is now subsumed in Chapter 47. While no significant changes took place on this section in 1986, there have been efforts made to refine the chapter this year. Specifically, more needs to be done regarding well definitions, hole abandonment and construction standards. It appears as though this will wait 'til 1988.

In Chapter 48, Section 1410, is the fruit of the old VGS "Groundwater Watchdog Committee". It is entitled "Groundwater Right of Action". Of all the 1986 legislation, this section stands on its own for empowering the individual citizen to take action against a polluter. The section abolishes the 300-year-old groundwater doctrine of absolute ownership and replaces it with a hybrid correlative rights and reasonable use doctrine. The section is unique in that it inclusively specifies the points of tort law which should be considered in bringing the action. This facilitates the job of the plaintiff's counsel. It also allows for cosideration of agricultural practices in groundwater contamination. Finally, but perhaps foremost, it recognizes that groundwater hydrology is a science and as such is not "mysterious and unknowable".

The law regarding Underground Storage Tanks is codified in Chapter 59. There is a size limitation for what is deemed to be environmentally significant viz. storage tanks. Tanks with a capacity of less than 1100 gallons are not considered here. Nor are sewage tanks or natural gas facilities. The major affected industry sector is the gas station.

The law stipulates that certain tank construction standards be met regarding double walls, leak detection, and monitoring. Periodic reporting is required regarding the tank's integrity. Furthermore, there are requirements for corrective action, reporting content releases and tank removal.

Solid Waste Management (Chapter 159) and Radioactive Waste Management (Chapter 157) also received legislative attention. Chapter 157 deals primarily with review of technologies, inventories of both radioactive waste generators and storage sites, transport of waste and available insurance. Other, equally important issues surrounding radioactive wastes are Vermont's participation in a regional storage compact and the analysis of the impacts of various alternatives for decommissioning Vermont Yankee.

Chapter 159 addresses with three substantive points. The first is to develop a plan for disposal of contaminated soils at in-State sites. The second is to develop a comprehensive state-wide program for the collection, treatment and disposal of septage and sludge. Thirdly, a contaminator's liability is extended to cover the costs of abating a contaminant release and the costs of investigation, removal and/or remedial action if warranted. The liability exposure is clarified in this statute and written so as to be widely inclusive of current or past property owners, transporters, possessors, waste facility owners or disposers. This brings Vermont's laws in closer accordance with the Federal laws.

The 1987 Session

The 1987 legislative efforts, while still formative, are comparatively less far-reaching and more focused than the 1986 laws. No environmental bill has passed both houses and been signed into law at this time. However, there are five bills currently in process.

The first is a solid waste bill designed to help municipalities plan and pay for trash disposal. Funding, as proposed, would start at $2.6 million in FY 88 and go to $5 million in the years following. Seventeen new positions would be funded at the Agency of Environmental Conservation.

The second bill would start an outstanding river designation system. The effect of this bill would be to restrict or prohibit gravel mining and hydroelectric dams from these rivers.

Thirdly, a $7 million funding bill is proposed to help small gas station owners pay for the replacement of underground storage tanks. A fourth bill will further regulate the sub-division of lots. This legislation, as proposed would close a provision in Act 250 by prohibiting a developer from developing over nine lots in a five-year period in one of Vermont's nine district environmental commission's jurisdictions. Finally, the cumulative impact of many developments in a rapidly growing area is being addressed in a re-introduced bill which had been killed in the closing days of the 1986 session.

Conclusion

Clearly, the Vermont Legislature has been environmentally active in the past two years. It is responding to a perceived cry for environmental protection. Why is there all this activity? Perhaps the Legislature had been relatively quiescent in the previous few years. Perhaps groundwater problems had been ushered into the fore in 1985 and 1986 by situations like Williamstown. Perhaps large ski area development had seemed to be too big or too harmful for several environmental groups. Perhaps Governor Kunin perceived a mandate in her election and subsequent re-election. Whatever the reason, 1986 was a "watershed" year and 1987 is a quieter encore.

If a constitution sets out the broad operating principles of a government, then the government's statutes will refine those principles to address the people's immediate concerns, These issues are then hammered out and given final definition in agency and departmental regulations and rules. While the regulations may be too specific and detailed for the lay public, regulations do give life to the laws. They indicate how the laws will operate on a day-to-day basis.

This article is by intention a summary. The issues are broad in scope because that is the scope of the legislation. The detail of how these laws are carried out will come into focus as the regulations are issued and adopted. Stay tuned, because that will be happening in the near future!

Acknowledgment

I thank the various people who have helped me write this article. Sources have included Jim Ashley and David Butterfield of the Department of Water Resources. I have also relied on several lawyers for assistance either with specific information on the above matters or their general opinions. These people include Richard Taylor of Middlebury and Jon Readnor of Rutland. Finally, the VNRC and reporters for the Burlington Free Press have kept me posted of current legislation. Errors in judgment or fact are my responsibility.

MINERAL OF THE QUARTER

LIMONITE

Limonite is a secondary mineral which is often used as an ore of iron or a pigment (red and yellow ocre). It is not found in crystallized form but in porous to compact form. It is often very impure, containing sand or clay. Modern mineralogists no longer consider it a mineral species but a cryptocrystalline form of the mineral goethite with variable water either adsorbed or held by capillary action. Its formula is $FeO(OH)_nH_2O$.

Limonite has a hardness varying from 1 - 5 1/2 and a specific gravity that varies from 2.7 - 4.3. These data show well in what impure condition the material often is found.

Limonite is the name used in the field for bog iron ore, which is a mixture of hydrous iron oxides of varying composition. Bog iron ore is produced in marshy and boggy areas by the action of iron-fixing bacteria found in the murky water. These bacteria digest iron from solution and leave behind ferrous oxides and carbonates as their waste product.

Small deposits of bog ore were very important sources of iron in the early history of Vermont. Most bog ore was found in the western part of Vermont in places such as Highgate and Swanton, Sheldon, Fairfield, Colchester, Milton, Monkton, Vergennes, Bristol, Shoreham, Orwell, Brandon and Pittsford. The swampy places where bog ore formed had been produced by the drying up of lakes formed during the glacial stages. Many of these deposits were used during the last decade of the eighteenth century and the first decade of the nineteenth century.

Furnaces to smelt these local deposits were built at Tinmouth, Bennington, Pittsford, Fairhaven, Sheldon, Vergennes and Swanton between 1783 and 1799. In fact, the iron industry played a very important role in the economic development of Vermont in its infancy. By the early nineteenth century, there were 8 blast furnaces and 26 forges and bloomeries (used to convert pig iron to wrought iron) in operation in Vermont.

Early in the nineteenth century, Vergennes was the center of the iron industry in Vermont. The Monkton Iron Company was financed by $250,000 in Boston capital. The works were situated just below the falls of the Otter Creek. At this spot the old river bed is very wide, so boats of up to 300 tons could reach the site from the lake. Here the blast furnaces, forges, bloomeries and other works were situated. Limonite ore from the Monkton ore bed (shown on the Middlebury topographical map) was brought as well as bog ore from Swanton and other northwestern Vermont locations. They produced their own charcoal from the trees of area forests to use for the smelting of the oxide ore to pig iron. Later coke was produced here also. The Monkton Company became the leading iron producer in Vermont. From here were shipped such items as wrought iron for ship building, sheet iron, hollow ware for kettles, nail rods, etc. These were shipped to places as far away as Boston and Troy, New York.

As an interesting historical sidelight, the availability of ship building supplies such as the iron and trees for masts was the reason that Vergennes was chosen by Thomas McDonough as the site to build the American fleet with which he vanquished the British at the Battle of Plattsburgh Bay on September 11, 1814. The $1007 worth of wrought iron used to build the fleet and 300 tons of shot used in the battle were produced with iron made at the Monkton Company. The cast iron cannon used in the battle were probably also produced at the site.

The financial depression after the War of 1812 and the discovery of richer deposits of iron ore in Pennsylvania caused the fortunes of this industry to wane in Vermont.

Information for this article was taken from the Quarterly of the Vermont Historical Society, v. XXI, no. 2, April 1953, p.118.

Submitted by
Ethel Schuele

STATE GEOLOGIST'S REPORT

The Office of the State Geologist is working on compiling a new edition of the Availability of Vermont Maps booklet. This booklet is used by private and public groups and individuals who are looking for map information. If you know of anyone who produces or sells maps of Vermont or part of Vermont, on any topic, please have them contact us at 103 South Main Street, Center Building, Waterbury, VT 05676 or 802+244-5164 so that we may include them in the booklet.

General information on aspects of geology in Vermont and specific information on Vermont locations and topics is always available from the Office of the State Geologist. Many references, both currently available and out-of-print, are available in our library.

NEW PUBLICATIONS

The following new reports and publications from the Vermont Geoloical Survey are now available:

Open-file reports:

1. Map of Vermont Metallic Mineral Deposits and Occurrences, scale 1:250,000, compiled by Alan J. McBean, 1985 plus locality ID sheets Blue-line ozalid print...$3.00

2. Map of Vermont Non-Metallic Mineral Deposits and Occurrences, scale 1:250,000, compiled by Alan J. McBean, 1985 plus locality ID sheets Blue-line ozalid print...$3.00

3. Stratigraphy and Bedrock Geology of the Northwestern portion of the St. Albans quadrangle and the adjacent Highgate Center quadrangle, by Charlotte J. Mehrtens and Rebecca J. Dorsey, 1986; 28 page text, 3 figures, 2 plates with 2 figures each. Complete paper copy...$5.00

Publications:

1. Sharon B. O'Loughlin and Dr. Rolfe S. Stanley, 1986, Bedrock Geology of the Mount Abraham - Lincoln Gap Area, Central Vermont:
Special Bulletin No. 6, Vermont Geological Survey.....$3.00

2. Barbara A. Strehle and Dr. Rolfe S. Stanley, 1986 A Comparison of Fault Zone Fabrics in Northwestern Vermont: Studies in Vermont Geology No. 3,
Vermont Geological Survey...$3.00

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PUBLIC NOTICE

The State of Vermont, Department of Water Resources, now requires that permits be obtained by all persons engaging in recreational gold dredging or mineral mining activities in all waters of the State.

Persons wishing to engage in such activity must contact the Regional Engineer at the appropriate District Environmental Office and obtain a permit application.

Permit applications will be reviewed pursuant to the jurisdiction of 10 V.S.A., Chapter 41, Subchapter 2, "Stream Alteration" or Section 1272 of 10 V.S.A., Chapter 47, Subchapter 1, "Water Pollution Control".

Questions regarding projects subject to this jurisdiction should be addressed to the Regional Engineer at the appropriate District Environmental Office.

Regional Office Locations

Districts #1 and #8 (Rutland, Bennington Counties): RFD #1, West Cottage, Pittsford Police Academy, Pittsford, VT 05763, 483-2300.

Districts #2 and #3 (Orange, Windsor, Windham Counties): RFD Box 33, No. Springfield, VT 05150, 886-2215.

Districts #4 and #6 (Chittenden, Franklin Counties): 111 West Street, Essex Jct., VT 05452, 879-6563.

Districts #5 and #9 (Lamoille, Washington, Addison Counties): 255 North Main Street, Barre, VT 05641, 828-2454.

District #7 (Caledonia, Essex, Orleans Counties): 180 Portland Street, St. Johnsbury, VT 05819, 748-8787.

Issued March 1987

ERRATUM

We regret the ommission of several lines in the following abstract published in the Winter 1987 GMG. The second paragraph is reprinted here with the corrections.

A DATA MANAGEMENT PROGRAM FOR THE STUDY OF LAKE CHAMPLAIN BOTTOM SEDIMENTS

Hunt, Allen S. and Glenn W. Walters,
Department of Geology, University of Vermont,
Burlington, VT 05405

.....

In order to store and manipulate existing data, a management system has been developed using an IBM compatible personal computer and commercially available software including a data base management program and a spreadsheet. Sediment data is stored in a single master database which is subdivided into tables, each containing a particular type of data. The common factor between tables is the aereal location of the sediment sample which allows compilation of originally discrete data for any given site. The system also provides flexibility in that new information can be added as it becomes available. A variety of techniques exist within the system for use in combining data and extracting subsets for further analysis. Statistical procedures such as correlation and regression can readily be performed and data plotted for sediments either from any given area of the lake or for the lake as a whole. Such information is useful in understanding the lake's present day depositional processes. It will also provide a rational means of selection parameters necessary in order to construct a surface sediment map. The sediment data may be assembled for the map using a personal computer. The map may then be constructed by hand plotting or, if facilities are available, by loading the data onto a personal or mainframe computer equipped with the appropriate software and a plotter.

MEETINGS

MAY 2 — **VGS SPRING MEETING**
See page 3 for details.

MAY 1-3 — NAGT, Eastern Section in Stone Ridge, NY.
See Winter 1987 GMG for details.

JULY AUG — **VGS SUMMER FIELD TRIPS** are in the planning stage.
These trips will be of interest not only to members, but also to teachers, to whom we hope they will be of practical use. Look for the Summer Issue of the GMG for details.

AUG 1-2 — Burlington Gem and Mineral Club's annual show will be held in the library of the South Burlington High School. Look for details in the Summer GMG.

OCT 16-18 — The 79th annual meeting of the New England Intercollegiate Geological Conference will be sponsored by Norwich University with headquarters at Vermont College in Montpelier.
All VGS members should receive a mailing shortly.

OCT 24 — **VGS BANQUET and ANNUAL MEETING** will be held at the New England Culinary Institute in Montpelier. The search for a challenging SPEAKER is now underway. Information will be mailed early in October, with requests for reservations.

Oh my God
Said the Brachiopod
As the period was a changing
It's plain to tell
That on my shell
There'll be some rearranging.

JRock

GREEN MOUNTAIN GEOLOGIST
VERMONT GEOLOGICAL SOCIETY
BOX 304
MONTPELIER, VERMONT 05602

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FIRST CLASS

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

SUMMER 1987 VOLUME 14 NUMBER 2

Bring the family to a
"light-fare-for-a-summer-day"

SUMMER FIELD TRIP

Precambrian through Cambrian Rock Formations in the Vicinity of Middlebury, Vermont

followed by a

PICNIC AND SWIM

SATURDAY, AUGUST 29, 1987
(RAINDATE: AUGUST 30)

9:30 A.M. to noon

EXECUTIVE COMMITTEE will meet at lunchtime.
(See page 3 for details)

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PRESIDENT'S LETTER

Dear Members,

The field trip is coming up soon. I hope to see many of you at that time. We will have an executive committee meeting during lunch to discuss the fall meeting. All are welcome to join the executive committee and contribute to the discussion.

As you know I am concentrating on teachers in Vermont and what we have to offer them. One purpose of the society is to contribute to public education and promote the proper use and protection of natural resources. I would like to develop a list of professional geologists who are willing to make themselves available, on a LIMITED basis to teachers. By this I mean spend an hour or so on an informal basis sharing ideas with a teacher or teachers. Please let me know if you can be considered available should a teacher in your area be interested in learning more about your area of expertise. Some members are teachers, and I would appreciate hearing from you too.

Thank you for your time and consideration.

Sincerely,
Shelley F. Snyder

VICE PRESIDENT'S LETTER

Dear Friends,

President Shelley Snyder gave the VGS the challenge this year to explore ways the Society might assist Earth Science teachers at the secondary school level. A first thought was to urge Earth Science teachers to take their students outdoors where the students could experience earth products and processes directly. To this end, we have urged VGS members to examine how they might share their knowledge with local high school teachers and to put that knowledge into a concrete product such as a high school level field trip guide. I strongly urge your committment to this effort. The VGS would then like to start a collection of such guides to different areas of Vermont.

Secondly, the VGS is attempting to learn the needs of Earth Science teachers and to make known to them the resources available through the VGS. Shelley and I attended the April 4th meeting of the Vermont Science Teachers' Association (VSTA) at Norwich University and had useful discussions. We have been invited to meet with the VSTA Board of Directors and to submit writings to the VSTA newsletter. A first such article will appear in the September newsletter when the teachers return to school. Also, I have been invited to give an Earth Science workshop at the VEA/NEA Teachers' Convention in October. I shall do so and I will certainly include a geology component and elicit further discussion.

In closing, I personally urge you to reflect on where, when, and how you became excited about geology; to remember the innate and perhaps untapped curiosity in many of our young people; and to share your joy and excitement about geology with the young people who are our future.

Respectfully,
Jeff Pelton

SUMMER FIELD TRIP PROGRAM

TOPIC: A look at Precambrian through Cambrian rock formations in the vicinity of Middlebury, Vermont

LEADERS: Charles Ratté, State Geologist
Lucy Harding, Middlebury College

DATE: Saturday, August 29, 1987

RAINDATE: Sunday, August 30

TIME OF DEPARTURE: 9:30 A.M.

ASSEMBLY POINT: By the Science Center at Middlebury College. From the center of Middlebury village, drive west on VT125. The Science Center is the first large gray stone building on the left.

LUNCH: Bring your picnic lunch. **The last stop** will be a picnic lunch at a swimming hole in East Middlebury.

EXECUTIVE COMMITTEE: Will meet at lunchtime. All are welcome to attend.

FIELD TRIP GUIDE: A handout will be available on the morning of the trip.

This field trip is particularily suited for use by classroom teachers of secondary and upper primary grade school children. It is a non-technical trip that will also be suitable for families. We will look at: the Dunham Dolomite and its contact with the Cheshire Quartzite (both Cambrian formations); the Cheshire Quartzite and the various features in its quartzite layers which indicate the direction of the bedding tops, considering whether the formation is folded or flat lying and observing the reaction of its phyllite interlayers to tectonic forces; the Eocambrian to Precambrian Pinnacle Formation; and an outcrop of supposed Precambrian Mt. Holly Formation, discussing the possibility that it is really Cambrian Cheshire Quartzite.

VGS BUSINESS & NEWS

NOMINATIONS COMMITTEE REPORT

The Nomination Committee - Brewster Baldwin and James Ashley - submit the following slate of officers for election at the annual meeting, October 24, 1987:

President	Jeffrey Pelton
Vice President	John Malter
Secretary	Alan Liptak
Treasurer	David Westerman
Board of Directors, 2 year	Ray Coish
Permanent Committees	
Advancement of the Science	OPEN
Geological Education	Sharon O'Loughlin
Public Issues	Eric Lapp

SPRING MEETING WINNERS

The decreased enrollment of undergraduate geology majors in recent years has finally had its effect on our Society. Although the presentations were of no less quality than in past years, there were only 8 students who participated in our annual spring meeting.

Winners were Ebbe Hart ("Structure and Stratigraphy of the Green Mountain Front at East Middlebury, Vermont") from Middlebury College for the undergraduate prize and Thomas Armstrong ("Tectono-stratigraphic Geology of the Granville-Hancock area, Central Vermont") from University of Vermont for the graduate student prize. The judges also awarded an honorable mention to Flenner Linn and Keith Klepeis from Colgate University for their paper, "A Quantitative Determination of Strain and Percent Volume Loss in Slates of the Taconic Allochthon".

Thanks to our judges - Barry Doolan, Jeffrey Pelton and Kathy Gingerich.

WHITE GEOHYDROLOGY SOLD

Chris White has sold his consulting firm, White Geohydrology, Inc., to Caswell, Eichler and Hill as of August 1. Brad Caswell lives in Corinth, VT and served as a Maine state hydrogeologist for a number of years.

Chris is changing course and will be attending Columbia University this fall to study for an MBA degree. He will concentrate in finance with the goal of working in investments in solid waste and natural resources. We will see him around from time to time because his family will continue to live in the Burlington area.

In the wake of the sale of his business, Chris has some field equipment which he would like to sell. This includes:

1. A Yellow Springs conductivity meter
2. 2 Powers well probes
3. A soil penetrometer
4. A teflon ball well bailer.

VGS MEMBERSHIP LIST - AUGUST 1987

It has been over two years since the membership list has been published. Many names have been added and subtracted in that time. If you discover any errors of omission or commission, please inform the treasurer (Dave Westerman) or the editor (Jeanne Detenbeck). We try our best to keep our mailing list current and correct, but occasionally we do goof. Note that only names of individual members are included here. We also have 14 corporate members.

Spafford ACKERLY	Department of Geology, Snee Hall, Cornell University, Ithaca, NY 14853
Thomas ARMSTRONG	8 Ethan Allen Avenue #24, Winooski, VT 05404
James ASHLEY	RR 1 Box 133, Danville, VT 05873
Robert L. BADGER	Department of Geology, VPI, Blacksburg, VA 24061
Brewster BALDWIN	Science Center-Geology, Middlebury College, Middlebury, VT 05753
Donald K. BALMER	Shannon & Wilson, Inc., P.O. Box C-30313, Seattle, WA 98115
Larry BECKER	28.5 First Avenue, Montpelier, VT 05602
Marland P. BILLINGS	Department of Geological Sciences, 24 Oxford St., Cambridge, MA 02138
Robert BLACK	P.O. Box 77, Pittsford, VT 05763
Mimi BOXWELL	Department of Earth Sciences, James Hall - UNH, Durham, NH 03824
Dwight C. BRADLEY	Dept. of Earth and Planetary Sci., Johns Hopkins Univ., Baltimore, MD 21218
James BUTLER	Dept. of Geology, 029-A, Univ. of No. Carolina, Chapel Hill, NC 27514
David BUTTERFIELD	38 George Street, Montpelier, VT 05602
Gwen BUTTLES	RR 2 Box 2952, Charlotte, VT 05445
Wallace CADY	348 South Moore Street, Lakewood, CO 80226
Stewart CLARK, Jr.	25 Marvin Street, Montpelier, VT 05602
Ray COISH	Science Center-Geology, Middlebury College, Middlebury, VT 05753
E. Stanley CORNEILLE, Jr.	4 Terrace Street, Randolph, VT 05060
John COTTON	P.O. Box 31, East Andover, NH 03231
Bret W. COX	985 North Avenue, Apt. E2, Burlington, VT 05401
Bruce COX	Dufresne-Henry, Inc., Precision Park, No. Springfield, VT 05150
Mary CRANDALL	17 North Street, Rutland, VT 05701
Fred CROWLEY	RR 2 Box 172, Springfield, VT 05156
Robert V. CUSHMAN	20 Court Street, Middlebury, VT 05753

Kevin DANN	Texas Hill Road, Huntington, VT 05462
James DAWSON	Center for Earth and Environmental Science, SUNY, Plattsburgh, NY 12901
Vincent DELLORUSSO	27A Chapman Lane, No. Williston, VT 05495
Jeanne C. DETENBECK	29 Collamer Circle, Shelburne, VT 05482
Robert J. DINEEN	c/o NYS Geol. Soc., RM3160 Cul. Ed. Center, ESP, Albany, NY 12230
Charles G. DOLL	1 Mansfield Avenue, Essex Jct., VT 05452
Barry DOOLAN	Department of Geology, University of Vermont, Burlington, VT 05405
John DRAKE	Department of Geology, University of Vermont, Burlington, VT 05405
Ballard EBBETT	RFD 1, Lyndonville, VT 05851
Sandria EBBETT	RFD 1, Lyndonville, VT 05851
Richard M. FISCHER	P.O. Box 1057, Montpelier, VT 05602
Brian FOWLER	RFD 7 Box 159, Gilford, NH 03246
Charles FOX	25 Denison Apt. 202, Hartford, CT 06105
David A. FRANZI	Center for Earth and Environmental Science, SUNY, Plattsburgh, NY 12901
John GARVER	Geological Sciences AJ-20, University of Washington, Seattle, WA 98915
Lawrence GATTO	RR 1 Box 371, Fairlee, VT 05045
Richard P. GILLESPIE	15 Spencer Drive, Nashua, NH 03060
Steven GOLDBERG	666 East Main Street, P.O. Box 2006, Middletown, NY 10940
Peter GOREAU	Science Center-Geology, Middlebury College, Middlebury, VT 05753
Eric R. HANSON	RR #1 Box 193, Huntington Center, VT 05462
Lucy HARDING	Science Center-Geology, Middlebury College, Middlebury, VT 05753
Glen HARRINGTON	130 Ipswich Road, Topsfield, MA 01983
Norman L. HATCH, Jr.	MS 926, U.S. Geological Survey, Reston, VA 22092
Herbert E. HAWKES	RFD 2 Box 162-5, Orleans, VT 05860
Joseph J. HAYES	RD 3 89 Terrace Street, Montpelier, VT 05602
Brian HECKENBERGER	49 Greenwood Terrace Apt. C-2, Montpelier, VT 05602
Craig HEINDEL	Wagner, Heindel & Noyes, Inc., P.O. Box 1629, Burlington, VT 05402-1629
J. Christopher HEPBURN	Geology and Geophysics, Boston College, Chestnut Hill, MA 02167
Malcolm HEYBURN	201 Walnut Tree Hill Road, Sandy Hook, CT06482
Arthur L. HODGES, Jr.	P.O. Box 26, Camden, DE 19934
Jon M. HOLLMAN	88 Berkshire Road, Newtonville, MA 02160
George E. HOLMAN	Elmore Mountain Road, Morrisville, VT 05661
John T. HUMPHREY	P.O. Box 108, Cambridge, MA 02142
Allen S. HUNT	Department of Geology, University of Vermont, Burlington, VT 05405
Brad JORDAN	Earth Science, Norwich University, Northfield, VT 05663
Robert JORDAN	Delaware Geological Survey, University of Delaware, Newark, DE 19716

Paul KARABINOS	Department of Geology, Williams College, Williamstown, MA 01267
H. Douglas KLEMME	R.R. 1 Box 179B, Bondville, VT 05340
Shirley KNOWLTON	Box C, South Londonderry, VT 05155
Kurt KOELLA	2922 S. Ninth Street #D, Kalamazoo, MI 49009
Robert G. LaFLEUR	Department of Geology, RPI, Troy, NY 12181
Eric LAPP	11 Greenfield Road, Bldg. 1 Apt. 3, Essex Jct., VT 05452
Fred LARSEN	9 Slate Avenue, Northfield, VT 05663
Crea LINTILHAC	Box 6080, Barnes Hill, Waterbury Center, VT 05677
Alan LIPTAK	11 Green Street Apt. 4, Bellows Falls, VT 05101
Leah MACH	P.O. Box 551, Battle Mountain, NV 89820
John MALTER	23 Hubbard Street, Montpelier, VT 05602
Winona MANNING	Route 1 Box 164, Williamstown, VT 05679
Ronald MARCOTTE	Box 71, Bakersfield, VT 05441
Linda G. MAREK	Extension Service, School of Nat. Res., Univ. of Vt., Burlington, VT 05405
Cameron McCORMACK	P.O. Box 402, Montpelier, VT 05602
Gregory McHONE	Department of Geology, University of Kentucky, Lexington, KY 40506-0059
Lance MEADE	P.O. Box 133, Pittsford, VT 05763
Charlotte MEHRTENS	Department of Geology, University of Vermont, Burlington, VT 05405
Mary Ann MENTO	RD #1, Arlington, VT 05250
Carolyn MERRY	P.O. Box 85, Enfield Center, NH 03749
Thomas S. MOON	Physics Department, Norwich University, Northfield, VT 05663
Alexis P. NASON	8 Timber Lane, Brattleboro, VT 05301
Duncan OGDEN	Landgrove, Londonderry, VT 05148
Sharon O'LOUGHLIN	11 Greenfield Road B1 Apt. 3, Essex Jct., VT 05452
Susan OPPENLANDER	12B Timberlake Drive, Colchester, VT 05446
Margaret G. OTTUM	RFD 2 Box 617, Johnson, VT 05656
Ronald PARKER	50 Pomeroy Street, Burlington, VT 05401
Sanborn PARTRIDGE	62 Ormsbee Avenue, Proctor, VT 05765
Jeffrey L. PELTON	RR 1 Box 86, Perkinsville, VT 05151
Mark PHILLIPS	276 W. Breckenridge, Ferndale, MI 48220
Rod PINGREE	P.O. Box 267, Jonesville, VT 05466
Andy RAIFORD	Geology Department, Castleton State College, Castleton, VT 05735
Nicholas RATCLIFFE	MS 925, U.S. Geological Survey, Reston, VA 22092
Charles A. RATTE'	4 Chestnut Hill, Montpelier, VT 05602
Thomas C. RAY	19 Pinehurst Drive, Shelburne, VT 05482
Stephen REVELL	RD #1 Box 128-B, Bristol, VT 05443

Dorothy A. RICHTER	180 N. Policy Street, Salem, NH 03079
Edward H. SALVAS	P.O. Box 396, Johnson, VT 05656
Jill SCHNEIDERMAN	Dept. of Geological Sci., Harvard Univ., 24 Oxford St., Cambridge, MA 02138
Ethel SCHUELE	33 Clover Street, So. Burlington, VT 05403
William SIOK	RD 1, Sherman Ave., Exeter, NH 03833
Rev. James SKEHAN	Weston Observatory, Boston College, Weston, MA 02193
Shelley SNYDER	72 Blacklantern Lane, So. Burlington, VT 05403
Stephen SOLOMON	Dept. of Geology, Memorial Univ., St. Johns, Newfoundland A1B 3X5, Canada
Bill SPITZEL	RR 2 Box 2952-A, Charlotte, VT 05445
D. Randall SPYDELL	P.O. Box 325, Hartford, VT 05047
Rolfe STANLEY	Department of Geology, University of Vermont, Burlington, VT 05405
James B. STEWART II	Terrace Heights, RD #1, Middlebury, VT 05753
William E. STOCKWELL	P.O. Box 24, Bomoseen, VT 05732
Steven J. STOKOWSKI, Jr.	Consulting Geologist, 10 Clark Street, Ashland, Ma 01721
Byron D. STONE	National Center MS 928, U.S. Geological Survey, Reston, VA 22092
Chris STONE	Calais Stage Box 910, Montpelier, VT 05602
Sharon STRASSNER	Meadow Way, Middlebury, VT 05753
John STRUNK	Box 4430, Mountain Road, Bristol, VT 05443
Sharon H. TANGEMAN	31 E. Spring Street Apt. 512, Winooski, VT 05404
David TARBOX	Seaburn & Robertson, Inc., Suite 307, 1516 Hillcrest St., Orlando, FL 32803
Peter J. THOMPSON	519 First Street West, Mt. Vernon, IA 52314
Roger B. THOMPSON, Jr.	RFD #2 Box 745, Woodstock, VT 05091
Terry F. THOMPSON	RFD #2 Box 745, Woodstock, VT 05091
Thelma THOMPSON	519 First Street West, Mt. Vernon, IA 52314
Preston TURNER	12 Walnut Street, Berlin, MA 01503
Diane M. VANECEK	Dole Hill RD# 1, Northfield, VT 05663
John S. WARREN	81 Green St., Brattleboro, VT 05301
Paul A. WASHINGTON	Box 75, E. Middlebury, VT 05740
Bruce G. WATSON	RR# 1 Box 787, So. Hero, VT 05486
Donald WERNECKE	Rte 3 Box 47, St. Johnsbury, VT 05819
David WESTERMAN	Earth Science, Norwich University, Northfield, VT 05663
Christopher WHITE	52 Seymour St., Middlebury, VT 05753
Nancy A. WILLIAMS	808 Della Drive, Lexington, KY 40504
Bruce D. WILSON	RD 2 Box 406, W. Brattleboro, VT 05301
Philip WINNER	584 So. Race Street, Denver, CO 80209
Michael WURTH	The Johnson Co., Inc., 5 State Street, Montpelier, VT 05602

CLIONA, THE BORING SPONGE, FROM THE DEVONIAN SHAW MOUNTAIN FORMATION, VERMONT

Charles G. Doll
Emeritus Professor of Geology
University of Vermont

ABSTRACT

Some interesting detail regarding *Cliona* in Plate 7, Figure 13 in Doll, 1984, is cited.

INTRODUCTION

The original purpose of the photograph in Plate 7, Figure 13 (Doll, 1984), taken at the Seaver Branch locality was to show echinoderm debris on the surface of a thin slab of the fossiliferous limestone, not knowing at the time that a rare Devonian fossil was also being photographed. Further study of the photograph revealed the fossil to be that of *Cliona*, the boring sponge. Continued scrutiny disclosed that *Cliona* is positioned at the posterior or hinge end of a brachiopod shell whose outer form and anterior border show through a veneer of fine-grained sediment (Fig. 1). (Also, in Doll, 1984, Plate 3, Figure 6, two fossil Clionas, one at the right anterior edge and the other at the right hinge end of a brachiopod shell, show their destructive work well.)

THE FOSSIL

Fossil specimens of *Cliona*-like borings from the Devonian have been termed *Clionolithes* and *Clionoides*. The writer's first acquaintance with these perforated brachiopod shells was in a beginning course in paleontology in college. At that time their actual architect was said to be unknown and this seems to be true today. In researching the literature, including textbooks on paleontology (few of the latter mentioning *Cliona* along with the sponge's marking on and perforations in shells; two of the more recent textbooks examined labeling and interpreting as *Cliona* what appear to be the vestiges of the boring sponge) the writer has been unsuccessful in locating a graphical description of a Devonian specimen. It still appears that in earlier papers only the fossil's destructive accomplishments are recorded. *Cliona*, the boring sulphur sponge, is classified among the monactinellida whose specular symmetry is monaxon.

The writer's somewhat generalized and interpretive drawing of *Cliona* is shown in Figure 2.

Further study of the photographed specimen has disclosed an apparent largeness of *Cliona*, which, coupled with several small marginal specimens sprouting spicules, could be indicative of a budding interval. Budding (asexual) is given as the usual mode of reproduction among the sponges. Offsprings of *Cliona* appear as new tubular extensions at the margin of the parent.

ACKNOWLEDGMENTS

The writer remembers well the enthusiasm of Robert B. Erwin, field assistant, in collecting fossils at the Seaver Branch locality, when the photograph of the limestone slab was taken in the early 1950s. The fossil has been discussed with Prof. Allen S. Hunt, Paleontologist in the Department of Geology, University of Vermont, who made helpful suggestions. The fossil's identity was determined by the writer and ideas expressed in connection with the fossil are his also. He appreciates the reading of the manuscript and comments by Profs. Allen Hunt and Barry Doolan.

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Figure 1. *Cliona* on brachiopod shell in upper right side of limestone slab, one inch to left of arrow head

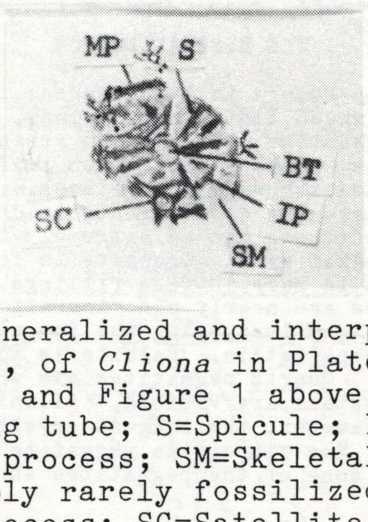

Figure 2. Generalized and interpretive drawing, by the author, of *Cliona* in Plate 7, Figure 3 (Doll, 1984), and Figure 1 above. Magnification 1X. BT=Boring tube; S=Spicule; IP=Probable interspicule process; SM=Skeletal membrane and cover (probably rarely fossilized); MP=Marginal connecting process; SC=Satellite *Cliona* (other marginal Clionas).

A HYDROTHERMAL MINERAL SYSTEM IN AND AROUND SEARSBURG RIDGE, SOUTHERN VERMONT

Paul A. Washington *
Department of Geology and Geophysics
University of Connecticut
Storrs, CT 06268

INTRODUCTION

During the course of uranium exploration within the Mount Holly complex of southern Vermont, a hydrothermal mineral system was discovered in and around Searsburg ridge. The minerals include various sulfides, graphite, thorium (mainly in allanite) with traces of uranium, and minor arsenides. Most of the mineralization occurs within pegmatites and veins, but disseminated graphite and iron sulfides are not uncommon.

THE AREA

Searsburg ridge is a northeast trending ridge with about 350 m topographic relief bound on the east by the Deerfield River and on the west by Pine and Rake Brooks with their many swamps. Vt. rte. 9 traverses it east-west providing a series of low, but useful roadcuts, and Vt. rte. 8 runs along its eastern slope, meeting rte. 9 at the crest of the ridge. The area is very sparsely settled, most of the land being owned by the Green Mountain National Forest.

The rocks (Fig. 1) comprising the ridge are primarily gneisses (with minor quartzite and calc-silicate) of the Mount Holly complex (Skehan, 1961). The contact with the overlying metasediments lies in the valley along the east side of the ridge. Despite the topographic relief, outcrop is very sparce over much of the ridge.

THE MINERALIZATION

Mineralization occurs in three forms: in pegmatites, in fissure fillings (which I will call veins), and disseminated through a host rock. The sulfides and arsenides generally are restricted to veins, although some iron sulfides also are locally disseminated through the gneisses. Thorium, on the other hand, is apparently always restricted to pegmatites, generally allanite (these can be extremely thin and virtually invisible to the naked eye). Graphite is found in all three forms, although it is rare in vein fillings.

The pegmatites are nearly monomineralic. Most are quartz, the only exceptions being the few allanite pegmatites and one microcline pegmatite. Calcite is not found anywhere within the system. Quartz pegmatites are white to clear and few individual crystals are visible. Allanite occurs in crystals up to 1 cm diameter, the largest crystals occurring in the widest veins. The microcline pegmatite contains crystals up to 7 cm long. None of the pegmatites show any sign of tectonic fabric.

* Mailing address: Box 75, East Middlebury, VT 05740

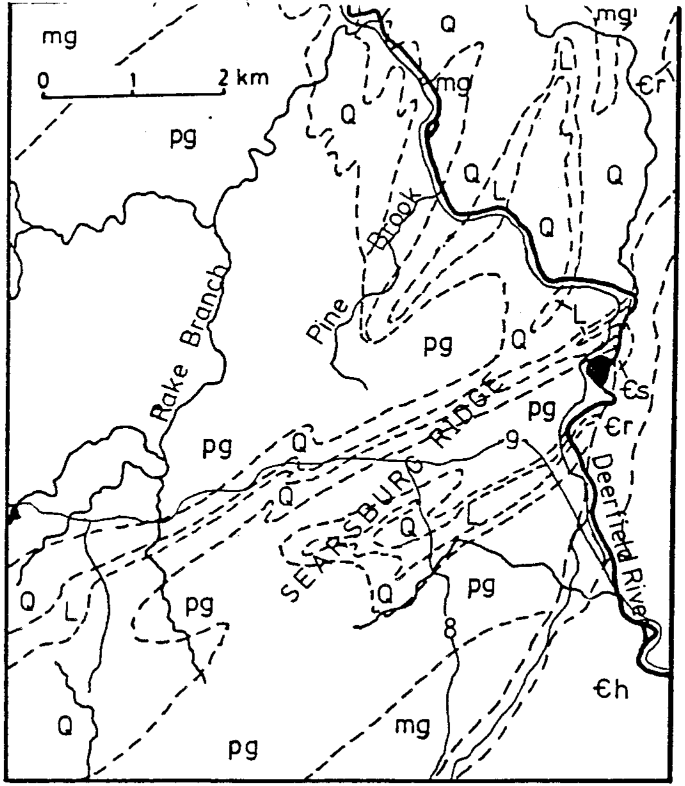

Figure 1. Geology of the area around Searsburg ridge after Skehan (1961).
pg - plagioclase gneiss;
mg - microcline gneiss;
Q - quartzite and quartz-gneiss;
L - calc-silicate and white gneiss;
Cs - Searsburg conglomerate;
Cr - Readsboro schist;
Ch - Heartwellville schist.

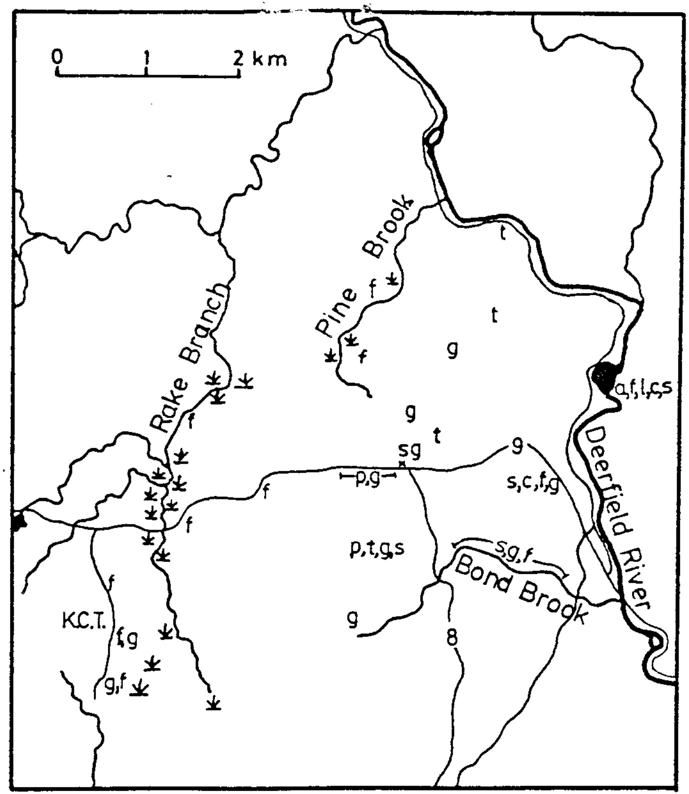

Figure 2. Hydrothermal mineral localities around Searsburg ridge.
K.C.T. - Kelly Camp Trail; s - sulfur;
g - graphite; f - iron sulfides;
l - galena; c - copper sulfides;
a - arsenides; p - pegmatites;
t - thorium (in allanite).

The most common matrix material in the veins is native sulfur, with a few veins being primarily metal sulfides, a couple having graphite matrix, and one being primarily arsenides. The most common sulfide is pyrrhotite, but it is normally found disseminated through the host rock. Within the veins, the primary sulfides are galena and various copper sulfides (including covallite and bornite). The commonness of graphite makes identification of molybdenite difficult, but a few flakes were spotted. The weathering of the arsenide vein and most of the sulfide veins makes identification of primary minerals difficult.

Disseminated minerals are generally limited to graphite and pyrrhotite. Some graphite flakes are larger than 1 cm diameter. Although generally a small component of the total rock, graphite locally exceeds 10% of the total rock volume. Pyrrhotite is generally secondary to graphite, but locally becomes the primary mineral where graphite is sparse. Pyrrhotite never occurs without graphite, but graphite frequently occurs without pyrrhotite.

Additionally, one breccia pipe was found. The matrix consists of nearly equal parts sulfur, graphite, and quartz. The included wall rock is a biotite-microcline-quartz gneiss highly altered by the infusion of sulfur and graphite. The width of the pipe (actually it is shaped more like a dike) is over .5 m.

AREAL DISTRIBUTION OF MINERALIZATION

The mineralization is quite unevenly distributed across the area (Fig. 2), small areas being quite mineralized with adjacent areas barren. Nevertheless, a definite pattern emerges.

Thorium is only found along the crest of the ridge and along the Deerfield River where it crosses the north end of the ridge. No significant radiation anomalies were found outside of this trend. Also restricted to this same zone are the pegmatites. The quartz pegmatites are best exposed in the roadcuts along rte. 9 just west of the intersection with rte. 8. The microcline and widest allanite pegmatites are buried atop the ridge beneath a power transmission line about 1 km to the south.

The most extensive graphite mineralization also follows the crest of the ridge, occurring in and around the pegmatites. Rather than the very spotty distribution of the pegmatites, the graphite is found over much of the ridge crest. It is, however, most concentrated near the pegmatites, with the highest concentration being within the breccia pipe near the intersection of rtes. 8 and 9. Otherwise the graphite is always associated with pyrrhotite mineralization, the best example being along Kelly Camp trail to the west of the ridge.

The sulfide mineralization, including pyrrhotite, is generally restricted to the valleys along each side of Searsburg ridge. The only good outcrops are found in roadcuts and the Searsburg dam exposure (all recently exposed surfaces). The most interesting mineral exposures are on the east side of the ridge near or in the Deerfield River. Copper minerals are found in a new (1978) roadcut on rte. 9, and galena with some minor copper sulfides is found at the Searsburg dam just over 1 km northeast. Also, galena was reported by Hitchcock and others (1861, p. 607, 609, sample II-68) from a boulder between these two localities. Outside of this area, most of the sulfide mineralization is pyrrhotite.

Where there is mineralization, the outcrop is very sparse. Often, the occurrence of the mineralization is only marked by iron and sulfur-stained rocks in stream beds. Using this evidence, sulfide mineralization extends south along the line of swamps on the west side of the ridge and southwest across Bond Brook on the east side of the ridge.

DISCUSSION

The areal distribution of hydrothermal minerals around Searsburg ridge are those expected for a hydrothermal mineral system. The pegmatites and associated high temperature phases (i.e., sulfur and allanite) are distributed along the axis with the lower temperature metal sulfides along the flanks. Since the pegmatites are clearly post-tectonic, the igneous source of these deposits must be buried beneath the ridge.

From a petrologic standpoint, this system is interesting in the large amount of graphite without any accompanying calcite. Apparently, the partial oxygen pressure (P_{O2}) in the "ore-bearing" fluids was very low, making graphite the stable carbon phase. This is confirmed by the occurrence of native sulfur which might otherwise have escaped as SO_2.

Additionally, the relatively small amount of non-iron mineralization and large amounts of excess sulfur suggest that the source body was poor in metals, especially non-iron metals. Interestingly, the source was at least somewhat rich in thorium, but little uranium was ever found (much to the chagrin of Urangesellschaft USA which was bankrolling the exploration effort); the low P_{O2} should have driven the uranium into silicate phases (e.g., microcline and/or allanite) if it had been present, but very little was present.

Finally, it should be noted that this system sheds additional light on the nature of the rocks concealed beneath the Green Mountain massif. The large quantities of graphite and sulfur would be consistent with an igneous body passing up through organic-rich strata, and the low P_{O2} indicates a lack of carbonates. Thus, any strata underlying the eastern Green Mountain massif in this area would most likely be continental rise or abyssal plane sediments.

ACKNOWLEDGMENT

The work reported here was done while the author was employed by the Urangesellschaft USA.

REFERENCES CITED

Hitchcock, Edward, Hitchcock, Edward, Jr., Hager, A.D., and Hitchcock, C.H., 1861, Report on the Geology of Vermont: Claremont, N.H., 982p.

Skehan, J.W., 1961, The Green Mountain anticlinorium in the vicinity of Wilmington and Woodford, Vermont: Vermont Geological Survey, Bulletin 17, 159p.

RECENT PUBLICATION

Roadside Geology of Vermont and New Hampshire
by Bradford Van Diver
Paperback $9.95 + $1.00 postage
1987 230 pages ISBN 0-87842-203-X

Mountain Press Publishing Comapny
P.O. Box 2399
Missoula, Montana 59806

Two years ago, I reviewed Roadside Geology of New York. Now, a companion volume by the same author, combining the geologies of Vermont and New Hampshire, has been published.

A discussion of pertinent geologic topics - minerals, rocks, geologic time, physiographic provinces, plate tectonics, and structural and glacial geology - in the first 50 pages, is an introduction for the non-geologist. Following this, the local bedrock and glacial histories are discussed in each road section chapter, and significant roadside features are described as the miles pass by. Sometimes short detours are suggested to points of interest such as mineral collecting sites. Each road section chapter is accompanied by a geologic map helpfully drawn by the author. Photos also show some scenes described in the text that are visible from the road. (I puzzled at a spectacular offset basalt dike pictured along Interstate 89 in New Hampshire, a road I have traveled many times in 20 years. To my chagrin, it was there; I had never looked aside at the right spot!)

The roads taken in Vermont are Interstates 89, 91 & 93, US4, US302, US9, VT100, VT125, US7 south from Burlington, US2 through the Champlain Islands, US2 from Montpelier east, and a northern traverse from Alburg to Derby Center. Separate chapters describe the Proctor marble quarries, the Barre granite quarries, Mt. Mansfield Toll Road, and Smugglers Notch.

To readers who know something about Vermont geology, the book will seem too brief. However, the large-scale tectonic picture which the author uses* reveals the landscape in a new light as it passes by at 50+ mph. This book deserves a place on the geologist's bookshelf, but it cannot substitute for field trip guides which deal in greater detail with specific rock outcrops.

*The author acknowledges that the 1985 GSA Bulletin paper by Rolfe Stanley and Nicholas Ratcliffe ("Tectonic Synthesis of the Taconic Orogeny in Western New England") provided a framework within which he could simplify his description of the complex plate tectonics events that occurred in this area.

Submitted by J.C. Detenbeck

Fossils are critters and other good stuff
Like flowers and plants that are quite old enough
Fossils are fun and they're interesting too
But you won't find no fossils down in the zoo.

JRock

STUDENT ABSTRACTS

These two abstracts were not available for publication in the Spring 1987 Green Mountain Geologist.

GLACIAL LAKE-SHORE LEVELS IN THE LAMOILLE VALLEY, VERMONT

Abendroth, Diane C., Department of Geology,
Middlebury College, Middlebury, VT 05753

Glacial lake shorelines, in the upper Lamoille Valley of Vermont, have been identified from a number of deltas and beach terraces. This has been accomplished by examining gravel pits and other exposures in the area between Hardwick and Morrisville. In addition, pertinent features have been interpreted from topographic maps.

Five lake-shore levels have been determined. Their elevations are approximately 1100, 900-920, 800, 740, and 660-680 feet AMSL. The shore levels in the Lamoille Valley were compared with lake stages identified by other studies in the neighboring Winooski, Stowe and Memphremagog valleys. This was possible with the use of correction factor of 4 ft/mile to N 10° W to construct water planes consistent with isostatic rebound (Larsen, 1972).

It is determined that the Lake at 1100 feet extended into the Stowe valley, but not through to the Winooski, or north into the Memphremagog, due to obstruction by glacial ice. The lake at 900-920 ft. appears to have been part of a stage of Glacial Lake Memphremagog (Hitchcock, 1906). No evidence for this lake level is found in the Winooski basin. The lake at 800 feet probably extended through the Stowe and Winooski, but was unable to cross the Elligo threshold into the Memphremagog Valley. The next shore level at 740, was confined to the Lamoille Valley. The evidence for shorelines between 640-680 may be attributed to Coveville Lake Vermont, which appears to have extended as far east as Morrisville in the Lamoille Valley.

A QUANTITATIVE DETERMINATION OF STRAIN AND PERCENT VOLUME LOSS IN SLATES OF THE TACONIC ALLOCHTHON

Linn, Flenner and Keith Klepeis, Department of Geology,
Colgate University, Hamilton, NY 13346

A study of strain using reduction spots and magnetic susceptibility anisotropy (MSA) has been conducted on slates of the Taconic Giddings Brook Slice. A comparison of the strain magnitudes using MSA and reduction spot analysis reveals that the two techniques produce similar results and suggests that MSA is a viable strain indicator in slates of the Taconic allochthon. Two sites in the Lake Bomoseen, Vermont, area were studied around a large (~1 km wavelength, ~3 km amplitude) overturned similar fold, on the hinge and limb respectively. The maximum to minimum strain ratios on the limb average to be 1.14 and the ratios on the hinge average to be 1.20. The strain data indicate that despite the overturned nature of the fold the cleavage developed through coaxial deformation. A deformation path has been deduced from deformation plots and is interpreted to represent the portion of deformation when volume loss was significant in the development of slaty cleavage. Scanning electron microscopy (secondary and backscatter modes) were used to recognize the domain-

al nature of slaty cleavage and to assess variations in the degree of its development between the two sites. In addition, SEM and petrographic analysis do not reveal pressure shadows, quartz veining or any other evidence for the recrystallization of quartz and feldspar within the slates. We, therefore, conclude that soluble quartz and feldspar have been removed from the system through pressure solution. Energy dispersive spectroscopy (EDS) has facilitated the semi-quantitative determination of the relative amount of silica loss between the quartz-poor and quartz-rich domains. The strain magnitudes have been compared to the percent volume loss between domains and a correlation has been made between strain magnitudes and volume loss during deformation. The role of volume loss in the modification of the overturned similar fold has also been determined.

A WOODS HOLE (WHOI) WORKSHOP

What, you may well ask, does oceanography have to do with Vermont geology? Read on if you advise students, have children of your own nearing college age, or are just concerned with the future of the geological sciences, because there is a message here for you.

I had the pleasure of accompanying my husband to Woods Hole Oceanographic Institute this June, where he was an invited participant in a College Teacher's Workshop. For one week we were treated to a series of lectures presented by members of each of the five departments of the Institute - physical, chemical and biological oceanographies, ocean engineering, and marine geology and geophysics - reporting about their current research. The purpose of the workshop was to introduce the 22 math, science and engineering college teachers to the exciting ongoing research in oceanography so that they will encourage students to enter the field for their graduate study. Unlike other geological scientists who are suffering from the loss of oil company support, oceanographers believe they are assured of increased funding for future research. The WHOI graduate program (in conjunction with MIT), as well as the other 8 members of JOI (Joint Oceanographic Institutes), are looking for applicants to their graduate programs who not only have good grades, but also have solid backgrounds in science and math and can demonstrate the ability to work independently. Math is an important word here, and the message is that geologists and biologists can no longer avoid being well-grounded in calculus and differential equations.

This workshop (as well as a similar one held in Seattle, Washington) will be held again next year. Advertisement for applicants will appear in professional publications, or interested faculty can write to: A. Lawrence Peirson, III, Assistant Dean, Education Office, Woods Hole Oceanographic Institute, Woods Hole, MA 02543

Submitted by J.C. Detenbeck

MEETINGS

AUG 29 **VGS SUMMER FIELD TRIP.**
See page 3 for details.

OCT 16 17 18 New England Intercollegiate Geological Conference sponsored by Norwich University at the Vermont College Campus in Montpelier. If you have not received a mailing and still want to attend these three days of field trips, contact:
David Westerman, Dept. of Earth Science, Norwich University, Northfield, VT 05663, (802)+485-2337.

OCT 24 **VGS FALL BANQUET AND ANNUAL MEETING**
A delicious dinner at the New England Culinary Institute has been planned, and at press time, arrangements are being made to have a distinguished guest speak to us after dinner. Details will appear in the Fall GMG. Save the date.

Again this fall, the Geology Department of the University of Vermont announces a lecture series. Lectures will be held in Perkins Building, Room 200 at 3:45 PM. For further information, contact Dr. Rolfe Stanley, Geology Department, University of Vermont, Burlington, VT 05405, (802)+656-3396.

SEPT 21 Dr. John Craighead, University of Vermont,
Minerals, Dust and Disease.

SEPT 28 Dr. Geoffrey Thompson, Woods Hole Oceanographic Inst.,
Hot Springs, Black Smokers and Ore Formation on the Mid-Atlantic Ridge.

OCT 5 Dr. Bruce Corliss, Duke University,
Functional Morphology of Deep-Sea Benthic Foraminifera and Paleoceanographic Implications.

OCT 19 Dr. Richard Nickelson, Bucknell University,
Structural Evolution of the Appalachian Foreland in Pennsylvania.

NOV 3-5 Dr. John Sutter, U.S.G.S., Branch of Isotopic Geology,
SHORT COURSE: Thermochronology.

NOV 16 Dr. Dwight Bradley, Lamont Geological Observatory,
Tectonics of the Acadian Foredeep in the Northern Appalachians.

The Kame came over the mountain
The Kame came over the sea
Funny thing about that Kame
It just came over me.

JRock

GREEN MOUNTAIN GEOLOGIST
VERMONT GEOLOGICAL SOCIETY
BOX 304
MONTPELIER, VERMONT 05602

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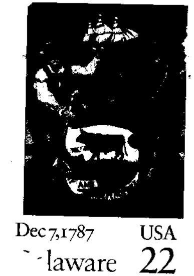

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PM

FIRST CLASS

Charles A. Ratté
4 Chestnut Hill
Montpelier, VT 05602

THE **GREEN MOUNTAIN GEOLOGIST**

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

FALL 1987 VOLUME 14 NUMBER 3

Don't miss this opportunity
to meet your fellow members during the

VGS FALL BANQUET & ANNUAL MEETING

at the
New England Culinary Institute
Montpelier, Vermont

SATURDAY, OCTOBER 24, 1987

starting at 5:00 P.M.

THE HONORABLE ROBERT STAFFORD

Senior Senator from Vermont

will speak about environmental issues

Make your reservations now!

DEADLINE OCTOBER 19, 1987

See page 3 for details.

Contents PAGE

PRESIDENT'S LETTER

Dear Members,

This is my last letter to you as President of this Society. I think we have started some exciting new contacts. Although slow in coming, teachers are beginning to seek us out to get information on Vermont Geology. In South Burlington the elementary schools are making a big push to study Vermont rocks, the rock cycle and why Vermont topography looks the way it does. I believe that this will slowly work its way up through the system. In any case, there is some positive dialogue between teachers and members of the Society.

Several field trips have been submitted and will be made available to teachers. Many members have come forward indicating an interest and desire to work with teachers on a limited basis to get Vermont geology in the classroom.

The summer field trip led by Chuck Ratte' was an excellent demonstration of how to organize a field trip using published materials.

The format for the fall business meeting will be a little different this year. Instead of a field trip and dinner, we will be having Senator Stafford speaking to the group. His topic will be environmental issues. I urge you to attend and I believe the evening will be an exciting one.

Sincerely,
Shelley Snyder

VGS BUSINESS & NEWS

GRANT-IN-AID

The Grand-in-Aid for Research money has been awarded for two projects which are now underway. Recipients are:
Eve Witten of the Environmental Studies Department at University of Vermont for "The correlation between the presence of radon gas and phosphate in dolostone rock in the Milton, Vermont area" and Michael Smith, Joseph Fiacco and Shaw Healy, Norwich University students whose joint project is "Relationship of ground water quality to geologic source for rock wells in central Vermont". The latter project will be completed by the end of the fall semester. Congratulations to these students. We look forward to presentation of these projects at future VGS meetings.

[Continued on page 4.]

VGS FALL BANQUET & ANNUAL MEETING

SCHEDULE:
- 5:00 P.M. Cash bar opens.
- 6:00 P.M. Dinner is served.
- 7:00 P.M. Senator Robert Stafford will speak about environmental issues.
- 8:30 P.M. (approximately) Annual Meeting and Election.

LOCATION: New England Culinary Institute, 250 Main Street, Montpelier, Vermont.

DIRECTIONS: From beautiful downtown Montpelier, drive north-easterly on Main Street, up the hill. At the steepest part of the hill, the road swings into a sharp left hand curve. As the road straightens and the grade flattens, immediately on your left is the New England Culinary Institute.

SEE ALSO MAP ON PAGES 8-9.

DINNER MENU:

Cream of vegetable soup
Tossed salad
Entree - choice of:
1. Chicken breast with roasted tomatoes and port wine sauce
2. Salmon on basil sauce

Rice with saffron
Dessert - choice of:
1. Fresh pear poached in wine
2. Apple tart

COST: $14.50 plus 6% meals tax plus 17% gratuity (approximately $18.00). Payment will be due at night of banquet.

RESERVATIONS: Must be made no later than OCTOBER 19th.

BY MAIL: Send the completed reservation form from page 11 in this newsletter to:
John Malter
P.O. Box 176
Waterbury, VT 05676.

BY PHONE: Call John Malter at (802)+244-7373 or Shelley Snyder at (802)+658-0575.

NOTE: Members and their friends who prefer to attend only the after-dinner speech and the annual meeting are welcome to come at 7:00 P.M. There will be ample seating for you.

ABSENTEE BALLOT: If you cannot attend, mail in your absentee ballot on page 13.

VGS BUSINESS & NEWS [Continued from page 2.]

TREASURER'S REPORT

Dave Westerman reports that our treasury has been moved successfully to a statement savings account in the Northfield Savings Bank. This account does not have the excessive charges that the previous one did and single cashier's checks or money orders are free of charge for money withdrawn. The current balance is $1841.64.

MEET THE OFFICERS

Jeff Pelton is our current Vice President and the nominee for President next year. He grew up in the rural farming community of West Rupert, Vermont in northern Bennington County. His education included elementary and secondary education at Salem Central School, Salem, New York; a B.A. degree in Economics from Middlebury College (1964); and a Masters of Natural Science from the University of Oklahoma (1972). Two years of service in the U.S. Army, including a tour in Vietnam, were followed by seventeen years of teaching science, primarily Earth Science, at Springfield High School. Current employment is with Soils Engineering, Inc., Charlestown, New Hampshire. In 1985 Jeff was an Earthwatch volunteer researcher studying the volcano Askja in Iceland under Dr. Geoff Brown, the Open University, England. Jeff has a stepson entering his sophmore year at Brown University, Providence, Rhode Island, and a daughter entering her sophmore year at Springfield High School, Vermont. Interests include outdoor sports - canoeing, bicycling, x-country skiing, and mountaineering - music, gardening, travel, Celtic culture and spiritual development. He resides at 409 Highland Road, Springfield, Vermont.

MINUTES AND SUMMER FIELD TRIP REPORT

August 30, 1987

After an interesting field trip led by State Geologist, Charles A. Ratte' and a picnic lunch at Texas Falls, the Executive Committee met briefly to discuss arrangements for the Annual Meeting and Dinner, as well as the needs of the State Geological Survey.

Following Chuck easterly along the banks of the Middlebury River, across the Monkton Quartzite, the Pinnacle Formation and onto the Mt. Holly Complex were:

David Butterfield	Jeanne Detenbeck	David Snyder
Alice Coish	Barb Mertz	Shelley Snyder
Ray Coish	Elyse Rudner	William Stockwell
Alan Coulter	Paul Scaramucci	Sharon Tangeman
Robert Cushman	Jeffrey Severson	Robert Trepanier

Brew Baldwin missed most of "that rock stuff", rejoining the trek at one of the later stops.

Chuck Ratte' proved a skillful guide and Sharon Tangeman a resourceful quartermaster with provisions, including sherry to supplement individual brown bag lunches.

At the Executive Committee meeting Shelley Snyder informed those present of verbal acceptance by Senator Robert Stafford as speaker for the Annual Banquet. (David Westerman has since reported written confirmation from Senator Stafford.)

Plans for the Annual Banquet were not fully confirmed as to price but we will sit down to eat at 6:00 p.m. and Senator Stafford will speak at 7:00 p.m. with the business meeting, including the election of new officers, to follow.

The Annual Dinner and Meeting is scheduled for 6:00 p.m., Saturday, October 24th, 1987 at the New England Culinary Institute, 250 Main Street, Montpelier, Vermont.

President Snyder next opened discussion of the work of the State Geological Survey. Chuck related the need for support to do new mapping in that we are 20 years behind. The bedrock mapping shown on the 1961 Centennial Geologic Map was done prior to the conceptual framework of plate tectonics and does not indicate much about brittle rock fractures which are of interest in ground water supply and protection. The surficial mapping program is valuable but is proceeding too slowly. Chuck would welcome letters of support from Vermont Geological Society members.

The Committee also discussed the concept of rain dates for Vermont Geological Society field trips as used on this occasion. The consensus seemed to be that rain dates can be beneficial with modern day forecasting being pretty good and telephone networking being effective at getting the news out quickly. Members with access to the Weather Channel can get accurate, up-to-the-minute forecasting.

Jeanne Detenbeck reminded everyone that the next newsletter needs to go out to the membership two weeks ahead of the reservation deadline.

President Snyder wants reports from all the Standing Committees at the October 24th Annual Meeting.

The question arose as to whether the NEIGC meeting is always held on the same weekend and how their schedule relates to setting the date for the VGS Annual Meeting. Setting our date to avoid theirs is difficult since their sponsorship rotates and notices only go out to the list of the previous year's attendees.

Jeanne Detenbeck also mentioned that we need to start thinking about the date for, and content of, the Winter Meeting.

Respectfully submitted,
David Butterfield,
Secretary

STATE GEOLOGIST'S REPORT

BEDROCK MAPPING PROGRAM: The following bedrock mapping projects were active during the 1987 summer/fall field season:

1. The southern portion of the Precambrian Green Mountain massif in the Londonderry, Sunderland, Woodford and Wilmington quadrangles is being mapped by Dr. Nicholas M. Ratcliffe and William C. Burton of the U.S. Geological Survey. The U.S.G.S. is cooperating in the statewide mapping program through the COGEOMAP (Cooperative Geological Mapping Program). This State/U.S.G.S. program is now completing its third year. The goal is to publish a new state bedrock map by 1996.

2. The Central Vermont Transect with mapping of the late Proterozoic, Cambrian and Ordovician "cover sequence" in the Waitsfield, Hancock and Roxbury quadrangles. This mapping is being conducted by Rolfe Stanley and graduate students from the University of Vermont.

3. Bedrock mapping in the Northfield quadrangle and analysis of the Taconian Line is being conducted by Dr. David Westerman, Norwich University.

4. Bedrock mapping in the Jeffersonville and Gilson Mountain quadrangles under the guidance of Dr. Barry Doolan and graduate students from the University of Vermont.

5. The Winooski River Valley Transect by Dr. Peter Thompson and Thelma Thompson from Cornell College, Mt. Vernon, Iowa.

Two surficial geology mapping projects were nearing completion after the 1987 summer field season:

1. The Bennington/Pownal quadrangles are being mapped by Drs. David DeSimone and David Dethier of Williams College, Williamstown, MA.

2. The Lewis Creek Valley in the vicinity of Starksboro/Hinesburg by Dr. David Franzi of SUNY, Plattsburgh, NY.

PUBLICATIONS: Our most recent publications resulting from the bedrock mapping program are:

O'Loughlin, S.B. and Rolfe S. Stanley, 1986, Bedrock Geology of the Mt. Abraham/Lincoln Gap Area, Central Vermont: Special Bulletin No. 6, VT Office of the State Geologist, Waterbury, VT.

Lapp, E.T. and Rolfe S. Stanley, 1986, Bedrock Geology of the Mt. Grant/South Lincoln Area, Central Vermont: Special Bulletin No. 7, VT Office of the State Geologist, Waterbury, VT.

These bulletins may be purchased from the State Library or the Office of the State Geologist for $3.00 + 4% tax.

FIELD TRIPS

1. Dr. Stanley and graduate students conducted a very informative two-day "working" field trip for the principals involved in Vermont's bedrock mapping projects on 9 and 10 July. Excellent discussion, centered around the new interpretations of structural and stratigraphic data presented at the outcrop, kept the group thoroughly excited in spite of 90 degree temperatures and excessive humidity.

2. On 17 August Dr. Franzi conducted a very enlightening "review" field trip of his field area in the Starksboro/Hinesburg area. We were joined by representatives from the Federal Soil Conservation Service whose soils mapping projects are closely tied to the surficial geologic materials. A serious effort is being made in the new surficial geology mapping program to coordinate the three-dimensional picture of glacial sedimentology and morphology to the soils mapping program.

3. A two-day (25-26 August) field trip was organized by the State Geologist's Office in cooperation with the U.S.D.A. Green Mountain Forest Service. Significant funding for the COGEOMAP program is provided by the GMNF for mapping on the federal lands in Vermont. The trip was guided by Dr. Ratte' with a great deal of help on field stops provided by Dr. Stanley and graduate students, Thomas Armstrong and Christine Kimball. A very informative evening session was provided by Dr. Nick Ratcliffe and Bill Burton who discussed their summers work in Southern Vermont. Sharon O'Loughlin provided an overview of Vermont Geology with a nicely illustrated 35 mm kodachrome slide show. The group also visited the Rochester/Verde Antique quarry, an old talc mine in Stockbridge and the famous underground marble quarry at Danby.

4. Dr. Ratte' conducted a half-day field trip along the East Middlebury River on 30 August for the Vermont Geological Society. This field trip was intended to provide elementary and secondary level school teachers with fundamental geologic information about the area, and to show how they can develop informative geologic field trips by using scientific publications on the geology of the state.

SPECIAL INFORMATION TALKS: (presented by Sharon O'Loughlin, Information Specialist)

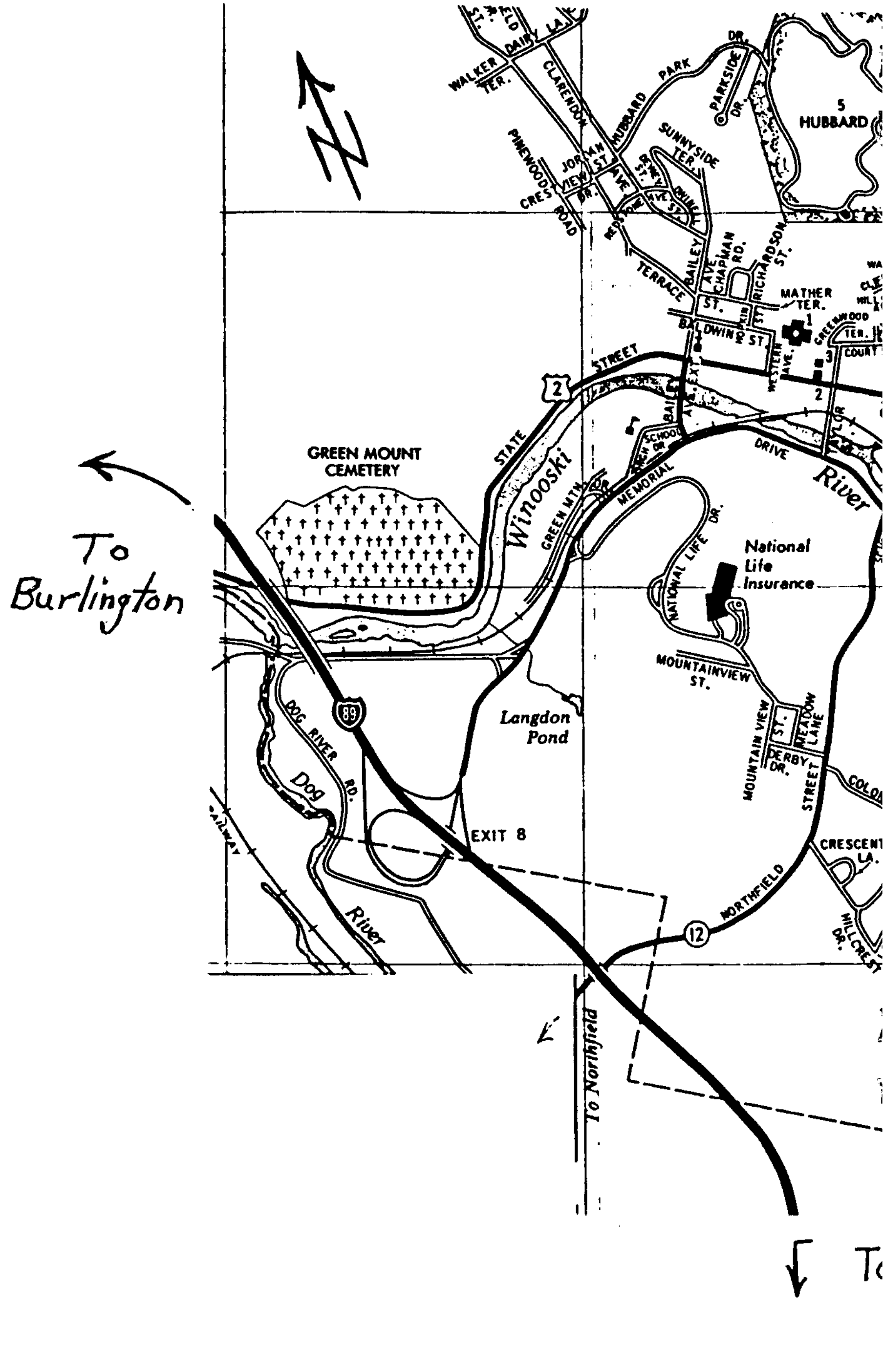
1. 12 May 1987, talk on Vermont rock types and their identification given to the 4th grade classes at Twinfield Elementary School in Plainfield.

2. 6 August 1987, presented a colored slide show at Jamaica State Park in Jamaica (VT) on the geology of the Physiographic Provinces of Vermont. Given to campers and park personnel.

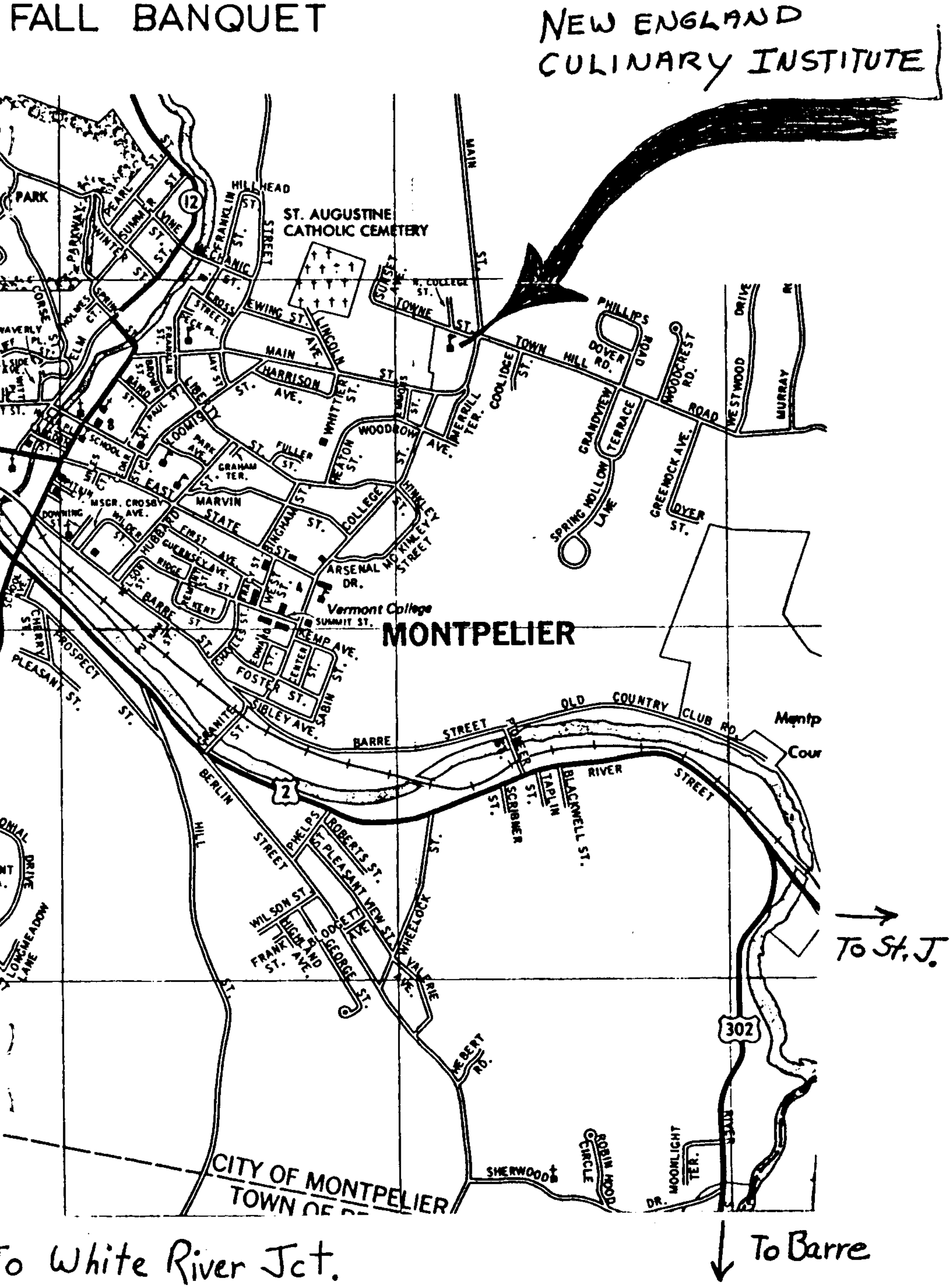
3. 23 September 1987, a talk on how rocks become soil given at the Washington County Conservation Education Field Days, Hubbard Park, Montpelier, primarily for 5th and 6th grade classes from Washington County.

[Continued on page 10.]

LOCATION MAP FOR



FALL BANQUET



[Continued from page 7.]

STILL TO COME:

4. 17 October 1987, conduct field trip for the New England Intercollegiate Geological Conference sponsored by Norwich University, Northfield, VT.

5. 20 October 1987, Vermont rock types and their identification, grades 1-6 at the East Montpelier Elementary School.

6. 23 October 1987, field trip to the Redstone Quarry (Burlington) for the Vermont Science Teachers Association.

SLOPE STABILITY PROGRAM: The five-year jointly funded program with the U.S. Geological Survey to evaluate the problems of slope stability in Vermont was completed with the 1987 summer field season. Several manuscripts are being readied for publication that relate to the work conducted during this program. Perhaps the most exciting development resulting from this program is now in the planning stages. The U.S.G.S. is proposing to use the information developed during the five-year program to use computerized GIS (Geographical Information Systems) technology to prepare a landslide susceptibility/probability map of Vermont. This map product plus other products:

1. digital data base for landslide related information;
2. procedure for landslide prediction and levels of uncertainty, and procedures for early warning and protection of the public;
3. large scale maps of landslide susceptibility/probability of areas that are a high risk to the health and safety of the public;

will be the goal of the next five-year program.

Charles A. Ratte'
State Geologist
103 South Main Street
Waterbury, VT 05676

30 September, 1987

RECENT PUBLICATION

The Geological Society of America has published its DNAG (Decade Of North American Geology) Centennial Field Guide for the Northeastern Section. It contains field guides with area maps to locations in CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT, New Brunswick, Newfoundland, Nova Scotia, eastern Ontario and Quebec. Each guide has been confined to four pages. Field areas in Vermont are presented by Charlotte Mehrtens, Brewster Baldwin and Rolfe Stanley.

The volume can be ordered from GSA for $43.50. Send check, money order or credit card number to:

GSA Publication Sales
P.O. Box 9140
Boulder, CO 80301

or call toll-free 1-800-GSA-1988.

Other DNAG Centennial Field Guides are now available for the Cordilleran Section ($43.50), Rocky Mountain Section ($43.50), and Southeastern Section ($40.50).

MEETINGS

OCT 16 17 18 — New England Intercollegiate Geological Conference sponsored by Norwich University at the Vermont College Campus in Montpelier. If you have not received a mailing and still want to attend these three days of field trips, contact: David Westerman, Dept. of Earth Science, Norwich University, Northfield, VT 05663, (802)+485-2337.

OCT 24 — **VGS FALL BANQUET AND ANNUAL MEETING**
Details on Page 3.

A reminder of the remaining lectures in the Visiting Lecture Series at the Geology Department of the University of Vermont in Perkins Building, Room 200 at 3:45 PM. For further information, contact Dr. Rolfe Stanley, Geology Department, University of Vermont, Burlington, VT 05405, (802)+656-3396.

OCT 19 — Dr. Richard Nickelson, Bucknell University, Structural Evolution of the Appalachian Foreland in Pennsylvania.

OCT 23 — Dr. Edward Sholkovitz, Woods Hole Oceanographic Inst., Chemical cycles in Chesapeake Bay: Rare earth element indicators.

OCT 26 — Dr. Dwight Bradley, Lamont Geological Observatory, Tectonics of the Acadian Foredeep in the Northern Appalachians.

NOV 3-5 — Dr. John Sutter, U.S.G.S., Branch of Isotopic Geology, SHORT COURSE: Thermochronology.

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Make your banquet reservations now!

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Charles A. Ratté
4 Chestnut Hill
Montpelier, VT 05602

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

WINTER 1987 VOLUME 13 NUMBER 4

TENTH ANNUAL WINTER MEETING

GUEST SPEAKER

Dr. James McLelland
Adirondack Geology

9:30 AM SATURDAY, JANUARY 24, 1987

ANGELL LECTURE CENTER

UNIVERSITY OF VERMONT BURLINGTON

COFFEE, donuts and conversation at 9:00 A.M.

EXECUTIVE COMMITTEE meets at 11:30. Come with your lunch.

DIRECTIONS: Park in the lot located between the Fleming Museum and Ira Allen Chapel on UVM Campus (enter from Colchester Ave. in block west of the hospital (MCHV). Walk south around the Votey Engineering Bldg. to Angell Lecture Center - the cantilevered building.

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PRESIDENT'S LETTER

Dear Members,

The winter meeting is almost here. We have a variety of exciting and informative professional papers to offer. I hope to see many of you during this conference. We will have an executive meeting during the lunch break and that will be open to all members who wish to attend. The topics on the agenda will include; 1. Teachers in Vermont and what we are in a position to offer them. This is a special interest of mine. If you have any thoughts I urge you to share them with me. Some suggestions received thus far include: the VGS acts as a repository for field trips that have been or are being used in area universities, colleges and secondary schools. The hope is that secondary school teachers will use the field trips. It has also been suggested that a course in methods and activities be presented by the society. A third possibility raised was a slide show about Vermont geology. I am confident there are many more good ideas out there. 2. A possible change in the annual meeting format. 3. We hope to have a summer field trip. Suggestions for summer field trips can be submitted.

I would like to take this opportunity to encourage all members to submit articles or "Letters To The Editor" to the GMG on issues or topics of personal interest or interest to the Society. If you have research you would like to share or a problem to propose to the membership, let us know.

Shelley F. Snyder

Shelley F. Snyder
President

WINTER MEETING PROGRAM

January 24, 1987
Angell Lecture Hall B106
University of Vermont Burlington, VT

COFFEE and DONUTS 9:00

MORNING SESSION

Opening remarks: Shelley Snyder, Convener. 9:30

1. N. Caplow and C. Prahl: Regional groundwater flow patterns in a bedrock aquifer under extensive pumping conditions 9:45
2. J. Clausen: Sediment export in the St. Albans Bay watershed 10:15
3. A. Hunt and G. Walters: A data management program for the study of Lake Champlain bottom sediments 10:35
4. F. Larsen and S. Ackerley: Southwest trending striations on the crest of the Green Mountains between latitudes $43^{\circ}50.8'$N and $44^{\circ}12.5'$N . . . 10:55

LUNCH: (Brown bag or local restaurants) 11:15

EXECUTIVE COMMITTEE MEETING: All are invited. 11:30
Bring your lunch and join in discussion of the following business: 1) cooperative programs with teachers, 2) change in annual meeting format, and 3) summer field trips.

AFTERNOON SESSION: BEDROCK RESEARCH

Opening remarks: Jeanne Detenbeck, Convener 1:00

GUEST SPEAKER

5. James McLelland: Adirondack igneous rocks: Their geochronology and evolution 1:05
6. J. Laird and W. Bothner: Taconian metamorphism in the northern Appalachians and another(?) Taconian line 2:00
7. D. Westerman: The structural history of rocks east and west of the Central Vermont Fault Zone (RMC) in the Montpelier-Northfield area 2:20
8. W. Bothner: Ordovician fossils in the Connecticut Valley Trough, central Vermont . . . 2:40

BREAK

9. R. Stanley: Tectonic geology of the pre-Silurian rocks of central Vermont 3:10
10. L. Harding and E. Hartz: Contact relationships of the Cheshire Quartzite between South Starksboro and Forest Dale, central Vermont. . . 3:30
11. R. Coish: Geochemistry of greenstones in central Vermont: A window on the early stages of opening of Iapetus 3:50
12. B. Doolan: Geology of the Hinterlands: the Gilson Mountain Quadrangle of northern Vermont 4:10
13. C. Ratté: Status of state bedrock and surficial geology mapping programs 4:30

ORDOVICIAN FOSSILS IN THE CONNECTICUT VALLEY TROUGH, CENTRAL VERMONT

Bothner, Wallace A., Department of Earth Sciences, University of New Hampshire, Durham, NH 03824

Middle to upper Ordovician biserial graptolites from two of C.H. Richardson's (1902-1918) fossil localities have been reconfirmed (Bothner and Finney, 1986). They occur in meta-limestone of the Waits River Formation, the basal unit of the Vermont Sequence (VS: Waits River, Gile Mountain, Northfield and Meetinghouse formations; Hatch, 1986), at the western margin of the Connecticut Valley Trough near Montpelier, Vermont. In addition, poorly preserved crinoid fragments have also been identified from the same unit, but appear less useful in constraining age than the graptolites. Lower Paleozoic spore and pollen were reported in the Waits River Formation by Dennis (1956). In spite of the loss of Richardson's original suite in the 1927 flood of the Vermont State Museum, the "compressed mica resembling graptolites" assessment of Foyles (1930), and the resulting "pseudograptolite belt of central Vermont" of Billings and Lyttle (1980), the VS now seem firmly based in the upper Ordovician rather than the Siluro-Devonian.

Some of the implications include (1) a correlation of the Waits River Formation with the upper Ordovician graptolite-bearing "Compton Formation" in southern Quebec (Bothner and Berry, 1985). A problem: Nearby Devonian plant remains (identified by F. Hueber, written comm. 1985) require a significant fault boundary. (2) An Ordovician, but post-Taconian, age assignment for much of the VS implies the presence of a syn- to immediately post-Taconian depositional basin (back-arc extensional?). Major faults (Taconian Line or RMC, Monroe Fault) must bound the trough. (3) These deposits were affected only by later Acadian deformation and metamorphism as indicated by fossiliferous Silurian and Devonian rocks on the east and west margins. The location and tectonic setting of the depositional basin and the mechanics of "emplacement" of the VS remain exciting challenges.

SEDIMENT EXPORT IN THE ST. ALBANS BAY WATERSHED

Clausen, John C., School of Natural Resources, University of Vermont, Burlington, VT 05405

Suspended sediment export has been sampled in the St. Albans Bay Watershed since 1981 in order to evaluate the effect of Agricultural Best Management Practice on erosion and sedimentation. Sampling has been conducted at an edge-of-field, in four tributary streams, within a wetland and in St. Albans Bay. Field sampling has been compared to sediment predictions using the model CREAMS. Results will be presented which discuss watershed differences, seasonal and long-term trends, wetland attenuation, best management practices, and model verifications.

GEOCHEMISTRY OF GREENSTONES IN CENTRAL VERMONT: A WINDOW ON THE EARLY STAGES OF OPENING OF IAPETUS

Coish, R.A., Geology Department,
Middlebury College, Middlebury, VT 05753

Greenstones in the Mt. Holly, Pinnacle, Underhill, Hazens Notch, Pinney Hollow and Stowe formations have chemical compositions similar to basalts formed in continental rift to ocean ridge environments. In the Mt. Holly, Pinnacle, Underhill and Hazens Notch formations, greenstones have high Ti, Zr, Y, and total rare earths similar to basalts formed in early stages of continental rifting. In contrast, most greenstones from the Pinney Hollow Formation have slightly lower Ti, Zr, Y and rare earths, and may have formed during later stages of rifting on distended continental crust. Greenstones from the Stowe Formation have Ti, Zr, Y and rare earths similar to mid-ocean ridge basalts, perhaps indicating their formation in an ocean basin. Complications arise in the Pinney Hollow Formation where greenstones of continental rift and ocean ridge affinities are juxtaposed. The occurrence of greenstones, representing rift and ridge environments, can be rationalized in a well known plate model, involving late Precambrian continental rifting and ocean basin formation followed by closing of the basin in the Ordovician.

GEOLOGY OF THE HINTERLANDS: THE GILSON MOUNTAIN QUADRANGLE OF NORTHERN VERMONT

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

The bedrock of the Gilson Mountain 7 1/2' quadrangle of northern Vermont consists of 9 mappable units included within 4 formations of pre-Lower Cambrian age (Tibbit Hill-Pinnacle-White Brook-Fairfield Pond). The lower part of the stratigraphy is exceptionally well defined and displays a spectacular but complex fold history of interbedded volcanic, volcanogenic, and quartzo-feldspathic metasediments. Three periods of folding are discernible in outcrop and in map pattern. The second fold event produced the dominant axial planar foliation (Sn). Sn-1 foliation parallels compositional layering through most of the area underlain by the volcanic stratigraphy of the Tibbit Hill Formation but mesoscopic folds associated with this foliation are rare. Sn+1 is a consistent steeply dipping crenulation cleavage of varying intensity.

Metamorphic intensity and degree of recrystallization decreases with time. The earliest metamorphism produced epidote amphibolite to possibly low amphibolite facies in the Tibbit Hill amphibole-bearing units; however, the recrystallization associated with Sn and Sn+1 has retrograded metabasites to greenschist facies assemblages. The earliest and most intense metamorphic textures appear to be confined to the Enosburg Falls anticlinorium.

In comparing the hinterland geology of the Gilson Mt. quadrangle with the adjacent foreland geology of the St. Albans and Milton quadrangles the following observations can be made: 1) the dominant foliation deforms progressively deeper structural levels in crossing from the foreland to the hinterland; 2) the Sn-1 foliation is weak or absent in the foreland and the most pervasive metamorphic event in the foreland is synchronous to Sn; 3) Sn foliation and related folding in the hinterland deforms large scale early folds of poorly constrained orientation and style; 4) movement on the Champlain thrust is synchronous or post dates the Sn of the foreland and postdates the Sn and Sn-1 of the hinterland; 5) Sn+1 deformation is similar in orientation and style but locally variable in intensity in both the foreland and the western hinterland.

Palinspastic restoration of the foreland-hinterland regions of northern Vermont based on the above and available geophysical constraints lead to the following conclusions: 1) a minimum of 20 km of westward transport occurred along the Champlain thrust; 2) the earliest metamorphism and deformation of the Tibbit Hill Formation occurred at minimum pressures of 5 kb.; 3) basement involvement appears to play an important role in shortening of the foreland-hinterland region during Sn and Sn+1 time but not during the earliest deformation/metamorphism of the hinterland; 4) westward transport of basement, synchronous with the development of Sn foliation, appears to have been responsible for the formation of retrocharriage in the upper crust of the central and eastern parts of the Vermont hinterland.

CONTACT RELATIONSHIPS OF THE CHESHIRE QUARTZITE BETWEEN SOUTH STARKSBORO AND FOREST DALE, CENTRAL VERMONT

Harding, Lucy E. and Ebbe Hartz, Department of Geology, Middlebury College, Middlebury, VT 05753

The Champlain Valley of western Vermont exposes a 2 km thick sequence of Cambro-Ordovician carbonates and quartzites deposited on the eastern continental margin of proto-North America. The Green Mountains Front (GMF) rises steeply from the east side of the Champlain Valley. Cambrian and Precambrian(?) quartzites, phyllites and dolostones of the Dunham, Cheshire, Forestdale, Moosalamoo, and Fairfield Pond formations are exposed at the GMF.

The Dunham Dolostone rests conformably on the Cheshire Quartzite and both are accepted as shallow water platform strata. The base of the Cheshire is not exposed for a 50 km stretch along the GMF. The Cheshire is thickest (720 m) in the middle of this interval, near Bristol, Vermont. This sequence contains more quartzite and less mudstone upsection. The Cheshire is cut by N-S high-angle faults; going eastward each Cheshire fault slice contains a higher percentage of mudstone. Evidently the Cheshire progrades eastward.

The Forestdale Marble near Lake Dunmore (Lana Falls) is a west-pinching dolostone tongue about 50 m below the top of the Cheshire.

The Moosalamoo and Fairfield Pond formations contain graded to massive wedge-shaped sand beds, thick mudstone beds and interlaminated sand and mud. Sedimentary structures are rare but show that the beds face up or west. The Moosalamoo and Fairfield Pond formations are faulted across the Cheshire and the Dunham, and are here interpreted as deep-water distal fan equivalents of the Cheshire.

A DATA MANAGEMENT PROGRAM FOR THE STUDY OF LAKE CHAMPLAIN BOTTOM SEDIMENTS

Hunt, Allen S. and Glenn W. Walters,
Department of Geology, University of Vermont,
Burlington, VT 05405

Data has been accumulated since 1964 on the nature and composition of bottom sediments in Lake Champlain. The data include color, grain size, organic and trace metal content, clay mineralogy, and gross petrological composition. Much of this information is available only in unpublished sources including U.S. Interior technical reports, masters theses, and student research reports. Compiled in a systematic manner, it ~~should~~ be used to produce surface sediment maps, study regional sedimentological trends, establish associations between sediment properties, and recall all available data for a given lake station.

In order to store and manipulate existing data, a management system has been developed using an IBM compatible personal computer and commercially available software including a database which is subdivided into tables, each containing a particular type of data. The common factor between tables is the aereal location of the sediment sample which allows compilation of originally discrete data for any given site. The system also provides flexibility in that new information can be added as it becomes available. A variety of techniques exist within the system for use in combining data and extracting subsets for further analysis. Statistical procedures such as correlation and regression can readily be performed and data plotted for sediments either from any given area of the lake or for the lake as a whole. Such information is useful in understanding the lake's present day depositional processes. It will also provide a rational means of selection parameters necessary in order to construct a surface sediment map. The sediment data may be assembled for the map using a personal computer. The map may then be constructed by hand plotting or, if facilities are available, by loading the data onto a personal or mainframe computer equipped with the appropriate software and a plotter.

TACONIAN METAMORPHISM IN THE NORTHERN APPALACHIANS AND ANOTHER (?) TACONIAN LINE

Laird, Jo and Wallace A. Bothner, Department of Earth
Sciences, University of New Hampshire, Durham, NH 03824

Taconian mineral assemblages in mafic and pelitic schists indicate that high, medium-high, and medium-pressure facies series metamorphism are preserved in north-central Vermont, medium-pressure metamorphism is recorded in cover rocks of the Berkshire Mountains, and medium-low pressure metamorphism occurs farther south in the Taconic Range and Dutchess County, NY. The age of metamorphism appears to be the same, 465±5Ma ($^{40}Ar/^{39}Ar$, amphibole). The boundaries between facies series, as we presently understand them, cross cut the boundaries of thrust packages defined by Stanley and Ratcliffe (1985) and the suspect terranes delimited by Williams and Hatcher (1983). If this hypothesis is confirmed, metamorphism must have occurred or continued after the juxtaposition of the terranes, or some contacts mapped as faults are lithologic boundaries.

Preliminary petrologic studies of mafic schist within the Missisquoi Formation, Vermont indicate metamorphism at low to medium pressure facies series, similar to Acadian metamorphism in the northern and central Connecticut Valley Gaspe Synclinorium, and distinct from medium to high pressure Taconic metamorphism to the west. The contact between the Missisquoi and Stowe formations, Worcester Mountains, Vermont marks a distinct change in structural style. East of the contact the Missisquoi Formation retains some primary sedimentary features, is simply cleaved, and generally lacks the strong shear fabric characteristic of the Stowe Formation west of the contact. The petrologic and field data suggest that the Missisquoi Formation was metamorphosed and deformed after, or at least elsewhere from, the Taconian orogen. Is the Stowe-Missisquoi contact the Taconian line?

SOUTHWEST-TRENDING STRIATIONS ON THE CREST OF THE GREEN MOUNTAINS BETWEEN LATITUDES 43°50.8'N AND 44°12.5'N

Larsen, Frederick D., Department of Earth Science, Norwich University, Northfield, VT 05663
Ackerley, Spafford C., Department of Geological Sciences, Cornell University, Ithaca, NY 14853

Southeast-trending striations are common on the main crest of the Green Mountains (Goldthwait compilation in Flint, 1957; Christman, 1959; and Christman and Secor, 1961) and on lesser mountain ranges such as the Worcester Range and the Northfield Mountains (S. Clark, pers. comm. 1986). The direction of movement of the last ice sheet as shown by the distribution of pebbles in indicator fans (Cuttingsville and Braintree) is generally to the south-southeast. In addition, erratics of reddish-brown quartzite from the Monkton Formation, which outcrops on the west flank of the Green Mountain anticlinorium between Bennington and Colchester, are found east of the Green Mountains in a zone that extends from Northfield to Brattleboro and into Massachusetts.

Ackerly (1986) discovered southwest-trending striations on the main crest of the Green Mountains betwee Mt. Horrid (lat. 43°50.8'N) and Applachian Gap (lat. 44°12.5'N). This indicates that a reevlauation of the general impression that the last ice sheet moved southeast obliquely across the entire north-south trend of the Green Mountains must be undertaken. As part of that reevaluation, The Great Pebble Campaign of 1974, a study of the Braintree indicator fan, 19km east of the Green Mountain crest, was redone to determine if there was any indication of movement to the southwest. No igneous rocks from the Braintree pluton have been found southwest of the pluton and no clasts of the brown-weathering calcareous quartzite from the Waits River Formation were found west or southwest of its outcrop area. In addition, clasts of gray and white quartzite derived from the Ottaquechee Formation and one ultramafic clast found in the vicinity of the pluton indicate that ice moved to the pluton from the north-northwest.

Detailed glacial maps of the area in question are not available so any conclusion must be conjectural at this time. It appears that southwest-moving ice on the crest of the Green Mountains was a local phenomena and may have been related to draw down of ice in the Champlain Valley during deglaciation.

ADIRONDACK IGNEOUS ROCKS: THEIR GEOCHRONOLOGY AND EVOLUTION

McLelland, James M., Department of Geology,
Colgate University, Hamilton, NY 13346

Recent acquisition of 13 new U-Pb zircon ages on Adirondack metaigneous rocks strongly suggests that Silver's (1969) age determinations and interpretations were correct. Mangeritic and charnockitic samples (4) yield near concordant ages ranging from 1100-1135 Ma. These results are not far different than an 1153±4 Ma age (Grant, 1986) on the Diana Complex (charnockitic). Mangerite-charnockite zircons are robust, doubly terminated, inclusion-bearing, finely zoned and Fe-stained. They appear to be primary igneous zircons. Zircons from anorthositic rocks are small, pink, equant, multifaceted, inclusion-free, and clear. They yield ages of ~1050 Ma and have been interpreted as metamorphic in origin (exsolution from pyroxene?). Silver (1969) reached the same conclusion on noritic and anorthositic rocks (1005-1062 Ma). Ages for two leucogranitic gneisses in the Highlands range from 1075-1083 Ma and may represent a separate igneous event. Alternatively these ages may reflect pre-metamorphic hydrothermal alteration. Petrographically similar rocks in the Lowlands give ages of ~1280-1300 Ma and have been interpreted as parts of a basement complex. If the age difference between the Highlands and Lowlands is real, it lends credence to the hypothesis that they represent two distinct terranes sutured along Carthage-Colton Mylonite Zone. The Canadian extension of this zone (Chibougamau-Gatineau Lineament) separates the Central Metasedimentary Belt from the Granulite Facies Terrane and may also be a suture.

Petrologic analysis of Adirondack metaigneous rocks strongly suggests that most represent rapakivi suite rocks emplaced in anorogenic, or mild rifting, environments during late Proterozoic time. The anorthosite-charnockite suite is considered to be bimodal with noritic/gabbroic rocks coring zoned complexes and providing the heat by which syenitic/granitic melts are produced from deep continental crust. This magmatism is part of the mid- to late-Proterozoic anorogenic magmatism that traverses North America, Greenland (Gardar Complex), the Baltic Shield, and the Soviet Union. Within the Adirondacks, it preceded the Ottawan phase (~1050 Ma) of the Grenville Orogeny but was itself preceded by an earlier fabric-forming metamorphic event (Elzviran phase?). The style of magmatic activity is believed to be that of shallow level caldera complexes together with ash-flow tuffs.

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STATUS OF STATE BEDROCK AND SURFICIAL GEOLOGY MAPPING PROGRAMS

Ratté, Charles A., State Geologist,
103 So. Main Street, Waterbury, VT 05676

The bedrock and surficial geology mapping programs had an unofficial start in the Spring of 1982 at an enthusiastic, impromptu, lunch time meeting assembled at the University of Vermont Geology Department during the Vermont Geological Society Spring meeting. The State Geologist's Office had recently received a grant from the Federal Department of Energy to monitor their high-level radioactive waste program. This grant provided monies to publish geologic studies that were germaine to their investigation of Vermont's crystalline rocks. Several Vermont Geological Survey Special Bulletin Series were published covering areas in the northern Green Mountain Precambrian massif and adjacent Paleozoic cover sequence that were under investigation by faculty and students from the Geology Department at the University of Vermont.

In the fall of 1983 the first State funded projects were initiated through a Memorandum of Agreement with Professors Frederick D. Larsen and David S. Westerman of Norwich University for surficial and bedrock mapping in the Northfield, Vermont 7 1/2 minute quadrangle. In the summer of 1984 a third State funded project was initiated in the Southern Green Mountain massif through a Memorandum of Agreement with Dr. James W. Skehan of Boston College. In the fall (October) of 1984 Vermont entered into a cooperative program with the U.S. Geological Survey (COGEOMAP) for remapping the bedrock and surficial geology of the state with the long range goal of producing new statewide bedrock and surficial geology maps.

In the meantime Drs. Rolfe S. Stanley, Charlotte J. Mehrtens and Barry L. Doolan and graduate students at the University of Vermont continued to conduct mapping projects some of which were supported financially by the U.S. Geological Survey, the National Science Foundation and the U.S. Forest Service.

In 1985 and 1986 additional funds from the State Geologist's Office were directed to the geologic mapping program. These funds made it possible to start three new bedrock mapping projects through Memoranda of Agreement with Dr. Charlotte J. Mehrtens (Northwestern Vermont Lithofacies Mapping Project), Dr. Barry L. Doolan (Gilson Mt. Quadrangle, north-central Vermont Project), and Dr. Peter J. Thompson (The Winooski River Valley Transect Project). Also a small amount of funding was made available to Drs. David P. Dethier and David J. DeSimone of Williams College, Williamstown, MA to begin a surficial mapping project in the Bennington-Pownal area.

In the second year of Vermont's involvement in the U.S. Geological Survey cooperative geologic mapping program (COGEOMAP), the State Geologist's Office requested "In-Kind" service of U.S.G.S. mapping personnel in the person of Dr. Nicholas M. Ratcliffe as the U.S.G.S. contribution to the cooperative arrangement. U.S.G.S. accepted this proposal and in the summer of 1986 Dr. Ratcliffe and two assistants conducted geologic mapping in the southern Green Mountain Precambrian massif and Paleozoic cover sequence. The U.S. Forest Service (Green Mt. National Forest) also provided funding to support Dr. Ratcliffe's and Dr. Stanley's projects in the Green Mountain National Forest.

In addition to the mapping projects, planning and administrative organizations have been developed which include:

1. Program director,
2. Co-director for surficial program,
3. Advisory Committee,
4. Regional Compilers and mapping project coordinators (bedrock program) and
5. Review Committee for maps and reports.

Although two surficial mapping projects (Northfield Quadrangle, and the Bennington-Pownal Area) are in progress, it is clear that the surficial program mapping requires a separate plan and administrative organization. A draft mapping plan has recently been sent out for review and comment.

Vermont's 1987 proposal for continued participation in the U.S.G.S. cooperative (COGEOMAP) program has been approved by U.S.G.S.

TECTONIC GEOLOGY OF THE PRE-SILURIAN ROCKS OF CENTRAL VERMONT

Stanley, Rolfe S., Department of Geology,
University of Vermont, Burlington, VT 05405

Detailed 1:12,000-scale mapping in the pre-Silurian rocks of Central Vermont since 1984 shows the following important relations: 1. The Middle Proterozoic rocks of the northern end of the Lincoln massif are progressively deformed to the east by east-over-west folds and post-metamorphic thrust faults of post-Grenvillian age (Prahl, 1985; DelloRusso, 1986). 2. The eastern boundary of the massif is marked by several synmetamorphic thrust faults (South Lincoln, Underhill and Jerusalem thrust faults) which are marked by slivers of Middle Proterozoic rocks (Tauvers, 1982; DelloRusso, 1986; Strehle and Stanley, 1986). 3. The Hoosac (Pinnacle), Underhill, Mt. Abraham, Hazens Notch, Pinney Hollow, Ottauquechee, and Stowe formations, to the east of the Lincoln massif, are marked by major pre-metamorphic and synmetamorphic thrust faults that have been tightly folded, refolded and then cut by minor post-metamorphic faults (O'Loughlin, 1986; Lapp, 1986). 4. Fabrics along synmetamorphic faults indicate a complex history of east-over-west movement followed in many places by later flattening which commonly obscure the earlier direction of fault movement. 5. The rocks within these formations can be divided into at least 7 thrust slices that record a complex history of deformation caused by later folding and renewed faulting. 6. The sequence by which the thrust slices were assembled differs to the east and west of the Underhill thrust fault. To the east the sequence is complicated by several generations of folds and faults which resulted in younger slices from the east moving over deformed and older slices to the west. West of the Underhill thrust fault the sequence of deformation progressed westward in "piggyback fashion". 7. Geochemical analyses of mafic rocks by Coish (1985, 1986) and his students at Middlebury College indicate that the mafic rocks become more oceanic as they are traced eastward from the Underhill through the Hazens Notch to the Pinney Hollow and Stowe formations. This progression is consistent with the tectonic evolution in central Vermont. 8. Correlation of mineral growth and structural sequence indicate that synmetamorphic faulting occurred during peak metamorphism and continued during retrogression to produce strongly elongated chlorite clusters (Lapp, 1986; O'Loughlin, 1986). 9. Older thrust faults, which are largely responsible for the distribution of thrust slices, occurred before and during peak metamorphism. 10. Analysis of mineral assemblages by Albee (1965, 1968), Laird and others (1984), and Walsh (1986) and amphiboles by Laird and Albee (1981, 1984), Kimball (1986), and Mock (1986) indicate that peak metamorphic conditions occurred at temperatures of 500°C - 530°C and confining pressures of 4 to 5 kbars (13 to 16km). 40Ar/39Ar analyses of barroisitic amphibole cores with actinolite rims from a greenstone in the Pinney Hollow (Laird and others, 1984) suggest that medium-high pressure (peak?) metamorhpism occurred during the Taconian orogeny (470 m.y.). Conventional K/Ar analyses of muscovite and biotite in the Mt. Abraham Schist to the west of the Pinney Hollow suggest that metamorphism continued until 385 m.y. (Laird and others, 1984). This younger age is interpreted either as the result of cooling from peak metamorphism (Sutter and others, 1985) or renewed metamorphism during the Acadian orogeny (Laird and others, 1984). Based on a continuous and progressive sequence of structural deformation and metamorphic fabric a Taconian age (Middle Ordovician) is preferred for most of the pre-Silurian geology of Central Vermont. The younger 385 m.y. age may be due to late movement of the Champlain thrust fault over a ramp.

REGIONAL GROUNDWATER FLOW PATTERNS IN A BEDROCK AQUIFER UNDER EXTENSIVE PUMPING CONDITIONS

Wagner, Heindel and Noyes, Inc., Staff,
P.O. Box 1629, Burlington, VT 05402-1629

Since 1980, regulatory agencies of the State of Vermont have fostered an increase in the study of the mechanics of groundwater flow in bedrock aquifers. In the process of securing environmental permits, detailed hydrogeologic studies have been carried out in a number of bedrock terranes throughout the state. In the West Dover area, which has undergone intensive development, a number of aquifer tests have been conducted. The anaylsis of data from these tests has revealed zones of well interference. These zones suggest intricate networks of fractures in the bedrock at depth. Current groundwater withdrawal patterns, the degree to which existing wells are connected by fractures, and well bores and aquifer coefficients will be discussed.

THE STRUCTURAL HISTORY OF ROCKS EAST AND WEST OF THE CENTRAL VERMONT FAULT ZONE (RMC) IN THE MONTPELIER-NORTHFIELD AREA

Westerman, David S., Department of Earth Science, Norwich University, Northfield, VT 05663

A geologic boundary passing north-south through Vermont separates rocks of the Missisquoi Formation (as used by Doll and others, 1961) on the west side from rocks of the Northfield Formation on the east side. This boundary is referred to informally as the RMC (Richardson Memorial Contact) and more formally as the Taconian Line (Hatch, 1982). Since it is neither a specific contact or a line but is instead a zone of intersecting faults, and since it may not everywhere represent a separation of rocks which experiences the Taconian orogeny and those that did not, it is referred to here as the Central Vermont fault zone (CVFZ). In the Montpelier-Northfield area, rocks of the Shaw Mountain Formation (Sil) are found only within the CVFZ, as is an assemblage of mafic and intermediate volcanics of uncertain age and correlation.

The structural history of rocks on both sides of the CVFZ in the Northfield 7.5-minute quad appears to be the same. Early isoclinal folding produced cleavage generally parallel to bedding. Then later isoclinal folding produced the predominant schistosity of the region which trends NNE and dips steeply to the west. This was followed by the production of a spaced cleavage which is found locally in the region with various styles and scales. This cleavage is often associated with crenulations and small-scale folds having moderate N- to NE-plunging axes. Finally a mylonitic cleavage formed, again locally (especially at lithologic contacts), parallel to the regional schistosity and obliterating all older structures. This cleavage is common in the CVFZ and may be temporally related to the spaced cleavage, representing zones of maximum strain. In the CVFZ it produced rocks very similar to the mylonites and phyllonites in the fault zone that separates the Stowe and Moretown formations along the Mad River in Moretown. Map patterns within the CVFZ are also very similar to those shown by Stanley and others (1984) for the East Hill fault zone (Stowe against Moretown).

Vermont Geological Society - Treasurer's Report

Jan 6, 1987

Balance as of 1/1/86		$528.31
Income		
Interest	48.74	
Dues	1170.25	
Publication Sales	786.09	
Reimbursement for GSA Booth	51.50	
Gift for Grant-in Aid of Research	1500.00	
	$3556.58	+3556.58
		$4084.89
Expenses		
Postage	318.55	
Printing/Xeroxing	735.78	
Office Supplies	45.93	
GSA Booth	103.50	
Service Fees	9.75	
Winter Mtg Expenses	28.94	
Checks	28.68	
Doll Prizes	50.00	
Box Rent	22.00	
Credit (Blackwell N.A.)	10.00	
Bulletin Sales	-55.00	
	$1298.13	-1298.13
Balance as of 12/31/86		$2786.76

Respectfully submitted,

David S. Westerman,
Treasurer

NEW MEMBERS

The following new members have been accepted by the Executive Committee since last summer:

Thomas Armstrong	Exeter, NH
Bret W. Cox	Burlington, VT
Peter Goreau	Middlebury, VT
Crea Lintilhac	Waterbury Center, VT
William Lynch	Parker, CO
Thomas Moon	Northfield, VT
Bill Spitzel	Charlotte, VT
Steven Stokowski, Jr.	Ashland, MA
Bruce Wilson	W. Brattleboro, VT

GRANT-IN-AID

Regrettably there were no applications for the Grant-in-Aid for Research which the Society announced in Fall 1986. This may have been due to poor timing. Thus, the Executive Committee revised the announcement and mailed it to 30 colleges in the area in December. The new deadline is APRIL 15, 1987. Please encourage eligible students to apply. If you need a copy of the announcement, write to the "Grant Committee", c/o VGS, Box 304, Montpelier, VT 05602.

CALL FOR STUDENT PAPERS - SPRING MEETING

The 14th annual presentation of student research papers will be held **MAY 2, 1987** at Middlebury College. Undergraduate and graduate students from any college or university who are engaged in research of Vermont or Vermont-related geology are invited to submit an abstract of no more than 300 words no later than **APRIL 15, 1987**. Talks are allotted 15 minutes with an additional 5 minutes for questions. The Society awards a cash prize to each of the best undergraduate and graduate student papers.

EDITOR'S REPORT

A deadline of January 30, 1987 has been set for receipt of field trip guides from 7 trip leaders who have promised to complete manuscripts for publication. With their cooperation, Volume 5 of Vermont Geology will be in the works late this winter and early spring.

An issue of professional papers, Volume 6, is also a distinct possibility in the near future. A paper (which must still go through USGS review) has recently been submitted to Vermont Geology and several other papers may be forthcoming. At this time, anyone wishing to submit a manuscript about or related to Vermont geology is invited to send it to:

Jeanne Detenbeck
(VGS Editor)
29 Collamer Circle
Shelburne, VT 05482

ANNUAL MEETING MINUTES - OCTOBER 11, 1986

The meeting was called to order at 8:17 PM by Acting President, Carolyn Merry. Present were 9 members and 3 guests.

The treasurer reported a balance of about $1000. Many members still have not paid dues. Sales of Volumes 3 and 4 have aided our fiscal well being. The Society's finances are now computerized. Report was accepted.

OLD BUSINESS

Field trip guides for the next Vermont Geology volume are pending. No other volume is in sight.

NEW BUSINESS

No nominations were forthcoming from the floor so it was moved that the secretary cast one vote for the slate of officers: Pres. Shelley Snyder, Vice-pres. Jeff Pelton, Treas. Dave Westerman, Sec. Dave Butterfield, Directors - Don Wernecke, 2 yrs., Stan Corneille, 1 yr.

Shelly Snyder then took over as President. She would like to see more teacher involvement in the Society during her term of office.

The Exec. Comm. will discuss the Winter Meeting on Nov. 12, 7:30Pm at John Malter's.

Jim Ashley reported that the Adminsitrative Comm. on Rules has adopted rules on water wells. There may be licensing of monitoring well drillers. Jim will provide a synopsis of the well drilling legislation for the GMG.

There were no applications for the Grant-In-Aid for research. $1500 is available. The status will be discussed at the next Exec. Comm. mtg.

Five new members were announced: Tom Moon, geophysicist; Brett Cox, hydrologist; William Lynch, exploration geologist; Bill Spitzel, hydrologist; and Tom Armstrong, structural geologist. There are about 140 members.

Carolyn Merry was thanked for taking over as acting President after Steve Goldberg left for greener pastures in NY.

Dave Westerman was given a round of applause for his field trip which 17 attended.

It was moved and seconded for adjournment at 8:52 PM.

Respectfully submitted,
John Malter, Sec. pro tem

EXECUTIVE COMMITTEE MINUTES - NOVEMBER 12, 1986

A meeting of the Executive Committee was held in Montpelier on November 12, 1986 at the home of John Malter. Present were Shelley Snyder, Jeanne Detenbeck, Dave Westerman, Jeff Pelton, Steve Revell and John Malter. The minutes of the Annual Meeting and the Treasurer's report were accepted. Included in the Treasurer's report were the following: 1) a current balance of $1,119.60, 2) many of our stalwart members being in arrears on their dues, 3) the Geotimes ad for the last volume of Vermont Geology having paid for itself, 4) bulletins selling well, and 5) a new member - Crea Lintilhac.

The next topic on the agenda was how to handle the fact that no one applied for the $1500 Grant-in-Aid of Research which the Society offered as support for a project involving bedrock geology and groundwater. The donors of the money have indicated interest in repeating this grant a second time if we can get someone to apply for and receive the first gift.

A recurring topic, that of holding the Annual Meeting at some time other than in the fall after the field trip, was discussed. It was agreed that this topic will come up for discussion by a larger group at the lunch-time meeting in January.

The time, location and program outline for the Winter Meeting were arranged, pending confirmation of the availability of our keynote speaker, Prof. James McLelland, Colgate University (see details on the cover page).

President Snyder introduced the topic of having the society help teachers in their efforts to develop outdoor geology exercises. The suggestion was made that professors at local colleges could develop a lesson outline quite easily by taking an introductory lab section to a nearby outcrop and assigning the students the task of determining the geologic history. In the process of evaluating and correcting the results of the assignment, the product (the "correct" answer) would evolve and could be made available to teachers in the secondary schools.

Discussion for the closing portion of the meeting included other ideas for working in the area of education (arranging slide shows on Vermont geology, helping set up an in-service day), the timing of the Spring Meeting and plans for NEIGC 1987. The Executive Committee also agreed to postpone accepting advertisements in the GMG.

Respectfully submitted,
David Westerman, Sec. pro tem

MINERAL OF THE QUARTER

"WHITE GOLD"

At this time of year only one mineral looms of sufficient importance to be highlighted. It belongs to the hexagonal system and occurs in masses, granular aggregates and crystals. Its skeletal crystals are best known and admired for their intricate beauty. Its physical characteristics are:

HARDNESS - 1 1/2
SPECIFIC GRAVITY - 0.916
COLOR - colorless to white, blue when thick
LUSTER - vitreous
FRACTURE - concoidal
CLEAVAGE - none, exhibits basal gliding
OCCURRENCE - abundant in Vermont in various forms

It is blessed by skiers and motel owners and cursed by ordinary motorists. Farmers know their summer's supply of water depends on an adequate accumulation of this mineral at higher elevations. Most city dwellers wish it would stay only on the mountains and not need to be shoveled from driveways and pavements.

By now you surely suspect that the mineral is ice. The lovely snowflake is a skeletal ice crystal. Ice occurs in Vermont as snow, frost and hail, as well as ice on ponds, rivers and lakes. It is very much a part of the Vermont scene.

Man has pondered the beauty of snow crystals since ancient times. Aristotle commented on the intricate form of the snowflake in the 4th Century B.C. A book on natural phenomena, published in 1555 by the Archbishop of Upsala, Olaus Magnus, included crude pictures of snowflakes. Ten years later Robert Hooke, the famous British physicist, included a page of drawings of snowflakes in his "Micrographia". He made his drawings outdoors after catching the specimens on a black cloth. The most famous and probably most dedicated student of snow crystals was W. A. Bentley of Jericho, Vermont. He spent almost 50 years capturing and photographing snowflakes, working out-of-doors with a plate camera. During his lifetime he recorded the image of more that 5000 different crystals and found no two alike. From his study he identified five general types of ice crystal structure:

A. Hexagonal columns (often called needles)
B. Hexagonal right pyramids
C. Hexagonal plates, ten or more times broader than thick (many with elaborate extensions on the corners)
D. Triangular plates
E. Twelve-sided plates

The needles and plane hexagonal plates form at high altitudes, where the amount of water vapour in the air is small. These forms occur in cirrus and cirrostratus clouds in which they are responsible for the striking halos sometimes seen around the sun or moon. The most intricate crystals with branching extensions form at higher temperatures in the presence of more moisture. These forms are more abundant in the front portion of a snowstorm, where the snow is heaviest and the clouds are greater.

It is possible to permanently record the shapes of these fleeting crystals by a method developed by V. Schaefer* in 1940. The total supplies needed are:

2 square feet of black velvet cloth tacked to a board
A card table
A flashlight
A whisk broom
A thermometer
Several clean microscope slides
A pointed glass rod of wire
A 1% solution of polyvinyl formula resin in ethylene dichloride

All equipment is set outside to reach air temperature. The velvet-covered board is set where it can catch the falling snow crystals. When several good specimens have been noticed, the board is brought to the table. The end of the glass rod is dipped into the resin solution and about half a drop of solution placed on a glass slide. While the end of the rod is still wet, it is touched to a crystal, and the crystal is brought to the drop on the glass slide. The solution will envelope the crystal. If it is a large crystal, another small drop may be needed to completely cover it. Several specimens can be placed side-by-side on one slide. Place the slide in a protected place when it is complete so that the solvent can evaporate. After evaporation is complete, the slide can be studied at leisure, in a warm room, with a microscope or good hand lens. What better winter field trip can there be?

*"How to Fingerprint a Snowstorm", Vincent J. Schaefer, Illustrated Library of the Natural Sciences, American Museum of Natural History, Simon and Schuster, N.Y., 1958.

Submitted by
Ethel Schuele

WATER QUALITY LEGISLATION - PART I HISTORY

At our Winter 1986 meeting, Jonathan Lash, Commissioner of the Department of Water Resources and Environmental Engineering, gave the keynote address, "Water Quality Legislation in Vermont", in which he presented an historical background, and put the problems met in trying to control water quality into perspective. Although we did not have the foresight to tape this address for transcription, we have obtained permission to publish a similar article drafted by Mr. Lash, which appeared in the Winter 1986 issue of Conservation Quarterly.

Some History and Background

In 1970, two years before passage of the Federal Water Pollution Control Act, the Vermont legislature adopted Act 252, prohibiting the discharge of wastes into the waters of the state without a permit (the same legislature passed Act 250, the state's land use planning). The new law for the first time gave state government broad authority to protect the quality of the state's rivers, streams, and lakes. It was needed.

Although the state had first passed water quality legislation in 1947, it had been toothless and not effective in preventing pollution. By 1970, more than 60 towns and thousands of individual homes and businesses were discharging untreated wastes.

Vermont pursued the elimination of sewage discharges with a vigor that was astonishing. Water Resources investigators traversed the state identifying and cataloging discharges through straight pipes, ditches, storm drains, and seeps. Ninety-two municipal sewage treatment plants were built at a cost of nearly $200 million. The state committed an average of 25 percent of its capital budget to the construction of pollution control facilities. Thousands of Vermonters and Vermont businesses pulled their sewage pipes from streams and lakes voluntarily and constructed septic systems at considerable cost with no state or federal aid. Where voluntary compliance could not be obtained, the state took enforcement actions against businesses, individuals, and towns.

As the new law was implemented, however, state oficials became increasingly concerned. Was getting the straight pipe out of the rivers only moving the problem around? Vermont was in the midst of a development boom and much of the development was taking place in upland areas. On May 10, 1971, Governor Deane Davis appeared before the Water Resources Board to ask that the Board take steps to protect "upland streams". He said

> *We have literally hundreds of these streams in Vermont and most of us are familiar with them. Such pure and unpolluted water as we have left in the state is to be found in these upland brooks and some remote mountain ponds.*
>
> *I believe it is absolutely essential that we protect these waters from new sources of pollution by whatever measures may be required.*

Davis went on to give two reasons for taking action. First, all the effort that was currently going into cleaning up the state's lakes and rivers would make little sense if the brooks and streams above them were being polluted. Second, the volume of water in upland streams for the most part fluctuates widely - the rushing spring creek is often only a trickle by late summer. The efficiency of a stream to assimilate effluent was a critical criterion in Davis' mind for determining whether there should be a discharge. "We all know some lovely little mountain brooks which ought never to have even the smallest amount of pollution introduced in them".

Davis believed that this issue of discharges into upland streams was a test of the state's resolve to have clean, pure water. "Tough standards", he said, "will hurt someone whether it be a developer seeking to build homes in a mountain area or whether it be a group of people already owing homes in remote locations. This is a price which we must pay, however, if we are ever to reach the goal of clean waters".

The Water Resources Board responded quickly to Governor Davis' request. The 1971 Water Quality Standards included an upland streams rule stating "there shall be no new or increased discharges to upland streams of any treated or untreated domestic, sanitary, commercial or industrial wastes ...(or) of any other wastes which would degrade in any respect the quality of the receiving waters. Where technically feasible existing discharges of such wastes to upland streams shall be eliminated by utlilzing off stream [on-site] disposal techniques." This meant that the Board wanted to eliminate direct discharges to upland streams by encouraging the use of on-site systems.

At first the Board defined as "upland" all those streams above 1500 feet in altitude with a flow rate under 1.5 cubic feet per second. A few years later, however, the Board broadened the definition to include "those Class A or Class B rivers, streams, brooks, creeks, upstream of the most upstream discharge of waste from an existing municipal waste water treatment facility". The new definition was a significant change because it expanded the concept of upland stream that had previously included perhaps a third of the state's streams to include approximately 90 percent of the flowing waters in the state. Not only were pristine upland brooks considered upland streams, so were many lowland streams in populated areas including some not so pristine streams running through Burlington and its suburbs.

The current water quality standards still contain the prohibition against discharges in upland streams. Discharges may only be permitted in waters designated "Class C" by the Water Resources Board. The Board has in the past generally refused to create Class C zones in waters designated upland streams.

Environmental Protection Rules

The water policy had effectively directed discharges into sewage treatment plants or into on-site systems where it would be treated naturally through the soil. But no one raised the question of whether effluent treated in the ground would have an impact on surface water. Certainly whatever impact there was, was a great deal less than that of direct, untreated discharges.

Governor Davis became concerned, however, that the on-site treatment systems that were being built were creating new health and environmental problems while attempting to solve an old one. He asked the State Health Board to promulgate emergency rules, which they did. They based the rules on several laws broadly authorizing the Board to take steps necessary to protect public health. The rules were later ratified by the legislature and authority to enforce them was transferred to the Department of Water Resources. They set forth detailed requirements for the construction of on-site or land based sewage treatment facilities. With a few minor exceptions any person building a new industrial plant, business, hotel, restaurant, apartment building or subdivision or modifying or expanding an existing facility must obtain from the Department of Water Resources a Certificate of Compliance showing that the proposed sewage disposal facility will meet the requirements of the rules.

The objective of these rules, which have come to be called the "Environmental Protection Rules", is to assure that on-site treatment systems are built in a manner that effectively disposes of wastes and prevents hazards to human health. The Environmental Protection Rules, however, are not based on Act 252. The laws emanating from Act 252 are aimed at protecting surface water quality; the rules are concerned with whether or not waste treatment systems are built and function properly. In reviewing applications for Certificates of Compliance under the Environmental Protection Rules the question is whether the proposed system will meet the strict standards in the rules, not whether the system will eventually have some impact on the waters of the state. Therefore, the classification of nearby surface water does not affect the decision whether to grant a certificate.

The prohibition on discharges in upland streams, the broad definition of upland streams, and the policy favoring the limitation of discharges to municipalities has meant that all development in upland areas has had to rely on on-site sewage treatment. Most systems are small (the septic tank and leach field for a single family home need only be equipped to handle about 500 gallons per day). But by the mid-1970s, resort developers were applying for Certificates of Compliance for systems with capacities of tens of thousands of gallons per day. Some of the systems were ordinary septic tank and leach fields; some involved secondary or tertiary sewage treatment plants discharging into leach fields; and some used a new technology, at least to Vermont, spraying secondary treated effluent into woodland areas. Although used elsewhere in the world for decades and used widely outside Vermont for 20 years, this technology was first used in the 1970s in Vermont in several state parks and in a state sponsored experiment at the Big Bromley Ski Area. By the end of the decade, most of the large on-site sewage treatment systems being proposed were spray systems. There are 21 spray systems now in operation in the state, 4 of them in state parks.

The construction of these very large on-site sewage treatment systems raised one new issue. Some of the systems obviously have an impact on adjoining streams. There is a demonstrable connection between the leach field or spray system and the waters of the stream. This raises the question whether such systems constitute a "discharge" under Act 252 and, therefore, require a discharge permit. Although the Department of Water Resources requires applicants to obtain a Certificate of Compliance under the Environmental Protection Rules for on-site systems, it has never required a discharge permit. There are important differences between the two. A permit may only be granted for a discharge into Class C waters. Discharge permits require public hearings, Certificates of Compliance do not. Discharge permits must be renewed every 5 years, Certificates of Compliance last for the life of a project or until it is modified. Most importantly, discharge permits are based directly on protection of surface water quality, while Certificates of Compliance are based on compliance with design standards intended to prevent sewage from surfacing and endangering public health.

After 10 years, the State found itself with two parallel water policies administered by the Water Resources Department. One based on water quality (Act 252) and the other based on the effectiveness of soil-based waste treatment systems (Environmental Protection Rules), and it had a broad definition of upland streams. One policy (Act 252) protects upland streams, the other does not. Under one policy, waste coming out of pipes is considered a discharge and needs a permit, under the other, waste placed in the ground does not need a discharge permit.

Part II, bringing water quality enforcement problems and their resulting legislation up-to-date, will appear in the Spring 1987 <u>GMG</u>.

MEETINGS

JAN 24 — **VGS WINTER MEETING.**
See Page 3 for details.

JAN 26 — First lecture in UVM Spring 1987 Lecture Series.
See complete list below.

FEB 21 — Well Driller's Workshop will be held at Vermont Technical College in Randolph. After coffee at 9AM, the meeting will focus on communicating with the public and technical matters (nuts and bolts, literally). Contact: Jim Ashley at Water Resources, 244-5638.

MAY 2 — **VGS SPRING MEETING.** Presentation of student research papers. Details in Spring issue of GMG.

MAY 1 to 3 — National Association of Geology Teachers, Eastern Section, Annual Meeting and Field Trips, Stone Ridge, NY. For information contact:
Lawrence R. Matson, Department of Geology
Ulster County Community College
Stone Ridge, NY 12484
(914)+687-7621 ext. 371

AUG 21 to 23 — SEPM Fourth Annual Midyear Meeting. Austin, TX. For information contact: Dr. Robt. A. Morton, General Chairman, Univ. of Texas at Austin, Bureau of Economic Geology, University Station, Box X, Austin, TX 78712.

OCT 16 to 18 — NEIGC The 79th Annual Meeting of the New England Intercollegiate Geological Conference will be held in Vermont on the weekend of October 16-18. The Department of Earth Science of Norwich University will host the conference, with headquarters set up at Vermont College in Montpelier, VT. If you wish further information about specifics of the conference, contact Fred Larsen or Dave Westerman, Dept. of Earth Science, Northfield, VT 05663. (802)+485-2310.

Through a generous foundation grant, the Geology Department will continue sponsoring its Visiting Lecture Series this spring. Lectures will be held in Room 200 Perkins Building at 3:45 P.M. with the exception of March 2nd. For further information contact Dr. Rolfe Stanley, Department of Geology, University of Vermont, Burlington, VT 05405, (802)+656-3396.

JAN 26 — Dr. James McLelland, Grenvillian and Pre-Grenvillian Evolution of the Adirondacks.

FEB 2 — Mr. Monty Fisher, A Geologist View of Environmental Problems and the Political World.

FEB 23 — Dr. Winthrop Means, Transmitted Light Microscopy of Deformed Materials.

MAR 2 — Dr. Ralph M. Raup, Extinction as an Evolutionary Process. (Co-sponsored by the Department of Zoology in Angell B112.

APR 7-9 — Dr. John Suppe, Foreland Deformation - Balanced Cross Sections (Short course).

APR 13 — Dr. Peter Robinson, The Acadian Orogeny in New England.

APR 20 — Dr. Joe Arth, The Use of Isotope and Trace Elements in Modeling Igneous Systems.

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