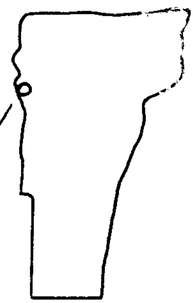
THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

SPRING 1982 VOLUME 9 NUMBER 1



It's got to be SPRING because - the Spring Meeting of VGS is coming!

FEATURING

the EIGHTH ANNUAL Presentation of STUDENT PAPERS

Saturday May 1, 1982 9:00 A.M.

Angell Lecture Center Room B-112

University of Vermont, Burlington

Directions: Park in lot adjacent to Ira Allen Chapel and walk south around Votey Engineering Building to Angell Lecture Hall, the cantilevered building.

CONTENTS

PRESIDENT'S LETTER

(1.) Spring Meeting: Members of the Vermont Geological Society have a wide range of interests and activities. One of our most important activities is that of encouraging research in geology by sponsoring student papers at the spring meeting. This year 10 undergraduates and 5 graduate students will present results of their research at the University of Vermont. But to whom? To anyone besides themselves? Hopefully not. I invite each and every member to attend the spring meeting. Who knows — you may be in on history by witnessing the first awkward steps of the next Charles Lyell, or the next J. Tuzo Wilson...

(2.) Nominations: Your attention is drawn to Article V of our constitution and bylaws. Article V calls for a three-member nominating committee to be appointed by the executive committee at the regular meeting following the annual meeting. This was not done at the winter meeting but will be done at the spring meeting. Members who would like to offer suggestions to the nominating committee for next year's slate of officers may do so by writing to the Society, Box 304, Montpelier by June 1, 1982.

(3.) GSA Section Meeting at Washington, D.C.: Several Vermonters (I use the term in the broadest sense. It includes all natives and all non-natives. Remember Vermont is a state of mind.) presented excellent papers about Vermont geology at the recent combined meeting of the Northeast and Southeast Sections of the Geological Society of America. Peter Tauvers, a UVM graduate student who won VGS Best Graduate Student Paper award at last year's spring meeting, gave an update on his thesis work with "Basement Cover Relationships in West-Central Vermont". Rolfe Stanley, speaking for himself, Dana Roy and Peter Tauvers, gave a summary of several year's work "Thrust Zones in the Pre-Silurian Eugeoclinal Rocks of Vermont". "Isostacy, Eustasy, Porosity — The Sediment Space Problem" is the title of the paper presented by Brewster Baldwin. Congratulations to Peter, Rolfe and Brew for their fine work and contribution to Vermont geology.

PROGRAM

MAY 1, 1982 ROOM B-112 ANGELL LECTURE CENTER

Registration: Coffee 9:00

Metamorphic Studies

1. John Bird: Reinterpretation of the metamorphic sequence near Bethel, Vermont 9:20
2. Paul Zeckhausen: Metamorphic conditions and structural relationships in southeastern Adirondack granulites 9:40
3. Christopher Goodhue: Metamorphic conditions and variations in fluid composition in high-grade carbonates from the southeastern Adirondacks 10:00
4. Gregory Murphy: An evaluation of the biotite-oxide geothermometer and its application to Precambrian amphibolite and granulite gneiss 10:20
5. Deborah Shelton: Metasomatic exchange of major elements in Archean metasediments of West Greenland 10:40

Coffee break

Sedimentary Studies

6. Paul Myrow: A paleoenvironmental analysis of the Cheshire Formation in west central Vermont 11:20
7. Guy Gregory: Paleoenvironments of the Dunham Dolomite, northwestern Vermont 11:40
8. Judith Bonzi: Environments of deposition in Crown Point section, New York 12:00

Lunch (brown bag)

Structural and Tectonic Studies

9. Andrew Franks: Geophysical, structural and petrological study of the Windham ultramafics, Vermont 1:20
10. Joseph DiPietro: The geology in Starksboro-South Starksboro, Vermont: A progress report . 1:40
11. Walter Burt: Stratigraphy and structure northeast of Brandon, Vermont 2:00
12. Stuart Richards: Structure and stratigraphy of a portion of the north end of the Middlebury synclinorium, New Haven, Vermont . . 2:20
13. Nathaniel Wilson: Structure and stratigraphy of the Chipman Formation north of Middlebury, Vermont 2:40
14. Linda Martin: Tectonic stratigraphy: The nature of the Bonsecours-Sweetsburg contact north of Lac Trousers near Eastman, Quebec . . 3:00
15. Craig Manning: Field relationships, petrography and tectonic setting of volcanic rocks from the Chagnon Mountain area, Quebec . 3:20

Business Meeting 3:40

PRESENTATION OF AWARDS

ABSTRACTS

REINTERPRETATION OF THE METAMORPHIC SEQUENCE NEAR BETHEL, VERMONT

Bird, John Q., Department of Geology,
Middlebury College, Middlebury, Vermont 05753

The tectonic histories of the Moretown Formation and Barnard volcanic member, Shaw Mountain Formation, and Northfield Slate in east-central Vermont are strikingly similar. Each shows three distinct deformational events as well as a post-kinematic biotite-grade recrystallization. The first event (D_1) is recorded by tight isoclinal folding (F_1) with strong axial planar schistosity (S_1). S_1 is the dominant foliation in the area. The second event (D_2) is seen as a series of open symmetrical folds (F_2) of the S_1 with an axial plane of N 80°E, 15°N. D_2 caused a wide variation in the orientation of S_1. The third event (D_3) is a gentle warping, with axial planes of N 70°E, 90°.

The Barnard gneiss and chlorite schist grades into Northfield phyllite within 2 meters; the contact pre-dates D_1 and is probably depositional.

Chlorite zone greenschist facies metamorphism (M_1) is associated with D_1. A second metamorphism (M_2) to at least biotite zone greenschist facies occurred during and after D_2. Most thin sections exhibit strong evidence of retrograde metamorphism from biotite zone to chlorite zone, after D_2.

Microprobe analysis of feldspars within the Barnard revealed compositions from Ab_{100} to Ab_{75}, with very few falling in the peristerite gap. The feldspars are transitional between the greenschist and amphibolite facies and are related to M_2.

With the use of a biotite-garnet geothermometer (Ferry and Spear, 1978) M_2 temperatures were calculated to be 400° to 450°C, which correlates well with accepted values for temperatures transitional between amphibolite and greenschist facies.

Evidently, the Moretown Formation is a post-Taconic deposit, and deformational features in it and younger units are due to the Acadian orogeny.

ENVIRONMENTS OF DEPOSITION IN CROWN POINT SECTION, NEW YORK

Bonzi, Judith, Department of Geology,
Middlebury College, Middlebury, Vermont 05753.

Of the Middle Ordovician strata exposed at Crown Point, New York, about 126 meters has been studied in the field and thin section to reconstruct environments of deposition. This interval includes much of the Chazy Group (Crown Point Limestone, Valcour Limestone), the Orwell Limestone, and part of the Glens Falls Limestone.

The Crown Point Limestone (0-59m) is mostly covered (5-23m; 26-44m). Locality A of Baldwin (1980) exposes 5m of lime-mud with dolomite laminae and traces of pyrite. The lime-mud is a horizontally burrowed pelmicrite to pelsparite with common nautiloids, Maclurites and other grazing(?) snails, pelmatozoan stems, and algae (Girvanella). This is probably intertidal. Locality B (23-26m) exposes cross-bedded lime-sand with scattered terrigenous grains, of a wave-washed environment. Locality C (44-59m) exposes almost featureless limestones and dolostones of a probable subtidal environment.

The Valcour Limestone (59-79m) represents a shore-zone environment. Interbedded lime-silt and dolomite at Locality D show vertical and horizontal burrowing in dolomitized pelmicrite, with sparse pelsparite. Fossils are restricted to Maclurites, pelmatozoan stems and fossil hash. The beds are probably intertidal. Locality E exposes cross-bedded oopelsparite (lime-sand), massive dolomite, and ripple-bedded quartzite, which indicate a shallow subtidal area with possible wash-over dunes.

The Orwell Limestone (79-101m) is mostly massive micrite and pelmicrite, with a few pelsparites and coarse storm deposits. Dolomite is rare; burrowing is common. Stromatoporoids, corals, nautiloids, clams, pelmatozoans and bryozoans suggest a sheltered shallow photic environment.

Typical thin graded beds of the Glens Falls Limestone (101-126+m) are biopelmicrite in the lower part and micrite above, suggesting turbidites and/or coarse storm deposits. The predominant fossils are brachiopods, bryozoans, trilobites and pelmatozoans. Absence of stromatoporoids, corals, and grazing snails suggest the sea floor is deeper than the active photic zone.

The section represents a variety of marine environments, from tidal flat in the Chazy to open shelf in the Glens Falls. Covered intervals hamper understanding of the cyclical patterns that modify this deepening trend.

STRATIGRAPHY AND STRUCTURE NORTHEAST OF BRANDON, VERMONT

Burt, Walter, Department of Geology,
Middlebury College, Middlebury, Vermont 05753

Field mapping on and near Lion Hill clarifies the structure and stratigraphy of a portion of the east limb of the Middlebury Synclinorium. A 920-foot section was measured, representing what Cady (1945) has mapped as the Monkton Quartzite, the Winooski Dolomite, the Danby Formation, and the Clarendon Springs Dolomite. The Monkton is 150 feet thick and is composed of interbedded immature blue-gray quartzite, multi-colored siliceous dolostones, black and green phyllite, and rust-colored calcareous siltstone. Bedding ranges from 1/8 inch to several feet thick. Abundant grains of blue rutilated quartz were observed in the quartzites and siliceous dolostones. The Winooski is predominately a pink dolostone with siliceous partings. Gray and mottled dolostone appears in places in the formation. Between 350 and 400 feet of the Danby was measured. It consists of protruding beds of commonly cross-bedded gray and reddish quartzite interbedded with gray dolostone. In addition it contains some silty beds. At least 120 feet of the Clarendon Springs exists in the area. It is a massive gray dolostone with silty ribs near the top of the section, and quartz stringers and geodes near the bottom.

The structure observed is north-trending, west-vergent, flexural slip and flow folds plunging 20 degrees south. The axial plane dips about 57 degrees east. Shearing, minor faulting and one major reverse fault dipping 60 degrees east, with a dip displacement of about 1000 feet, disrupt the stratigraphic continuity on several scales. Evidence for two deformations is found in crenulation of cleavage in micas in thin-section, and in a slight warping of the fold orientation plotted on an equal-area projection. Corroded and embayed quartz grains, numerous quartz veins, and the presence of two, east-dipping narrow bands of lead/zinc ore, comprised of pyrite, chalcopyrite, galena, sphalerite and pyrrhotite, suggest there was extensive fluid activity in the area.

THE GEOLOGY IN STARKSBORO - SOUTH STARKSBORO, VERMONT: A PROGRESS REPORT

DiPietro, Joseph, Department of Geology, University of Vermont, Burlington, Vermont 05405

The Pinnacle Formation, exposed within the core of the Lincoln anticline, can be subdivided into three major quartzo-feldspathic units. From oldest to youngest they are: 1) a sericite-chlorite schist with blue quartz clasts, mottled calcareous laminae and a general absence of biotite; 2) a dark grey sericite-biotite-chlorite schist with abundant feldspar clasts; and 3) a green, sericite-chlorite phyllite with several marker beds, including the Forestdale Dolomite, which traditionally has been considered a member of the Underhill Formation. The Fairfield Pond Phyllite Member of the Underhill Formation overlies the Pinnacle Formation on the west limb of the Lincoln anticline. The uppermost unit of the Pinnacle Formation and the Fairfield Pond Phyllite are not present on the east limb of the Lincoln anticline indicating that tectonic contacts are present on this limb along the approximate trace of the Pinnacle Formation-Underhill Formation boundary. Two major fault slices are recognized, the Jerusalem slice and the Underhill slice, both of which are coeval with the earliest recognized folds. The Jerusalem slice consists of a fine-grained quartz-laminated schist. Erosional outliers of this unit are present on the west limb of the Lincoln anticline. The Underhill slice consists of a variety of schists, foliated quartzites and greenstones, none of which can be correlated with rocks to the west. The rocks of the Underhill slice contain medium to medium-high pressure amphiboles (Laird and Albee, 1981).

GEOPHYSICAL, STRUCTURAL, AND PETROLOGICAL STUDY OF THE WINDHAM ULTRAMAFICS, VERMONT

Franks, Andrew L., Department of Geology, Middlebury College, Middlebury, Vermont 05753

The subsurface structure and petrology of three steatized serpentinite bodies in Windham are studied. They lie in the Appalachian ultramafic belt and occur in upper-greenschist facies deep-water sediments of the Lower Ordovician Stowe Formation. VERMARCO, INC. has conducted extensive exploratory drilling in and around the bodies. The combined information provided by the results of the drilling, gravity prospecting, and surficial mapping has been used in constructing a three-dimensional plexiglass model of the subsurface structure of the bodies. The bodies are steep-sided and lenticular. Absence of high temperature contact aureoles with surrounding formations, their lenticular shapes, and the occurrence of relatively unaltered infolds of country rock recorded in the drill core data indicate that their emplacement is tectonic rather than intrusive. Thus, the bodies are considered to represent serpentinized ophiolitic slices obducted during mid-Ordovician times.

The formation of the "black wall" metasomatic zone separating the ultramafics and country rock is well illustrated. The bodies grade locally outwards from an irregular serpentine core to talc-carbonate rock (grit talc) to steatite (essentially pure talc). The black wall shows the common sequence chlorite to biotite to quartz-chlorite-sericite-(garnet) schist. The major mobile elements involved in the formation of the black wall are Si (given up by the country rock) and Mg and Ca (released during the steatization of the serpentine). The black-wall sequence represents a system in frozen partial equilibration between the ultramafics and schists.

Two-dimensional computer modeling of gravity data for the unmined southernmost body indicates that a talc pod, documented by exploratory drill data, is not sufficient to account for observed patterns of gravity variation along traverses over the body. A steep-sided lenticular pod of chromite and/or magnetite located adjacent to and slightly below the eastern side of the talc body can best account for the difference between the observed pattern of gravity variation and that calculated for the talc body alone.

METAMORPHIC CONDITIONS AND VARIATIONS IN FLUID COMPOSITION IN HIGH-GRADE CARBONATES FROM THE SOUTHEASTERN ADIRONDACKS

Goodhue, Christopher, Department of Geology,
Middlebury College, Middlebury, Vermont 05753

Phase equilibria relations and the mineralogical variations observed within Precambrian carbonate bodies in the southeastern Adirondacks suggest a complex history of highly variable fluid composition on an outcrop scale. The bodies are lenticular forms which presumably intruded the surrounding quartzo-feldspathic gneisses along planes of weakness subparallel to the gneissosity. Abundant xenoliths within the carbonate bodies cover a wide range of composition from charnokitic to pyroxenitic.

Metamorphic conditions were calculated to be on the order of 8 to 10 kb and 800°to 820°C. These figures exceed those suggested by Bohlen and Essene (1977), implying a slightly more severe thermal regime for the southeastern Adirondacks during the Grenvillian. This information correlates well with contemporary work on gneisses in the same area (Zeckhausen, 1982). Using these physical constraints and theoretical phase equilibria relations for pure phases, fluid compositions were modeled for the carbonates. The ubiquitous assemblage of K-spar+Cc±Dol and the sporadic appearance of pholgopite indicate that fluids generally had an X_{CO2} of >0.5. Correction for actual mineral compositions has the effect of increasing the stability field of phlogopite, thus increasing the lower limit of X_{CO2} at the temperatures obtained. The spatially distinct assemblage of Cc+Woll+Qtz+Di+Gross however indicate very water-rich conditions assuming uniform temperatures throughout the carbonate bodies. As the calcite and quartz grains included within larger crystals of wollastonite do not touch, it is assumed that the assemblage lies above the curve for

$$\text{calcite + quartz} \rightleftharpoons \text{wollastonite} + CO_2$$

thus restricting X_{CO2} to a maximum of about 0.25.

Modeling of the phase relations observed for some of the xenoliths contained within the carbonate indicate significant degrees of mass transport between carbonate and the xenoliths. High degrees of mobility of Al, Ca, K, Mg, and Fe are indicated by the results. The presence of xenoliths demonstrates that the carbonates acted as igneous bodies which may have migrated significant distances through the crust.

PALEOENVIRONMENTS OF THE DUNHAM DOLOMITE, NORTHWESTERN VERMONT

Gregory, G.J., Department of Geology, University of Vermont, Burlington, Vermont 05405

Recent paleoenvironmental study of the Lower Cambrian Dunham Dolomite of northwestern Vermont has delineated a cyclical mosiac of four major facies along the western limb of the St. Albans synclinorium north of Burlington. The distribution of these lithologies represent transgression on a passive shelf during Waucoban time.

Rocks exhibiting peritidal sedimentary features are a cyclical package of 1) thinly interbedded dolomicrite and silty dolomicrite, diagenetically modified to sedimentary boudins. This unit is bioturbated throughout. Unit 2 of this package is represented by thin, continuous beds containing laterally linked hemispheroid stromatolites with associated intraformational conglomerates and vertical bioturbation. These are often spatially associated with unit 3, thin, discontinuous dolospar beds. These dolospars show planar bases and convex upward tops, with small scale cross-stratification, and generally concentrate sand-sized terriginous material. Unit 4 of this cycle is a coarsely crystalline dolospar, with cryptalgal planar laninae locally interbedded.

Transitional with and overlying the peritidal cycles are rocks with subtidal-open shelf affinities. Generally, this environment is represented by thick bedded, massive dolomicrite. Quartz sand and other fine-grained terriginous material is distributed in an irregular, patchy manner throughout this unit, and is often concentrated in the ubiquitous horizontal burrows. Local planar stromatolite sequences support a low energy regime within these beds. Dolospar beds, thicker but essentially unchanged in internal character from unit 3 of the peritidal facies, occur within this environment as well.

The two previous environments are transected by lenticular, discontinuous dolomitic sandstone beds, downcutting into the substrate. These exhibit small scale cross-stratification, and contain several lithologies as clasts both intraformational and exotic in origin. These are interpreted as channels cross-cutting the shallow shelf.

Units representing deeper water environments are represented by two separate lithologies. Thick, massive dolospar units, not unlike unit 3 of the peritidal facies but considerably thicker, are interpreted as representing shelf-edge sand shoals. Overlying these dolospar units are thick, complex polymictic subaqueous debris flow breccias, marking the boundary between shelf and basin. These are fed with terriginous material by the channel facies sandstones.

This facies mosaic, with its spatial arrangement, illustrates a transgressive event on a passive continental margin, analagous to present day sedimentation in Shark Bay, Australia (Davies, 1970).

FIELD RELATIONSHIPS, PETROGRAPHY AND TECTONIC SETTING OF VOLCANIC ROCKS FROM THE CHAGNON MOUNTAIN AREA, QUEBEC

Manning, Craig E., Department of Geology, University of Vermont, Burlington, Vermont 05405

Pillowed volcanic rocks cap allochthonous ophiolite sequences in the southern Quebec portion of the northern Appalachians. Lavas from the Chagnon Mountain ophiolite were mapped and sampled to determine field relationships, petrography and tectonic setting of extrusion.

Three groups have been distinguished: an olivine phyric type, a plagioclase phyric type, and a clinopyroxene and plagioclase phyric type. The first two volcanic lithologies are dark green and form the extrusive cap to the now dismembered ophiolite sequence. They appear similar in the field, but microscopic examination shows that the first group is made up of a fine-grained, recrystallized groundmass and minor chlorite pseudomorphs after olivine, whereas the second group has a subophitic to intergranular groundmass of clinopyroxene and plagioclase with sausseritzed plagioclase phenocrysts. These rocks are found directly overlying ophiolite lithologies, and as isolated thrust slivers throughout the area. The third volcanic suite is light green, with zoned phenocrysts of clinopyroxene and plagioclase, and can be distinguished from the other two in the field. These rocks are found in one place in the volcanic pile over the ophiolite with uncertain contact relationships, but are predominantly found as thrust slivers throughout the area. All rocks in the study area are metamorphosed to at least lower greenschist facies.

Discrimination schemes showing magma affinity and tectonic setting on the basis of clinopyroxene compositions indicate that the dark green plagioclase phyric lavas are of within-plate affinities and that the light green volcanics with clinopyroxene and plagioclase phenocrysts are of subalkaline island arc affinities. Although such schemes should be used with caution, the findings lend support to a model in which the alkaline lavas of a seamount or leaky transform represented a significant anisotropy in the ocean's crust. This zone of weakness could have given rise to a subduction zone dipping seaward, allowing for the alkaline affinities of the leading edge of the overriding plate now exposed as as ophiolite sequence. Finally, continued subduction led to the development of an island arc on the upper plate.

TECTONIC STRATIGRAPHY: THE NATURE OF THE BONSECOURS-SWEETSBURG CONTACT NORTH OF LAC TROUSERS NEAR EASTMAN, QUEBEC

Martin, Linda M., Department of Geology, University of Vermont, Burlington, Vermont 05405

Detailed mapping north of Lac Trousers has established the deformational history along the Bonsecours-Sweetsburg Contact (BSC) and its relation to ophiolites in southern Quebec. Lower Paleozoic quartz-sericite schist of the Bonsecours Formation forms the core of the Green Mountain-Sutton Mountain anticlinorium in southern Quebec and is in contact to the east with quartzite, slate and phyllite of the Sweetsburg Formation. Ultramafic/mafic bodies, not present in the Bonsecours Formation, occur along the BSC and within the Sweetsburg Formation.

Field evidence has shown the BSC, contacts between the ultramafic and mafic rocks, and the contacts between the ultramafic/mafic rocks and the surrounding metasediments to be tectonic. Evidence for fault contacts includes: truncation of units along a common surface, truncation of fold structures at contacts, fault slivers along contacts, and the sheared nature of the rocks at the contacts. The tectonic nature of the BSC requires rethinking of the stratigraphic sequence proposed by previous workers. These results agree with recent work to the south in northern Vermont which has shown this same contact to be a zone of closely spaced faults (Hollis-Gale, 1980; Stanley and Roy, 1982).

Based on a detailed structural analysis, four fold generations and at least two major thrusting events are present. The first faulting event (T_1) is pre- to syn- F_1 and includes imbrication of the ultramafic, mafic, chloritic schist and greywacke rock types along with imbrications of ultramafic rocks into the Sweetsburg Formation. The second major faulting event (T_2) incorporated these imbricate slices into the Sweetsburg Formation and brought the Sweetsburg tectonic package in contact with the Bonsecours Formation. The map pattern of the area is predominantly controlled by F_4 folding and T_2 faulting. Post F_4 faulting may have occurred along some of the major faults.

AN EVALUATION OF THE BIOTITE-OXIDE GEOTHERMOMETER AND ITS APPLICATION TO PRECAMBRIAN AMPHIBOLITE AND GRANULITE GNEISS

Murphy, Gregory, Department of Geology,
Middlebury College, Middlebury, Vermont 05753

The recently developed biotite-oxide geothermometer, base on the partition Ti and Fe^{++} between two phases, was applied to Precambrian amphibolite and granulite gneisses in the Adirondack Mountains, southwest Australia, and southwest Greenland. The goal of the work is to evaluate the accuracy of the geothermometer and to develop geothermal gradients for the areas. The Australia area yielded temperatures ranging from 616°C to 852°C, with an average of 740°C, which is in good agreement with the petrologic findings of Stephenson (1979). Geothermal gradients of 53°C/km and 66°C/km were developed across a 0.5kbar pressure gradient.

A general isotherm pattern for the Adirondacks was constructed, and a detailed pattern for the Colton area was examined. The detailed area shows excellent agreement with the textural and petrologic findings of Engel and Engel (1960). The muscovite limit which was found in field assemblages corresponds to the 740°C isotherm; this agrees with experimental stability data for muscovite. Temperature gradients correspond to the progressive metamorphism seen in the field. The Emeryville to Colton traverse gives a geothermal gradient of 30° to 40°C/km.

Comparisons of temperature data given by other geothermometers implies the biotite-oxide geothermometer more accurately records peak metamorphic temperatures than the Goldman and Albee (1977), Perchuk (1970), and Thompson (1976) garnet-biotite methods in Australia, and the two-feldspar two-pyroxene, and garnet-biotite methods in the Adirondacks.

A PALEOENVIRONMENTAL ANALYSIS OF THE CHESHIRE FORMATION IN WEST CENTRAL VERMONT

Myrow, P.M., Department of Geology, University of Vermont,
Burlington, Vermont 05405

An investigation aimed at defining the sedimentology and depositional history of the Lower Cambrian Cheshire Formation in west central Vermont was begun during the 1981 field season. The Cheshire has been considered by early workers to be a homogeneous sandstone unit representing beach deposits (Thomas, 1877). Field work in the Bristol-Starksboro region reveals the lower Cheshire to be a deposit of considerable lithologic diversity. Several cycles of sedimentation are evident. Five distinct lithofacies have been recognized as representing sediment deposited in a tidal flat environment. Environmental interpretations are based largely upon assemblages of physical and biogenic structures. The lithofacies recognized and their environmental interpretations are listed below:

Facies 1 - upper mud flats. This facies is characterized by densely bioturbated, grey, argillaceous, fine-grained quartz arenite.

Facies 2 - sand flats. This facies consists of thin-bedded, horizontally laminated to ripple cross-laminated, shale draped, quartz arenite.

Facies 3 - lower sand flat - shallow subtidal. This facies is characterized by thin to thick bedded, plane bedded, and horizontally stratified to tangentially cross-stratified quartz arenite beds.

Facies 4 - tidal creek. This facies consists of structureless to finely laminated, thin lenticular sand bodies.

Facies 5 - storm deposits. This facies is a conspicuous unit that consists of very continuous, pink, quartz arenite sand sheets.

The first three facies above are gradational in nature and are cyclically repeated in vertical succession. This is thought to be the result of environmental migration during transgressive/regressive events. Facies 4 and 5 occur within each of the first three facies.

Preliminary studies of the upper Cheshire suggests that this is a lithologically distinct unit of considerable stratigraphic complexity. Two distinct facies have been recognized:

Facies 1. This facies is primarily pink to white, massive, structureless quartz arenite.

Facies 2. This is a highly variable facies that consists of either a) thin interbeds of phyllite and sandstone, b) quartz arenite with thin disseminated stringers of phyllite, or c) quartz arenite with small lenticular pods of shale.

The massive quartz arenite of Facies 1 is interpreted as having been deposited in a subtidal environment. Facies 2 assemblages indicate periods of decreased hydrodynamic activity. The mechanism for hydrodynamic fluctuations is relative sea level changes as described for the lower Cheshire.

STRUCTURE AND STRATIGRAPHY OF A PORTION OF THE NORTH END OF THE MIDDLEBURY SYNCLINORIUM, NEW HAVEN, VERMONT

Richards, Stuart L., Department of Geology, Middlebury College, Middlebury, Vermont 05753

Field work, statistical fabric analysis, and microscopic examination of hand samples and thin sections from the Middlebury Limestone and the Beldens member of the Chipman Formation reveal evidence for two major deformational events in the autochthonous Middle Ordovician continental platform carbonate sequence of the Middlebury synclinorium. The area studied lies west of U.S. 7 near the New Haven River.

The Beldens member, particularly in outcrops just west of the Dog Team Restaurant, consists of fairly pure white to pink marble with one or two-foot interbeds of tan to orange beeswax-weathering dolostone. The dolostone beds and the presences of worm burrows suggest intertidal and shallow subtidal deposition. The Beldens displays ductile flowage of limestone, boudinage of dolostone, and probable attenuation of limbs.

The Middlebury and Beldens exhibit two fold styles. Both are west-vergent with south-plunging fold axes. One is the recumbent isoclinal passive to flexural-flow folds. Superimposed on these folds is a series of upright flexural-slip folds associated with a fault found on the New Haven River. The Middlebury grades upward from the Beldens through what may be a refolded bedding-plane thrust into a markedly schistose dark blue-gray thin-bedded incompetent granular limestone, with schistosity decreasing away from the contact.

Thin-section examination generally reveals a heavily metamorphosed, altered and recrystallized carbonate matrix with several generations of calcite veins. Both detrital and authigenic quartz and feldspars were found, while ghosts of fossil fragments may have been observed. Chlorite and sericite indicate low-grade metamorphism, while wild folding indicates ductile flow, possibly of unconsolidated material. This ductile flow in the isoclinal recumbent folds is attributed to the Taconic orogeny, while brittle deformation and upright folds are correlated with the Acadian orogeny.

METASOMATIC EXCHANGE OF MAJOR ELEMENTS IN ARCHEAN METASEDIMENTS OF WEST GREENLAND

Shelton, Deborah H., Department of Geology,
Middlebury College, Middlebury, Vermont 05753

In the Nordre Strömfjord region of West Greenland carbonate bodies are interspersed with a sequence of quartzo-feldspathic gneiss and pelitic rocks. The carbonate bodies are enclosed in metasomatic reaction zones which record element diffusion. Rocks from the reaction zone were analysed for the major element concentrations of Na_2O, Al_2O_3, SiO_2, K_2O, MgO, TiO_2, P_2O_5, MnO, FeO and CaO. The purpose of these analyses was to determine the direction of element migration in the vicinity of a carbonate body. In determining the mobility of the elements the number of moles of the specific element were plotted against distance from the carbonate body. SiO_2 increases fairly systematically moving away from the carbonate. CaO and MgO show opposite results. CaO drastically decreases in concentration while MgO abruptly increases in concentration moving away from the carbonate body. FeO mole concentration remains fairly constant close to the carbonate and then shows extreme oscillation away from the carbonate. There is no apparent systematic pattern to the mole percent concentration for Na_2O. Al_2O_3 and TiO_2 show identical results. Their ratios remain constant across the traverse.

The results indicate that the proximity of the carbonate body affected the migration of major elements across the area. There are two possible mechanisms of migration for the major elements. One is solid state diffusion and the other is fluid interaction of transport. The different diffusion rates of the major elements are the possible results of these two mechanisms of migration.

STRUCTURE AND STRATIGRAPHY OF THE CHIPMAN FORMATION NORTH OF MIDDLEBURY, VERMONT

Wilson, Nathaniel C., Department of Geology, Middlebury College, Middlebury, Vermont 05753

The Chipman Formation was studied north of Middlebury and east of U.S. 7, at the north end of the Middlebury synclinorium. It consists of the Burchards limestone, Weybridge member, and Beldens member. The Burchards is smooth-weathering gray to dark gray limestone with pods of brown dolostone. Bedding is the only observable primary structure. The Weybridge consists of silty dark dolostone in raised ridges interbedded with layers of finer-grained gray limestone. Primary structures include bedding, cross-bedding, and channels. The Beldens is largely light blue-gray to black limestone interbedded with tan to brown smooth- to beeswax-weathered dolostone. Bedding and some cross-bedding are the only sedimentary structures observed. Environment of deposition of the Chipman is probably intertidal, because of channels, dolostone, cross-bedding, and some worm-burrowed beds.

Mapping reveals five orders of folding; the 3d, 4th, and 5th order subsidiary folds are readily seen in outcrop. These are west-verging inclined to recumbent folds that plunge 10 S. On average, the axial plane strikes N 6 W and dips 60 E. Minor structural features include boudinage of dolostone beds and flowage of limestone beds. In certain lithologies, there is a second deformation, which consists of small-scale folds with nearly vertical axial planes.

Thin sections show detrital quartz and feldspar, suggesting influx of sediments from the west. Low-grade metamorphism, which masks primary structures, has formed euhedral pyrite, has recrystallized the calcite, and has developed muscovite and chlorite along cleavage planes. Flowage, folds, shear, and veins, which appear in outcrop, are also common in thin section.

METAMORPHIC CONDITIONS AND STRUCTURAL RELATIONSHIPS IN SOUTHEASTERN ADIRONDACK GRANULITES

Zeckhausen, Paul, Department of Geology,
Middlebury College, Middlebury, Vermont 05753

A new roadcut in Fort Ann, New York, was studied to bracket P-T conditions during metamorphism that affected this part of the Adirondacks. Temperatures of the granulite metamorphism were determined using the Ti vs Fe^{++} in biotite (geothermometer of Carmichael, unpublished), the biotite-garnet thermometer of Ferry and Spear (1978), the biotite-clinopyroxene thermometer of Ellis and Green (1979), and two computer program analyses of key metamorphic reactions. Temperatures obtained average approximately 810°C ±40°C. These temperatures mark the peak of metamorphism in the granulite facies that in the Adirondacks is dated at 1.2 billion years ago.

Pressure estimates were obtained using phase relationships and the thermodynamic properties of the considered minerals. Two reactions used to make pressure estimates are:

$$\text{Phlog} + 3\ \text{Sill} \rightleftharpoons 3\ \text{Spinel} + \text{K-spar} + \text{Qtz} + H_2O(g)$$

$$4\ \text{Enst} + \text{Anorth} \rightleftharpoons \text{Diop} + \text{Pyrope} + \text{Qtz}$$

Pressures obtained were about 9 kb at 810°C. These values are further supported by the upper stability of sillimanite (the only Al_2SiO_5 polymorph that appears) at 9.5 kb at 810°C.

Structurally these P-T conditions probably correspond to the rotation and folding of meta-igneous boudins that occur in the outcrop. Because the metamorphic fabric in the outcrop is dramatically draped over the boudins and is truncated by them, the fabric evidently developed before or during the boudin rotation.

Pressure and temperature estimates (810° ± 40 C, 9 kb + 1kb) are significantly higher than those put forth by Bohlen and Essene (1977). They estimate temperature at ≤ 650 C for my outcrop areas. It appears that their feldspar and Ti-oxide temperature estimates mark re-equilibration temperatures and not true peak values. McLelland and Isachsen (1980) suggest P-T conditions of 650° to 800°C and 7 to 8 kb, based on the work of others (de Waard, 1969; Bohlen and Essene, 1977; McLelland and Whitney, 1977; and Whitney, 1978). The extreme upper limit of their P-T estimates overlap with my estimates; in turn, my estimates are consistent with those of Goodhue (1982), who concurrently examined carbonate rocks in the same outcrop.

ERRATUM

The corrected version of Fred's abstract for the Winter 1982 meeting follows:

LATE-GLACIAL AND POSTGLACIAL HISTORY OF THE NORWICH UNIVERSITY CAMPUS

Larsen, Frederick D., Department of Earth Science, Norwich University, Northfield, Vermont 05663

The central part of Norwich University campus is built on a kame about 60 feet high in the middle of the Dog River valley. Recent excavations in the flank of the kame provide details about its glacial origin. On the northwest flank of the kame, collapsed ice-contact lake deposits are overlain by undeformed lake sediments formed by currents that moved southward in glacial Lake Roxbury. Lake Roxbury formed when the retreating ice sheet blocked the north-draining Dog River valley and caused melt water to drain south and over a 1,010-foot threshold at Roxbury. The lowest deposits exposed on the southeast flank of the kame are also collapsed and overlain by southeast-dipping lake sands that parallel the soil profile at the surface, and increase in dip and degree of deformation with greater depth of burial. This suggests that deposition of lake sediments occurred while a buried ice block was melting.

Following drainage of the glacial lake, two stream terraces were formed on the western side of the university. The terraces are underlain by pebble gravel deposited by a north-flowing stream that may have graded into a glacial lake in the Winooski River valley. Down-cutting by the Dog River and subsequent lateral migration of its meanders produced the topography we see today. The late-glacial and postglacial history can be summarized as follows: (1) deposition of lake sediments in contact with buried ice, (2) collapse of lake sediments during melting of buried ice, (3) deposition of undeformed lake sediments, (4) drainage of the glacial lake, and (5) development of stream terraces and the modern flood plain.

VGS BUSINESS & NEWS

NEW MEMBERS

It is a pleasure to welcome so many new members both individuals and organizations which have been accepted by the Executive Committee since the Winter Issue of the GMG was published:

David J. Cable	Charlotte, Vermont
John Cotton	East Andover, New Hampshire
Kevin T. Dann	Huntington, Vermont
Robert Mitchell	Houston, Texas
John Rand	Cundy's Harbor, Maine
Steven Revell	Bristol, Vermont
Bart Stryhas	Ludlow, Vermont

Baker Library, Dartmouth University, Hanover, N.H.
Geological Sciences Library, Harvard University, Cambridge, Massachusetts
Rutland Historical Society, Rutland , Vermont

VERMONT GEOLOGY

Volume 2 has gone to the printer and will be ready for sale at the spring meeting, where you will be able to save postage charges. For those unable to attend the spring meeting, there is an order blank stapled in the center of this issue of GMG. Make the treasurer happy by ordering early !

The editor's thoughts can now turn to volume 3. Speakers at this year's winter meeting will receive written solicitations to submit manuscripts, but these are not the only papers we want to publish. Any manuscript which meets the criteria listed below is solicited for volume 3:

1.) The major context of the paper must relate to an accepted earth science discipline, and must involve Vermont geology but not necessarily restricted to Vermont geographical borders.

2.) The paper must present some element of new information gathered either through research or observation and experience, or must be a compilation of information from a variety of sources presented in a creative fashion using new analytical and interpretive procedures.

3.) Papers must be written in a clear, concise and well-organized style, and must show literary integrity and honesty through proper credit-giving and referencing techniques.

All manuscripts will be reviewed by the editorial committee and at least two outside reviewers.

Mail 3 copies of the manuscript to:
Vermont Geological Society Editor
Box 304
Montpelier, Vermont 05602

WINTER MEETING REPORT

It was a good meeting with both old and new members present (an early morning count showed 47 in attendance). The keynote speaker, John Cotton, led us in "A Hydrogeologic Stroll out of the Pleistocene", showing slides of glacial deposits as they are developing today in Greenland, with their accompanying glacial ice at times spectacular, and comparing them with the existing glacial features seen in New England. This was followed up by a discussion of the methods used for exploring and monitoring ground water in glacial deposits and bedrock in New England.

Notes from the Executive Committee meeting by Larry Becker are presented below:

Teacher workshop and the fall meeting were subjects of discussion as to where, when, and who. Chuck Ratté proposes idea of cross section across Vermont, maybe tie in with Osberg's look for key field localities. Jeanne Detenbeck thinks Osberg may only be looking for the top of the line stuff, like the Champlain Thrust. Fred proposes a trip in Northeastern Vermont/Western New Hampshire that could be an overnight in Colebrook, N.H.. There was more discussion about the Trans Vermont field trip mostly along Vt. Route 4 with the idea of inviting J.B. Thompson to lead.

Discussion of developing a VGS stance on oil and gas legislation. We have missed the House Natural Resources Committee but could make the Senate Natural Resources Committee for testimony. Chuck proposes that a committee should be set up but he can't be on it because of his involvement with the development of the legislation. What is needed is a group of people to read the legislation, which will take time, and develop a position. Names that were mentioned were Al Hunt, John Stevens, Dave Butterfield (he may have a conflict). Fred will contact by phone.

FOSSIL OF THE QUARTER

Foraminifera

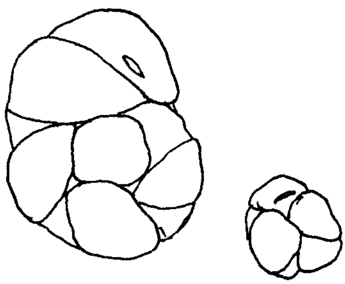
The Foraminiferida are related to the amoeba. Like the amoeba, the single cell of amorphous protoplasm engulfs its food with a pseudopod, absorbing it through the cell wall. Waste removal also takes place directly through the cell wall. However, unlike the amoeba, the "foram" builds a calcereous, agglutinated or pseudochitinous shell or test. The pseudopodia are extruded through perforations in the test. In the multilocular (many chambered) forms, the animal builds successively larger chambers much like a nautilus. Chamber arrangement ranges from straight like a string of pearls as in the genus Dentalina, to complex coiling of the family MILIOLIDAE, where chambers are added about an axis on up to five planes. While the test is usually less than 1 mm. in diameter, there are a few spectacular exceptions which range as high as 100 mm. The composition of the test provides the basis for division of the order Forminiferida into suborders. Wall microstructure and number of chambers define family lines.

Forminifera occupy the benthonic and planktonic zones of the world's oceans. Many of the benthonic forms are discoidal or fusiform in shape. The test may be calcareous, agglutinated or pseudochitinous. The benthonic forms, which make up the majority of foraminifera species, occupy brackish to marine niches in estuaries to the deep ocean. Within each habitat, characteristic assemblages occur. Sediment characteristics, salinity and temperature, as well as depth, control species assemblages. This makes them valuable as tools used in interpretation of local paleoenvironmental conditions. The planktonic foraminifera are calcareous with globular form and spines to aid in staying afloat in ocean currents. Because they have a wide geographic range, are abundant, and evolve rapidly, the planktonic foraminifera are excellent stratigraphic indicators.

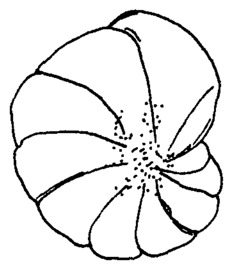
A geologist drilling for oil wants to maintain rigid stratigraphic control of the drill depth. Because the rock is broken into small bits and then flushed out of the hole, macrofossils are destroyed. Because of their size, the foraminifera are not as vulnerable to the drill bit. With the foraminifera as a guide, the geologist has the tool he needs to identify stratigraphic horizons.

Here in Vermont, of great interest to local geologists are the marine clays under Lake Champlain. The stages of development of the Champlain Valley are defined by biostratigraphic zones and acoustical horizons. The foraminifera in the Champlain Sea sediments have helped to interpret the history of the marine stage. By examining the species present and the proportions of some species with respect to others, a general trend may be seen in which the Champlain Sea becomes more shallow and less saline through its evolution.

Two groups of foraminifera dominate the Champlain Sea assemblages. The genus *Protelphidium* tolerates lower salinity and more shallow water depths than does the genus *Islandiella*. Both are arctic foraminifera. As the sediments become younger, *Protelphidium* becomes more numerous than *Islandiella*. *Protelphidium* numbers then drop to zero, marking the end of the Champlain Sea. This decrease in salinity conforms to the known history of the Champlain Valley. Shortly after the marine invasion, the northern region of the Champlain Valley began to rebound more rapidly than the southern end. With the shallowing of the sill area, the waters of the Champlain Valley became freshened and formed the Lake Champlain we know today.



genus; Islandiella



genus: Protelphidium

Representatives of the dominant foraminifera found in the Champlain Sea.

Submitted by Shelley Snyder

RECENT PUBLICATIONS

"Late Wisconsinan Glaciation of New England," 1982, Grahame J. Larson and Byron D. Stone, Editors, Kendall/Hunt Publishing Company, Dubuque, Iowa, 242 p, $24.95, case-bound, 8 1/2" x 11" format.

"Late Wisconsinan Glaciation of New England" constitutes the proceedings of a symposium held at the March, 1980, meeting of the Northeast Section of the Geological Society of America in Philadelphia, Pennsylvania. It contains 13 papers, 12 of which are regional studies, and one is a numerical model of deglaciation of New England. The major impetus for the symposium was the compilation of the surficial geologic map of Massachusetts, therefore it is not surprising that five of the papers are about Massachusetts. There are two papers about Connecticut, two on Maine, and one each on Long Island, New Hampshire and Vermont.

The contents of the volume are laid out logically starting with two papers on the maximum extent of the last ice sheet in southern New England and Long Island and proceeding with ten papers on the effects of the ice sheet as its margin retreated northward. A recurrent theme is the style of deglaciation; whether or not the ice sheet was active or stagnant just proir to its disappearance at a particular locality. Evidence cited in several papers indicates that the ice sheet was active and vigorous when the ice margin was located in southern New England. The presence of moraines, morphosequences, thrust-faulted late-glacial sediments, and other evidence for readvance, support the concept of an active ice margin. An alternate view, held by Robert F. Black of the University of Connecticut is that the ice sheet in eastern Connecticut underwent regional stagnation and that the mapping of morphosequences has been overextended.

The one paper on Vermont, "Deglacial History of Western Vermont" by G. Gordon Connally, will stir controversy because the author evokes an almost instantaneous rebound of the crust in order to explain the present-day elevations of major ice-contact deltas on the east side of the Champlain Valley.

The volume is valuable because it contains good summary papers and it documents the state of the art in New England Pleistocene studies. Not enough about northern New England? You're right, that was the subject of a symposium held in Bangor in March, 1981. Proceedings of "Late Wisconsinan Deglaciation of Northern New England and Adjacent Canada" hopefully will be published next year. The two volumes together represent a landmark in studies of the glacial history of New England.

F.D. Larsen
Norwich University

Notice has reached Vermont of the publication of Bulletin No. 2 of the Maine Geology volumes, by The Geological Society of Maine in January 1982. The contents are as follows:

Gravity Studies Over Bays-of-Maine Igneous Complex, S. E. Maine ... Robert J. Biggi and Dennis S. Hodge

Mesozoic Mafic Dikes of Southern Maine ... J. Gregory McHone and Joyce C. Trygstad

The Waldoboro Moraine and Related Glaciomarine Deposits, Lincoln and Knox Counties, Maine ... Geoffrey W. Smith, Kim S. Stemen and Ron S. Jong

Shell Hash in the Gravel Beaches on Islands of the Central Maine Coast ... Allen C. Myers

A Quantitative Study of an End Moraine at Roque Bluffs, Maine ... Robert P. Ackert, Jr.

The James Bowdoin Mineral Collection ... Benjamin B. Burbank

Copies are available at $5.00 each (plus .25 Maine tax for in-state purchasers) from: The Geological Society of Maine, c/o F.M. Beck, Inc., 140 Main Street, Yarmouth, Maine 04096. Make checks payable to The Geological Society of Maine.

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

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

FIRST CLASS

4 shoes }
4 } kits to rebuild cylinders
(2) FRONT

metal to metal
cylinders leaking

4 brakes → #300.00
wheel
cylinder
replaced

#40.00 scored
(inspected on)

#30 back

#39 > #99.95 } 4 wheels
shoes
drum-turning
repack

#135-140 usually

cylinders
spring kits

11.75
11.75

ADDENDUM

PETROLOGY OF THE BARNARD VOLCANICS

Thomas, Charles, Department of Geology
Middlebury College, Middlebury, Vermont 05753

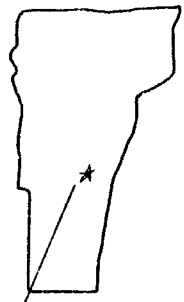
Samples from the Barnard volcanic member of the Moretown Formation, near Bethel in central Vermont, were analyzed by electron microprobe to determine their protolith. Lying between the Moretown Formation to the west and the Northfield Slate to the east, the Barnard rocks are meta-igneous with the exception of one band of phyllite near the Moretown contact. The Barnard member is divided into four lithologies on the basis of their igneous parents. Hornblende chlorite amphibolite is a metamorphosed basalt, biotite chlorite schist is derived from andesite, muscovite-biotite schist was originally dacite, and quartz-rich gneiss was rhyolitic.

The metamorphic grade of the Barnard varies between greenschist and amphibolite facies (Bird, 1982). Na is the only element likely to have been influenced by metasomatism. Variations between lithologies are a function of protolith. Bulk compositions vary little at any one site for most of the twenty-five site samples. Adjacent rocks that are quite different in composition are probably tectonically emplaced.

Bulk composition and CIPW norms of the Barnard rocks show that most of them follow a calc-alkaline trend of crystallization, lacking the iron enrichment found in tholeiitic rocks. Basalts that do show iron enrichment plot somewhere between true tholeiites and true calc-alkalines, a characteristic commonly found in extrusives from a young island arc (Ringwood, 1975). Rhyolites and dacites are derived from a more mature arc. Apparently, the Barnard volcanics consist of rocks from all phases of an island arc.

A new technique for melting rocks, devised by Crispin Butler, was tested and found highly dependable. A light placed between two parabolic mirrors effectively fused rocks of all compositions, including those with high viscosity, high melting temperature and abundant volatiles.

THE GREEN MOUNTAIN GEOLOGIST



QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

FALL 1982 VOLUME 9 NUMBER 2/3

Come to the FALL FIELD TRIP

(A close look at the Pomfret Dome)

&

DINNER & ANNUAL MEETING

(The August Lion in Randolph)

SATURDAY, OCTOBER 23, 1982

details on page 3.

CONTENTS

PRESIDENT'S LETTER

On page 8 of this issue, Chuck Ratte has listed geologic work in progress in the Green Mountain state. During this past summer I was directly involved in a project related to postglacial uplift that was supported by the U.S. Geological Survey. The project was directed by Carl Koteff of Reston, Virginia, who is mapping the surficial geology of the Essex Junction 7.5-minute quadrangle. The purpose of Carl's work is to document field evidence for the former levels of stages of glacial Lake Vermont and the Champlain Sea. The reason for choosing the Essex Junction quadrangle is that the area includes deltas built into Lake Vermont by the Winooski River in immediate post-glacial time. The area also has terraces formed by the Winooski River that grade westward onto the delta (now occupied by Burlington International Airport) built into the Champlain Sea. Carl hopes to eventually document the exact amount of postglacial uplift in the Champlian Valley by tracing shorelines north and south of the Essex Junction quadrangle.

In the Connecticut Valley, my work took me over a 180-kilometer stretch of glacial Lake Hitchcock between Northfield, Massachusetts, and Woodsville, New Hampshire, and up the Ammonoosuc River nearly to Littleton. The work was of a reconnaissance nature and involved checking out existing man-made and natural exposures of deltaic sediments, particularly those with topset and foreset beds exposed. The topset-foreset contact approximates the former level of the glacial lake into which the delta was built. When the surveyed elevations of topset-foreset contacts are plotted on a north-south projected profile they indicate that the former shoreline of Lake Hitchcock rises to the north at a gradient of about 0.9 m/km.

The shoreline of Lake Hitchcock is well established in Massachusetts and that shoreline was documented to extend northward into Vermont and New Hampshire for at least 21 km. For the next 70 km to the north, topset-foreset contacts for three deltas lie 9.2 m, 9.6 m, and 4.3 m below the projected level of Lake Hitchcock. North of these three deltas, are deltas, one at Hartland and the other at Quechee Gorge, that plot closer to the level of Lake Hitchcock projected north from Massachusetts and the Brattleboro area. During this past summer an excavation at the Quechee Gorge Motel had a topset-foreset contact at an elevation of 632 ft. ASL, right on the projected level of Lake Hitchcock.

The Quechee Gorge delta is an ice-contact delta that I believe was built by meltwater streams flowing directly into Lake Hitchcock from a stagnant tongue of ice in the Ottaquechee valley. The Quechee Gorge delta and its role in the formation of Quechee Gorge was the subject of a GEOMORPHOLOGY NOTE that appeared in the Winter-1982 issue of the Green Mountain Geologist.

(continued on page 10)

FALL FIELD TRIP & ANNUAL MEETING

TOPIC: A close look at the Pomfret Dome, a fine example of the interpreted "cleavage" dome produced as the result of the unfolding (doming) of a recumbent fold. Included in the field trip will be stops that reveal (or do they?) the true stratigraphic positions of the Waits River, Standing Pond and Gile Mountain Formations, the origin of the Standing Pond Volcanics and the potential for mineral resource development in the Pomfret Dome area.

LEADER: Charles Rattè

DATE: Saturday, October 23, 1982

TIME: 10 A.M.

PLACE: Assemble at the country store parking lot in Sharon, Vermont, at Exit 2 off Interstate I-89. We will car-pool from this location and return to this location at the end of the field trip.

REFERENCES: You may wish to bring the following references:

Lyons, J.B., 1955, Geology of the Hanover Quadrangle, N.H.- Vt.: GSA Bulletin, v. 66, p. 106-146.

White, W.S., 1949, Cleavage in east-central Vermont: AGU Transactions, v. 30, p. 587-594.

White, W.S. and Jahns, R.H., 1950, Structure of central and east-central Vermont: Journal of Geology, v. 58, p. 179-220.

The following U.S.G.S. 7 1/2 minute topo maps can be used to locate the field trip stops:
Queeche, Vt.; South Royalton, Vt.; Sharon, Vt.; and Woodstock North, Vt.

SCHEDULE:

10:00 A.M.	Leave Sharon, Vermont
Lunch	Bring your own brown bag lunch or purchase food at the country store in Sharon before starting on field trip.
3:30 P.M.	Return to Sharon
4:00 P.M.	Happy Hour at August Lion in Randolph (see directions below)
5:00 P.M.	Dinner at the August Lion
6:30 P.M.	Annual Meeting at August Lion

RESERVATIONS: There will be no need for reservations. Dinner will be ordered from the regular menu at the August Lion, best described as a medium-priced, fine restaurant, whose entrees are priced from $6.50 to $11.00. Some entrees are steak Marsala, deep sea platter, pork chops, spaghetti and a daily special. There is an excellent salad bar.

DIRECTIONS: From Exit 4 on I-89, take Route 66 west toward Randolph, joining Route 12 south. Route 12 turns south near the fire station and crosses a bridge at the bottom of a hill. August Lion is next on the right.

VGS BUSINESS & NEWS

NOMINATION'S COMMITTEE REPORT

The committee, composed of Stewart Clark, chairman, Bill Glassley and Allen Hunt, presents the following slate of officiers for election at the 1982 annual meeting:

President	Christopher White
Vice President	Barry Doolan Lance Meade
Treasurer	Dorothy Richter
Secretary	Laurence Becker
Director-2 years	Brewster Baldwin

If you are unable to attend the annual meeting on October 23, please mail in your absentee ballot, found on page 5 of this issue of the GMG.

SPRING MEETING REPORT

This was another banner year for student research in Vermont, prompting one member of VGS to exclaim, "The quality of the papers is mind-boggling!" Stewart Clark and Fred Larsen judged the 12 undergraduate papers and chose Charles Thomas of Middlebury College to receive that group's award. Mr. Thomas was a late entrant to the program and consequently his name and abstract did not appear in the GMG. For the record, his abstract has been reprinted on page 7 of this GMG. Serving as judges for the 4 graduate student papers were Brewster Baldwin and Chuck Ratté, who chose Linda Martin of University of Vermont to receive the award in that group. Cash awards were presented to both students.

ABSENTEE BALLOT 1982

OFFICERS

(Vote for one for each office)

President	Christopher White	☐
Vice President	Barry Doolan	☐
	Lance Meade	☐
Treasurer	Dorothy Richter	☐
Secretary	Laurence Becker	☐
Director-2 years	Brewster Baldwin	☐

If you will not be able to attend the annual meeting on October 23, 1982, please return this ballot in an envelope with the word "BALLOT" in the lower left hand corner and your name and address on the upper left corner. Mail it to:

Vermont Geological Society
Box 304
Montpelier, Vermont 05602

before October 22, 1982.

DETACH HERE

STUDENT ABSTRACT

PETROLOGY OF THE BARNARD VOLCANICS

Thomas, Charles, Department of Geology,
Middlebury College, Middlebury, Vermont 05753

Samples from the Barnard volcanic member of the Moretown Formation, near Bethel in central Vermont, were analyzed by electron micropobe to determine their protolith. Lying between the Moretown Formation to the west and the Northfield Slate to the east, the Barnard rocks are meta-igneous with the exception of one band of phyllite near the Moretown contact. The Barnard member is divided into four lithologies on the basis of their igneous parents. Hornblende chlorite amphibolite is a metamorphosed basalt, biotite chlorite schist is derived from andesite, muscovite-biotite schist was originally dacite, and quartz-rich gneiss was rhyolitic.

The metamorphic grade of the Barnard varies between greenschist and amphibolite facies (Bird, 1982). Na is the only element likely to have been influenced by metasomatism. Variations between lithologies are a function of protolith. Bulk compositions vary little at any one site for most of the twenty-five site samples. Adjacent rocks that are quite different in composition are probably tectonically emplaced.

Bulk composition and CIPW norms of the Barnard rocks show that most of them follow a calc-alkaline trend of crystallization, lacking the iron enrichment found in tholeiitic rocks. Basalts that do show iron enrichment plot somewhere between true tholeiites and true calc-alkalines, a characteristic commonly found in extrusives from a young island arc (Ringwood, 1975). Rhyolites and dacites are derived from a more mature arc. Apparently, the Barnard volcanics consist of rocks from all phases of an island arc.

A new technique for melting rocks, devised by Crispin Butler, was tested and found highly dependable. A light placed between two parabolic mirrors effectively fused rocks of all compositions, including those with high viscosity, high melting temperature and abundant volatiles.

STATE GEOLOGIST'S REPORT

A great deal of geologic work is being conducted in Vermont by government, private industry, and researchers. Some of the projects that we are aware of that may interest readers of the Green Mountain Geologist are listed below:

U.S. Geological Survey

1. CUSMAP projects (Conterminous U.S. Mineral Assessment Program)
   a. Northeastern Vermont   Lewiston 1^{o} x 2^{o} Quadrangle
   b. Central Vermont   Glens Falls 1^{o} x 2^{o} Quadrangle
2. Massive Sulfides of New England (Orange County copper belt in Vermont)
3. Green Mountain National Forest Rare II and Wilderness Area mineral resource evaluations.
4. Geochemical characteristics of granitic plutons in northeastern Vermont.
5. Postglacial uplift in Vermont, current studies in northwestern Vermont and Connecticut River valley.
6. Conodont-based age determinations in low-to-medium grade metamorphic rocks (search for Conodonts in Waits River Formation).
7. Tectonics of New England.

Industry

1. North American Exploration - new core drilling at Cuttingsville pyrrhotite occurrence.
2. Western Geophysical - seismic survey of northwestern Vermont as part of oil and gas exploration for Columbia Gas Transmission Inc.
3. Evaluation of phosphate potential in northwestern Vermont - Mobil Chemical Company, Phosphorus Division.
4. Reconnaissance survey for manganese oxide - Union 76 Molycorp.
5. Base metals - Utah International Inc.
6. Base metals - Texas Gulf, Inc.

Researchers

1. Structural and petrologic analysis of Orange County copper district, University of Cincinnati, Dr. Malcolm Annis.
2. Cold regions erosion processes, USA CRREL, Hanover, N.H., L.W. Gatto.
3. Waits River - Gile Mountain studies, Johns Hopkins University, George Fisher.
4. Tectonic analysis of northcentral and northwestern Vermont, University of Vermont, Rolfe S. Stanley.

Additional geologic work is undoubtly being conducted in Vermont that we are not aware of. If you wish to make your work known, we would appreciate it if you would fill out the form found in this copy of the Green Mountain Geologist and return it to the address indicated.

Charles Ratté, State Geologist

GEOLOGIC PROJECTS IN VERMONT

If you or anyone you know are (or intend to be) engaged in any geologic work (research, investigations, consulting, etc.) in the State of Vermont or directly related to the State, I would appreciate it if you would complete the following questionnaire for each project being conducted. Please return to:

Dr. Charles Ratté, State Geologist
Agency of Environmental Conservation
Montpelier, Vermont 05602

NAME & AFFILIATION____

ADDRESS AND PHONE____

COWORKERS AND AFFILIATIONS______________________________

ADDRESS AND PHONE____

TITLE & BRIEF DESCRIPTION OF PROJECT___________________

____

STARTING DATE_______________ COMPLETION DATE______________

LOCATION OF PROJECT______________________________________

WHERE WILL THE RESULTS OF THIS WORK BE AVAILABLE?

____

WILL YOU KEEP FIELD NOTES ON FILE?_______________________

DO YOU INTEND TO PUBLISH THE WORK?___ WHERE?______________

WOULD YOU MAKE A COPY AVAILABLE FOR THE FILES OF THE VERMONT STATE GEOLOGIST AT OUR EXPENSE?_______________________

HOW WOULD YOU CATEGORIZE THIS WORK? (CIRCLE APPROPRIATE ONE)

Geophysics	Hydrology, Geohydrology, Hydrogeology
Engineering Geology	Mineralogy, Geochemistry
Economic Geology	Environmental Geology
Igneous Geology	Glacial, Surficial, Geomorphology
Metamorphic Geology	Paleontology, Historical Geology
Structural Geology	Sedimentary Geology, Stratigraphy

Other (Specify)____

Please provide me with an address or forward this questionnaire to anyone you know who is conducting geologic work in Vermont.

Thank you,

Charles A Ratté, State Geologist

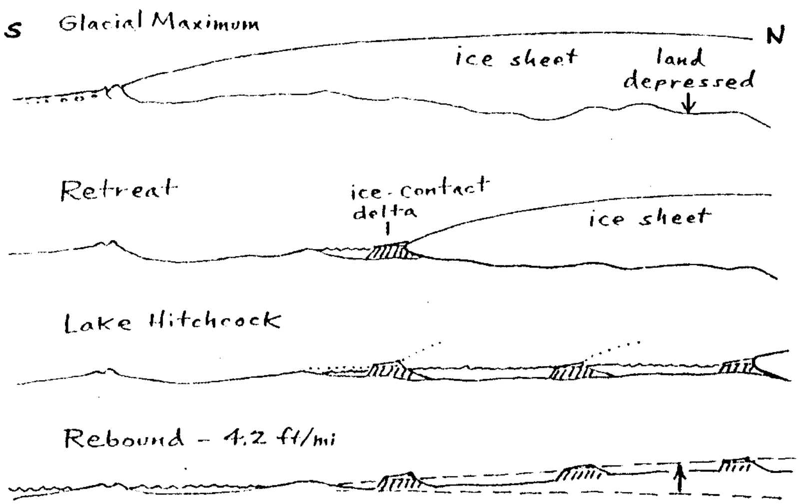
PRESIDENT'S LETTER continued...

The series of diagrams at the bottom of this page illustrate the development of a sequence of ice-contact deltas formed at the margin of the retreating ice sheet and their subsequent uplift following removal of the weight of the ice. Imagine for the sake of argument that the middle delta in the bottom two diagrams is 9.6 m below the level of Lake Hitchcock. The obvious question is how can deltas be built at the Lake Hitchcock level at Brattleboro and at Quechee Gorge, and 9.6 m below the Hitchcock level at sites between Brattleboro and Quechee Gorge. The simplest answer is that the lower deltas are younger (formed in a lower lake, but are not ice-contact) or that they represent older deltas trimmed off at a later time by streams.

At this time, with the study still in an early reconnaissance stage, it would be wrong to place much credence in any one particular theory, however there is a very remote chance that anomalies in Lake Hitchcock delta levels may be related to postglacial tectonics, a subject that we and the Nuclear Regulatory Commission are interested (awk,awk, a subject in which...).

I do not believe that is necessary to evoke neotectonics to explain the position of low deltas between Brattleboro and Quechee Gorge, however a similar case has been documented or is being documented in eastern Maine (D.Westerman, pers. commun.). It certainly points to our lack of surficial geologic maps in Vermont when we start to look for published information that relates to a problem like this.

My apologies for the late arrival of this GMG. I know that geologists have set schedules like everyone else, but I also know that geologists can react swiftly and change plans. I ask you to do your best if you have no plans for next Saturday and join us for Chuck's field trip and dinner at the August Lion.



MEETINGS

OCT 12 Start of BSCES/ASCE Geotechnical Lecture Series (see information below).

OCT 18-21 GSA Annual meeting in New Orleans, Louisiana. Many VGS members will be presenting papers.

OCT 23 VGS Fall Field Trip and Annual Meeting (see page 3).

MAR 23-25, 1983 Northeastern section of GSA at the Concord Hotel in New York's Catskill Mountains.

The following announcement was received by VGS:

Engineering Geology is the subject of the 1982 BSCES/ASCE Geotechnical Lecture Series to be held at Massachusetts Institute of Technology in the fall of 1982. Experts in the field of Engineering Geology will present the following topics:

Slope Stability, Dr. Douglas Piteau
Coastal Engineering, Dr. Miles Hayes
Urban Geology, Dr. Robert Leggett
Underground Construction, Dr. Dougal McCreath
Engineering Seismicity, Dr. Lloyd Cluff
Regulatory Geology, Mr. Richard Meehan

The lectures will be held on Tuesday evenings from 6:30 to 9 pm on October 12, 19 and 26, November 9 and 16 and December 7. The registration fees will be: BSCE section members $95, non-members $120 and students $35. Lecture notes for the entire series are included in the registration fee or may be purchased separately for $35. Additional details and registration forms are available from Tom Lamb, in care of Stone & Webster Engineering Corp., P.O. Box 2325, Boston, MA 02107.

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

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

MONTPELIER, VT
OCT 5
PM
1982

ALWAYS USE ZIP CODE

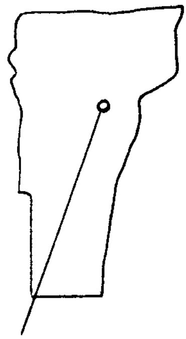
FIRST CLASS

Charles A. Ratte'
4 Chestnut Hill
Montpelier, VT 05602

THE GREEN MOUNTAIN GEOLOGIST

QUARTERLY NEWSLETTER OF THE VERMONT GEOLOGICAL SOCIETY

WINTER 1982 VOLUME 8 NUMBER 4



Come to the FIFTH ANNUAL WINTER MEETING of THE VERMONT GEOLOGICAL SOCIETY

Featuring papers about Vermont's
ground water and surficial geology

KEYNOTE SPEAKER: JOHN COTTON
Water Resources Division, U.S.G.S.

"An Overview of New England
Ground Water Conditions"

SATURDAY FEBRUARY 20, 1982 9:00 A.M.
PAVILION AUDITORIUM (State & Taylor)
MONTPELIER, VERMONT

CONTENTS PAGE

PRESIDENT'S LETTER

Dear VGS Members,

Geology continues to be near the forefront of the daily news and this past month was no exception. Geologists are often being quoted and asked for their interpretation of geologic phenomena. The transmittal and publication of correct information is a critical matter for all of us. Although not a geological phenomenon, the release of radioactive gas from Three Mile Island and its subsequent identification at Albany, New York, and its probable passage over part of Vermont, point out the fact that we all need correct information presented within a time span that makes it useful to us.

Two earthquakes, one in New Brunswick, the other in New Hampshire, and their attendant aftershocks shake the ground and our confidence in the communications media to transmit basic facts in a clear and concise manner. There on the front page of the Sunday, January 24, 1982, Burlington Free Press was former V.G.S. president Rolfe Stanley explaining that certain faults, including the Champlain Thrust, represented "the most likely" seismic hazards. I think I understand the symbiotic relationship between a reporter and a college professor. They both are trying to present the best possible information to the public. The article was excellent and I'm only "nit picking" when I say that I wish Rolfe or the reporter had said that there are millions of ancient faults in this old continent and that it is under stress as it is being rafted westward by a tarry asthenosphere and that minor shifting along any old fault could occur at any time and often does. Rolfe could have said these things, he may or may not have said them, or a reporter could have used a selective filter in hearing or a polarized pen in writing. My point is not so much the above but what I heard an announcer at WEZF-FM, Burlington, say the next day in reference to the Free Press article. He said that Dr. Stanley had said that the Champlain Thrust was a seismic hazard! No if's, no ands, no "most likely", no "possible" seismic hazard, but <u>a seismic hazard</u>.

In another vein (quartz that is), former V.G.S. president Brewster Baldwin apparently has found the fountain of youth. A photograph accompanying his January 15, 1982, letter to the editor of the Burlington Free Press purports to be a likeness of Brew. A black obituary-type line surrounding his letter at first gave me a start, then I realized it was a photo from the geologic record. Brew takes on the "creationists" for their denial of rational inquiry and describes the timing of glacial events and how those events are much older than the 6,000 to 10,000 years required for Genesis. (It's not clear to me when it

(Continued Page 10)

VGS WINTER MEETING PROGRAM

Pavilion Auditorium, Montpelier, Vermont

Registration (no fee); coffee and donuts 9:00

MORNING SESSION Charles Ratté presiding 9:30

KEYNOTE SPEAKER: JOHN COTTON
Water Resources Division, USGS
Concord, New Hampshire

"An overview of New England ground water conditions" 9:40

1. J. Ashley: Vermont's ground water data system . 10:20
2. W. Ladue: Well testing and aquifer coefficients in Vermont 10:40
3. L. Becker: Methods of outlining aquifer protection areas surrounding existing municipal ground water supplies in the state of Vermont 11:00
4. G. Smith: Fracture trace analysis for well siting in a glacial terrain 11:20
5. C. Ratté and D. Bradley: The Waits River Formation – most favorable bedrock aquifer in southeastern Vermont 11:40

LUNCH BREAK 12:00

AFTERNOON SESSION Charles Ratté presiding

6. F. Larsen: Late-glacial and postglacial history of the Norwich University campus . . 1:00
7. C. White: Mode of deglaciation in areas of moderate relief 1:20
8. F. Larsen: The 1981 Great Pebble Campaign, Cuttingsville, Vermont 1:40
9. G. Simmons, J. Mann and C. Jaupart: Heat flow in New England 2:00

ABSTRACTS

VERMONT'S GROUND WATER DATA SYSTEM

Ashley, James W., Vermont Department of Water Resources, Montpelier, Vermont 05602

In 1965 the Vermont Legislature passed an Act requiring the licensing of all persons engaged in the "business of drilling wells for underground water in the State of Vermont", and required these persons to file a report on each well drilled. Since that time, the Department of Water Resources, which administers this law, has received and filed over 26,000 well reports. While most drillers are neither geologists nor expert map readers, their reports have usually covered not only the basic facts, but have given some insight into the character of the water and geology they encountered.

These well driller reports have provided invaluable information on Vermont's ground water resources as well as defining Vermont's varied subsurface glacial and bedrock geology. Many test drilling programs for muncipal and industrial water supplies have developed directly through use of these records, as well as an aquifer protection program to protect our public water supplies. The well driller's reports have also provided the basis of a number of regional reports evaluating Vermont's ground water resources.

Glacial geologists have used the driller's descriptions to locate and define eskers, till layers, preglacial channels, evidence of multiple glaciation and many other glacial features. Hard rock geologists have used these records to define fracture locations and trends, thickness of the Champlain overthrust, depth of weathering and many other bedrock characteristics.

Vermont's ground water data system is currently undergoing significant changes to make this data more accessible and usable. In addition to updated data summary sheets, all wells are being assigned a grid location reference number. Field confirmed locations are being plotted on topographic maps, and all files are being prepared for microfilming. Approximately 3,000 well driller's reports have been computerized, and computer data systems are currently being evaluated which would permit complete computerization of these files. The Department of Water Resources encourages all persons interested in Vermont's underground resources and features to make use of its Data System.

METHODS OF OUTLINING AQUIFER PROTECTION AREAS SURROUNDING EXISTING MUNICIPAL GROUND WATER SUPPLIES IN THE STATE OF VERMONT

Becker, Laurence R., Assistant Water Resources Planner, Vermont Department of Water Resources, Montpelier, Vermont 05602

A procedure for defining aquifer protection areas surrounding large public water supplies in the State of Vermont was developed during 1981. One hundred and thirty-four (134) ground water systems have been mapped. The boundaries of the ground water protection areas have been based on knowledge of surficial and bedrock geology, and hydrologic data. All available data was collected for each ground water source site and a geologic interpretation was made to encompass the suspected recharge within the aquifer protection areas. Sources included wells in unconsolidated material, bedrock wells and springs. Springs and bedrock wells were located, while a geologic reconnaissance was conducted at unconsolidated sites.

Because Vermont's geology is complex, each site is assumed to have a different character and the aquifer protection areas are outlined accordingly. The methods of determination vary depending on the nature of the source and available data used for interpretations, but the approach to solving aquifer protection geologic problems can be placed into some general categories. The categories include: unconsolidated wells of unconfined or leaky character with or without available pump tests, confined unconsolidated systems, bedrock well sites that can be described by an infiltration or leakage model adjusted to structural trends, spring sites in unconsolidated material and at the interface between unconsolidated material and bedrock with high or low divides in the upslope direction, and springs in bedrock. The sources are analyzed by various techniques including: analyses of local geologic conditions based on existing information and a field reconnaissance visit, information on radius of influence, flows net analysis, Darcy's law, and infiltration calculations.

WELL TESTING AND AQUIFER COEFFICIENTS IN VERMONT

Ladue, Winslow, Vermont Department of Health, Burlington, Vermont 05401

A review of existing hydrogeologic analyses of well pump tests conducted over the last 20 years reveals the presence of three types of aquifers in Vermont. The bedrock, unconfined gravel and confined gravel aquifers' median transmissivities fall into the 10^2, 10^3, and 10^4 - 10^5 gpd/ft ranges respectively. Storage coefficients, formation losses, well losses, and radius of influence are also discussed for each aquifer. The use of standard hydrogeologic methods is illustrated in each type of geologic setting.

LATE-GLACIAL AND POSTGLACIAL HISTORY OF THE NORWICH UNIVERSITY CAMPUS

Larsen, Frederick D., Department of Earth Science, Norwich University, Northfield, Vermont 05663

The central part of Norwich University campus is built on a kame about 60 feet high in the middle of the Dog River valley. Recent excavations in the flank of the kame provide details about its glacial origin. On the northwest flank of the kame collapsed ice-contact lake deposits are overlain by undeformed lake sediments formed by currents that moved southward in glacial Lake Roxbury. Lake Roxbury formed when the retreating ice sheet blocked the north-draining Dog River valley and caused melt water to drain south and over a 1,010-foot threshold at Roxbury. The lowest deposits exposed on the southeast flank of the kame are also collapsed and overlain at the surface and increase in dip and degree of deformation with greater depth of burial. This suggests that deposition of lake sediments occurred while a buried ice block was melting.

Following drainage of the glacial lake, two stream terraces were formed on the western side of the university. The terraces are underlain by pebble gravel deposited by a north-flowing stream that may have graded into a glacial lake in the Winooski River valley. Down-cutting by the Dog River and subsequent lateral migration of its meanders produced the topography we see today. The late-glacial and postglacial history can be summarized as follows: (1) deposition of lake sediments in contact with buried ice, (2) collapse of lake sediments during melting of buried ice, (3) deposition of undeformed lake sediments, (4) drainage of the glacial lake, and (5) development of stream terraces and the modern flood plain.

THE 1981 GREAT PEBBLE CAMPAIGN, CUTTINGSVILLE, VERMONT

Larsen, Frederick D., Department of Earth Science, Norwich University, Northfield, Vermont 05663

The purpose of the 1981 Great Pebble Campaign was to map the distribution of syenitic pebbles derived by glacial erosion and transport from the Cuttingsville pluton. Thirty seven samples of 100 pebbles each were collected by students in the area south and east of the pluton. Isopleths of total syenitic pebbles define an area of high concentration, presumably the direction of glacial movement, S35°E of the pluton. The direction is consistent with that of an indicator fan shown on a map of New England indicator fans by Flint (1971).

The 1981 Great Pebble Campaign brings to eight the number of indicator fans mapped by students in the area of the so-called "Shelburne drift" theorized by Stewart and MacClintock (1969, 1970) to have been formed by ice moving to the southwest. Seven of the indicator fans clearly show movement to the southeast and one, derived from the Mt. Ascutney pluton, shows a high concentration of syenite pebbles due south of the source area.

All 37 sample sites of GPC '81 are on terrain underlain by the Precambrian Mount Holly Complex and east of miogeosynclinal rocks of the Vermont Valley. Twenty three of 37 samples contained one to four percent clasts of reddish-brown Monkton Quartzite indicating transport from the northwest, from the general vicinity of the City of Rutland. Clasts of Monkton Quartzite commonly are found throughout central Vermont east of the Green Mountains, and have been transported a minimum distance of 120 km to Erving, Montague, and Wendall, Massachusetts. The distribution of glacially-transported syenitic clasts from the Cuttingsville pluton and reddish-brown clasts from the Monkton Quartzite is not consistent with a "Shelburne drift" deposited by southwest-moving ice.

THE WAITS RIVER FORMATION - MOST FAVORABLE BEDROCK AQUIFER IN SOUTHEASTERN VERMONT

Rattè, Charles, State Geologist, Agency of Environmental Conservation, Montpelier, Vermont 05602
Bradley, Dwight C., Department of Geological Sciences, SUNY at Albany, Albany, New York 12222

Average yields and well depths of over 300 water wells located in five geologic formations (Northfield, Waits River, Gile Mountain, Standing Pond and Littleton) were compared and rated. A rating formula based on the perfect well being zero depth and having infinite yield, R (rating value) = 200 (average yield/average depth), was used to evaluate the performance of wells in each formation. The rating value of the Waits River Formation is 8.2, 30 percent higher than the closest competitors, the marble member of the Gile Mountain Formation (6.2) and the Northfield Formation (6.2).

The formations were analyzed on the basis of topographic, geographic and lithologic location. It is believed that the abundance of highly porous and permeable, weathered, impure marble beds, providing as much as 50 percent porosity in the Waits River Formation, accounts for its distinction as the most favorable bedrock aquifer.

8

HEAT FLOW IN NEW ENGLAND

Simmons, Gene, Jeff Mann, and Claude Jaupart*, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Heat flow has been measured during the past five years at 150 localities in New England. Most localities are in the southern half of the states of Vermont and New Hampshire, and in western Maine. Values range from 0.2 to 2.2 HFU[a].

Most holes were at least 500 feet deep. A few were deeper than 1000 feet. They were drilled originally as water wells and had been shut in for at least several months at the time of measuring temperatures. Most of them were non-productive; a few were awaiting installation of equipment. Thus, the gradients that were used in the determination of heat flow are near equilibrium.

For the measurement of thermal conductivity, we used either cuttings from a pile typically found near each hole or samples from nearby road cuts or outcrops for the few holes for which no cuttings were obtained. Thermal conductivities were determined with a needle-probe.

The samples were also used to determine the total thorium, potassium, and uranium contents with gamma ray spectrometry. From the relative concentrations, we calculated the heat production. The data for heat flow, Q, versus heat production, A, for New Hampshire are fit quite well with a linear relation, $Q = b_o + b_1 A$. The parameters b_o and b_1 differ insignificantly from the values obtained by Francis Birch, Robert Roy, and Edward Decker in the mid-1960's from eight localities situated on plutonic rocks. On the basis of the data for New Hampshire, we conclude that the metasedimentary rocks and plutonic rocks obey the same general Q-A relationship.

The Devonian metasedimentary rocks of Vermont, however, depart significantly from the trend of plutonic and metasedimentary rocks of New Hampshire. A linear relation appears to be satisfactory. The parameters obtained from the regression analysis are 0.2 HFU for the intercept and approximately 40 km for the slope. These data are interpreted by us to indicate that the thermal flux through the base of the crust is approximately 0.2 HFU and the average heat generation measured at the surface of the earth for the Devonian metasedimentary rocks extends throughout the crust.

The present thickness of the new data requires a change in thickness of the heat generating layer from approximately 15 km in New Hampshire to approximately 40 km in Vermont. Such a dramatic change across the state boundary, the location of major faults proposed previously by others, is interpreted by us to indicate that the fault zone constitutes a major crustal feature.

---

*now at the Institute de Physique du Globe de Paris, Laboratoire de Géochimie et Cosmochimie, Université Paris 6, 4 Place Jussieu, 75230 Paris 5, France

[a] HFU = Heat Flow Unit = 1.0 $\mu cal/cm^2\text{-}s\text{-}^oC$.

FRACTURE TRACE ANALYSIS FOR WELL SITING IN A GLACIAL TERRAIN

Smith, Gary L., D. L. Maher Company, P.O. Box 127, North Reading, Massachusetts 01864

Many municipal water supplies in New England are exceeding their safe sustainable yields due to the continuing growth in population, consumption and periodic droughts. Through the application of photogeologic techniques, utilizing high and low altitude aerial photography, new municipal and industrial sources of ground water in crystalline and sedimentary bedrocks are now being successfully explored and developed. Successful high yield wells have been drilled that are overlain by as much as 125 feet of till or as much as 58 feet of varved lacustrine sediments. While geologists have long recognized the presence of straight to curvilinear stress-relief features on the earth's surface, fracture-trace mapping locates zones of structural weakness in the earth's crust, where water wells with yields as high as 300 gallons per minute have been located.

Due to unexplained phenomena, the bedrock fracturing may manifest itself on the earth's surface (very similar to a fingerprint) in the form of linear features comprised of light or dark tonal striping in soils, alignment of vegetative patterns, straight stream segments or depressions, water or wind gaps in ridges, or other linear alignments. The relative abundance or lack of moisture in the fracture zones will affect the size of tree crowns or foliage growth.

If a water table is deep in a fracture zone, trees growing directly along the fractures will be healthier, due to easier and deeper root penetration. If high water tables are present, the roots may be drowned and the trees may be stunted or die along the fracture. It is most desireable to site water wells at the intersection of two or more fractures. These intersections may appear in the form of a star, trident x, or v-shaped patterns on aerial photographs.

MODE OF DEGLACIATION IN AREAS OF MODERATE RELIEF

White, Christopher M., White Geohydrology, Inc. RD 1, Box 240, Bristol, Vermont 05443

At least four theories of deglaciation have been developed for explaining the distribution of glacial deposits in New England. The areas of moderate relief in the New England region present a special problem in applying these theories because of the paucity of stratified drift and the highly variable till thicknesses. The four theories, and their advocates, are: mid Western "loop moraines" (Taylor, 1903), "normal" retreat-thick snout-no glacial stillstands (Lougee, 1940), stagnation-zone retreat (Jahns, 1941), and large-scale downwasting and stagnation (Stewart, 1961 and Stewart and MacClintock, 1969).

In the last 25 years, much work has been done in the field of ice physics. Based on this previous work, additional research was done to develop models for deglaciation in areas of moderate relief. The governing concept involved is the existence of a variety of thermal regimes at the base of a late-glacial ice mass. The glacial base may vary from "wet-base" or "warm-base" to "cold-base" with a change of a few degrees Celsius. In this range of temperatures, the glacier base has dramatically different ice strengths and therefore intricate erosional or depositional environments. Extension of previous work indicates that this variety may exist with ice thicknesses as thin as 20 meters.

In applying this theory to the Wilmington, Vermont, quadrangle, where I did my field work, a general pattern of glacial deposits suggested that models could be developed for three broad physiographic situations. These are: slope facing down-glacier, slope facing up-glacier and valley bottoms. Ice mass behavior and a resultant series of thermal regimes are postulated for each situation. An important corollary is that many glacial features, especially those composed of non-stratified drift, do not have simple geomorphic lineage, but may be due to compound thermal regimes.

(Continued from Page 2)

became 10,000 years.) A week or so later a woman wrote to the Free Press supporting the account of creation in the bible. Both Brew and this woman told the readers how it was but not why it was, except that the woman spoke of faith. What I wish Brew had documented for Free Press readers was how radiometric dating works and how carbon-14, potassium-40, and other geologic clocks stretch the age of the earth back to about 4.5 billion years. Brew's last sentence, "Creationism cannot co-exist with evolution in a science course," hits the mark dead center. Congratulations, Brew.

A timely article that relates radiometric dating to early man and thereby to the creation-evolution argument can be found in the February, 1982, issue of Scientific American. Authors of "The Fossil Footprints of Laetoli", Richard L. Hay and Mary D. Leakey, report on hominid footprints found in volcanic ash near Olduvai Gorge, Tanzania. Potassium-argon dates by Garniss H. Curtis bracket the age of the footprints between 3.5 and 3.8 million years. The tracks were made by bipedal hominids that had not yet developed tool-making techniques.

F. D. Larsen

VGS BUSINESS & NEWS

TREASURER'S REPORT

The financial condition of the Vermont Geological Society for January 1, 1981 to December 31, 1981 is as follows:

Cash on hand January 1, 1981		327.44
Income		794.42
Dues	524.00	
Interest	28.44	
Gifts	15.48	
Sale of Vermont Geology	199.00	
Sale of back issues of GMG	27.50	
Total	794.42	
Expenses		600.01
Office supply (consumable)	85.79	
Office supply (hardware)	8.14	
Post Office box rent	20.00	
Postage: General	48.00	
Vermont Geology	72.97	
GMG	115.71	
Printing GMG	125.56	
Vermont Geology publication cg.	29.86	
Xerox	10.61	
Winter meeting	23.03	
Awards	50.00	
Bank charges	2.40	
Miscellaneous	7.94	
Total	600.01	
Balance for 1981		+194.41
Income	794.42	
Expenses	600.01	
Balance	194.41	
Cash on hand December 31, 1981		521.85
Cash on hand January 1, 1981	327.44	
Income	794.42	
Total credits	1121.86	
Total debits	600.01	
Balance	521.85	

Vermont National Bank NOW account statement dated 12/31/81 shows a balance of 521.85.

Stewart Clark
Treasurer

Membership has grown during 1981. The Vermont Geological Society added 23 new members. There were 77 active members and 13 members with dues unpaid for 1981.

MEMBERSHIP LIST

Spafford Ackerly	239 North St., Burlington, VT 05401
Eric Allinson	Box 195, Montpelier, VT 05602
James Ashley	RFD West Danville, VT 05873
Robert L. Badger	43 Gloria Ave., Rutland, VT 05701
Baker Library	Dartmouth College, Hanover, NH 03755
Brewster Baldwin	Science Center - Geology, Middlebury College, Middlebury, VT 05753
Donald K. Balmer	Shannon & Wilson, Inc., 1105 N. 38th St., Seattle, Washington 98103
Larry Becker	28.5 First Ave., Montpelier, VT 05602
Bibliothek der Bundesanstalt für Geowissenschaften und Rohstoffe	Postf. 51 01 53, 3000 Hannover 51, Federal Republic of Germany
Marland P. Billings	Dept. of Geology - Harvard Museum, 24 Oxford St., Cambridge, MA 02138
William Bosworth	Dept. of Geology, Colgate University, Hamilton, NY 13346
Dwight C. Bradley	Dept. of Geological Sciences, SUNY at Albany, Albany, NY 12222
Jon P. Broderick	PO Box 560, Shelburne, VT 05482
David Butterfield	RFD #1, Montpelier, VT 05602
Wallace Cady	348 So. Moore St., Lakewood, CO 80226
Chaplin Library	Norwich University, Northfield, VT 05663
Stewart Clark, Jr.	25 Marvin St., Montpelier, VT 05602
Ray Coish	Science Center - Geology, Middlebury College, Middlebury, VT 05753
Elizabeth Conner	Box 35, Waitsfield, VT 05673
E. Stanley Corneille, Jr.	4 Terrace St., Randolph, VT 05060
Mary Crandall	17 North St., Rutland, VT 05701
Fred Crowley	17 Birch Ct., Springfield, VT 05156
Robert V. Cushman	20 Court St., Middlebury, VT 05753
Thomas A. Davies	Int. Oceanographic Inst. Inc., 2600 Virginia Ave. SW, Suite 512, Washington, D.C. 20037
James Dawson	Institute for Man and Environment, SUNY, Plattsburgh, NY 12901
Jeanne C. Detenbeck	RFD #1, Box 209, Shelburne, VT 05482
Robert J. Dineen	c/o NYS Geological Survey, RM 3160, Cul. Educ. Center, ESP, Albany, NY 12230
Charles G. Doll	1 Mansfield Ave., Essex Jct., VT 05452
John Drake	Dept. of Geology, University of Vermont, Burlington, VT 05405
John Drobinski	222 Boston Post Rd., Sudbury, MA 01776
Charles J. Duzinski	8 Prospect St., Brattleboro, VT 05301
Ballard Ebbett	RFD 1, Lyndonville, VT 05851
Sandria Ebbett	RFD 1, Lyndonville, VT 05851
Richard M. Fischer	25 Liberty St., Montpelier, VT 05602
Brian Fowler	RFD 7, Box 159, Gilford, NH 03246
J. Charles Fox	26 Westmoreland Drive, West Hartford, CT 06117

Peter M. Garrity	c/o J. Nessel, RD3, Montpelier, VT 05602
Lawrence Gatto	Route 244, Ely, VT 05044
Richard P. Gillespie	164 Harris Road, Nashua, NH 03060
Susan L. Guhl	PO Box 1412, Montpelier, VT 05602
James Hall	FRD 2, Randolph, VT 05060
Peter B. Harris	The White Mountain School, Littleton, NH 03561
Herbert E. Hawkes	RFD 2 Box 162-5, Orleans, VT 05860
Leah Haworth	1221 Garfield Ave., Niagara Falls, NY 14305
Craig Heindel	RD 1 Box 185, Shelburne, VT 05482
J. Christopher Hepburn	Geology and Geophysics, Boston College, Chestnut Hill, MA 02167
Malcolm Heyburn	Meore Way, Mountain View Estates, Washingtonville, NY 10992
Arthur L. Hodges	PO Box 26, Camden, Delaware 19934
George E. Holman	Elmore Mt. Road, Morrisville, VT 05661
John T. Humphrey	195 West St., Reading MA 01867
Allen S. Hunt	Dept. of Geology, University of Vermont, Burlington, VT 05405
Nancy Jannik	Dept. of Natural Sciences, Bently College, Waltham, MA 02254
Shirley Knowlton	Box C, South Londonderry, VT 05155
Winslow Ladue	102 Park St., Burlington, VT 05401
Frank J. Lanza	38 Terrace St., Montpelier, VT 05602
Fred Larsen	9 Slate Ave., Northfield, VT 05663
Jeffrey L. Limoge	Rural Route #2, Morrisville, VT 0566
Alan R. Liptak	RT 4, Cedar Ct. Apt. 10, Potsdam, NY13676
John Malter	23 Hubbard St., Montpelier, VT 05602
Winona Manning	Route 1, Williamstown, VT 05679
Ronald Marcotte	Box 71, Bakersfield, VT 05441
Linda G. Marek	Water Resources Center, 601 Main St., Burlington, VT 05405
Gregory McHone	Dept. of Geology, 925 W. Michigan St., Indianapolis, Indiana 46202
Lance Meade	PO Box 133, Pittsford, VT 05763
Mary Ann Mento	RD #1, Arlington, VT 05250
Carolyn J. Merry	PO Box 85, Enfield Center, NH 03749
Alexis P. Nason	8 Timber Lane, Brattleboro, VT 05301
Peter Northrup	4400 S. Quebec #E205, Denver, CO 80237
Duncan Ogden	Landgrove, VT 05148
Sanborn Partridge	62 Ormsbee Ave., Proctor, VT 05765
Jeffrey L. Pelton	RFD 2 Box 6, Springfield, VT 05156
John Pratt	Sand Hill Road, Castleton, VT 05735
John R. Rand	Cundy's Harbor, RD 2 210 A, Brunswick, ME 04011
Charles A. Ratté	4 Chestnut Hill, Montpelier, VT 05602
Thomas C. Ray	Dept. of Geological Sciences, ES215 SUNYA, 1400 Washington Ave., Albany, NY 12222
Dorothy A. Richter	RFD #2, Apt.8, Beckley Hill, Barre, VT 05641

Edward H. Salvas	Box 1107, Stowe, VT 05673
Ethel Schuele	33 Clover St., So. Burlington, VT05401
Dinah Shumway	Box 131, North Springfield, VT 05150
William Siok	RD 1, Sherman Ave., Exeter, NH
Rev. James Skehan	Weston Observatory, Boston College, Weston, MA 02193
Shelley Snyder	72 Blacklantern Lane, South Burlington, VT 05401
Stephen Solomon	c/o General Delivery, Canmore, Alberta, Canada TOL OMO
Rolfe Stanley	Dept. of Geology, University of Vermont, Burlington, VT 05405
James B. Stewart II	Terrace Heights, RD #1, Middlebury, VT 05753
William Stockwell	6 Country Hill, Brattleboro, VT 05301
Byron Stone	National Center MS 928, U.S.G.S., Reston, VA 22092
David Stoner	RFD #1 Box 2160, Starksboro, VT 05481
David Tarbox	PO Box 435, Bristol, VT 05443
Sandra A. Thiel	RR 1 Box 115, Airport Rd., Warren, VT 05674
Peter Thompson	67 West Street, Hadley, MA 01035
Roger B. Thompson	RFD #2, Woodstock, VT 05091
Terry Thompson	RFD #2, Woodstock, VT 05091
Thelma Thompson	67 West Street, Hadley, MA 01035
Preston Turner	12 Walnut Street, Berlin, MA 01503
Diane Vanacek	19 Summer St., Northfield, VT 05663
Phillip Wagner	48 Henderson Ter., Burlington, VT 05401
John S. Warren	Marlboro College, Marlboro, VT 05344
Arnold E. Waters, Jr.	Lower Waterford, VT 05848
Bruce G. Watson	16 Scotsdale Rd., Burlington, VT 05401
Christopher White	RFD #1 Box 240, Bristol, VT 05443
Richard Willey	9602 Aloa Drive, Baltimore, MD 21234
Michael Wurth	Box 96B, Warren, VT 05674

Our publications are also mailed to:
Vermont Department of Libraries
Bailey/Howe Library at the University of Vermont
U.S.G.S. Library at Reston, Virginia

NEW MEMBERS

Welcome to these new members who have been accepted by the Executive Committee since the last issue of GMG:

John Drobinski	Sudbury, Massachusetts
Susan Guhl	Montpelier, Vermont
Arnold E. Waters, Jr.	Lower Waterford, Vermont

PRESIDENT'S ANNUAL REPORT

A year ago when I was elected your president, I stated that we would dedicate the year to GROUND WATER. Well, the good Lord must have heard my words, for it seems like we have had nothing but rainy weather ever since those words were uttered. I do believe ground water levels have recovered and then some. Members of the Society (the Ground Water Protection Watchdog Committee) have been staying abreast of the development of the state's ground water protection strategy and will continue to do so in the coming year. The upcoming winter meeting will be calling for papers related to Vermont's ground water resources and hopefully will reveal the type of professional work being conducted in the state both the research and applied arena. The special summer field trip conducted by Bob Cushman and Brew Baldwin was largely devoted to questions related to ground water in glacial deposits along the Green Mountain front from Bristol to East Middlebury. Specifically, we looked at the Middlebury ground water situation and the problems they face in developing a protection plan for their municipal wells. Part of doing something about ground water problems is understanding the problems themselves, and we learned that they range far beyond the scientific and technical solutions.

Our winter meeting greeted a new first in the presentation of technical papers in the Applied Geology in Vermont session. It is hoped that this fledgling start will develop into more than an occasional event at our winter meetings. There is a strong interest in recognizing the professional geologist working in the applied geology field. An outgrowth of this interest resulted in the creation of our Applied Geology Ad Hoc Committee. I will ask a representative of that committee to report to you later tonight.

The Executive Committee took an important and necessary step this year in establishing three basic criteria which will be used for evaluating papers submitted for publication in Vermont Geology. Beyond having no criteria on which to evaluate papers submitted to the Editorial Committee, it was apparently assumed erroneously, that all papers presented at the Winter Meeting would automatically be published in Vermont Geology. The Winter Meeting does serve as the central focus for presenting the results of high quality professional work, and papers presented at the meeting may be submitted for publication in Vermont Geology. The Editorial Committee will accept additional papers submitted for publication. Where the Winter Meeting focuses on a single theme, it is desirable to have an issue of Vermont Geology devoted to covering this theme.

Our membership has increased this year and we are now over the 100 mark. One problem in maintaining membership has been the lack of a reminder. A new membership card was developed by the Executive Committee and will be sent out with the next GMG. It will require that you return one-half of the card with your dues payment. The returned half will serve as the current membership file. Life membership was discussed by the committee, but the question was not resolved.

Our regular events were successful again this year and thanks should be extended to the organizers:

Spring student papers at Middlebury - B. Baldwin
Teacher's Workshop - Bud and Sandi Ebbett
Annual meeting and field trip - Bud and Sandi Ebbett
Summer Applied Geology field trip - Bob Cushman and B. Baldwin

GMG - Jeanne Detenbeck
Vermont Geology - Jeanne Detenbeck

And this brings me to my closing statement. This is a great organization and it's not until you really get involved that you begin to believe it. It is a volunteer thing and because of that it can be frustrating, but there are great people, interested people, and fine professionals in the Vermont Geological Society. I ask you to continue to support this organization and give it some of your time - you'll be glad you did.

Charles Ratté
President 1981

REPORT OF FALL FIELD TRIP AND ANNUAL MEETING

It was a great day for a field trip, we even had blue sky! The snow promised the night before did materialize, blanketing the forest floor above Lake Willoughby, and a strong north wind ruffled the lake's surface, but these proved no obstacle to the 16 hearty geologists who assembled at Lyndon College on Staurday, October 24. Hot coffee and two freshly baked coffeecakes gave us a good start on a full day's journey over and around glacial landforms surrounding Lake Willoughby. We walked up over a series of push moraines separated by melt water channels on the eastern side of the lake, and scrambled through a boulder train of convincing glacial origin. A serpentine meltwater channel at the southern end of the lake proved to be a real puzzle.

As the sun set, bringing on a cold evening, the warmth and good food at the Cutter Inn was welcome. At the conclusion of the meeting, the Ebbetts were thanked for a perfect day all round.

GSA's DNAG FIELD GUIDE PROGRAM

In response to an inquiry about how VGS might participate, Philip Osberg writes "We are planning to publish in a single volume a description, including location and geological aspects, of those exposures where geological relation ships can be observed which served to decipher the geology of the region. Each outcrop must tell a "complete" story about some aspect of the geology that has regional implications. Obviously, the exposure must be moderately accessible and be "spectacular"." In due course they will be soliciting help from local groups such as ours.

LETTER FROM CANADA

To the readers of the Green Mountain Geologist:

I was in Vermont recently to visit and to investigate the rumours of oil company activity in the state. I was both happy and chagrined to find the rumours true. As a consulting well-site geologist, I would be overjoyed to be able to ply my trade in Vermont. As a Vermonter though, I am unhappy about the lack of regulation of this potential oil boom.

Without going into too much detail, the areas which should be of concern to Vermonters are:

1) environmental protection (i.e. aquifer contamination guidelines,
2) conservation and control of the resource (i.e. leasing and licensing guidelines), and
3) the collection of geologic data.

This third area of concern is of primary importance to the Vermont Geological Society. The demand for geologic data by governments varies considerably from place to place. In Vermont there would be a gold mine (oil well?) of information available if oil companies were required to surrender copies of well logs, core samples and drill cuttings samples to the state government at the conclusion of drilling. This information should be kept confidential for at least one year to allow the company which risked drilling to make exclusive use of it, but then it should be released to the public. The release of this data will provide a more competitive atmosphere for the industry as well as food for the academic thought.

I believe it is in the best interests of the Vermont Geological Society to be aware of and involved in the formulation of the regulations to control hydrocarbon exploration in Vermont. It is, after all, the geologists who have pointed out Vermont's hydrocarbon potential. Anyone interested in more information please feel free to contact me.

Sincerely,

Steven Solomon
Starksboro Energy Ltd.
M120, 345-4 Avenue S.W.
Calgary, Alberta
Canada T2P 0J1

GEOMORPHOLOGY NOTE

MORE ON THE ORIGIN OF QUECHEE GORGE

McHone (1981, G.M.G., Vol. 8, No. 3, p. 6) has brought attention to the origin of Quechee Gorge. Several of his statements as they relate to the geomorphology and glacial history of the gorge area should be clarified.

An adage that works well in the glaciated terrain of the Northeast is (or should be) that wherever there is a narrow segment of an otherwise broad valley, look nearby to find a buried preglacial channel. Quechee Gorge is narrow and straight in contrast to the broad and curving valley of the Ottauquechee River above and below the gorge area (Fig. 1). As we look nearby for a possible buried channel we really don't have far to look because there is a large flat area with elevations around 640 feet east of the gorge. The flat surface extends 0.5 km east from the Quechee Gorge bridge and measures 1.5 km north-south including a southern portion dissected by stream erosion.

The flat surface is underlain by gravel and sand deposits at the surface and finer-grained sediments at depth. The surface represents the top of an ice-contact delta deposited across the valley of the Ottauquechee River. The delta formed as a result of melt-water streams issuing into glacial Lake Hitchcock from a stagnant tongue of ice that occupied the Ottauquechee valley. The margin of the ice tongue could have been located at the present 600-foot contour along the north side of the delta or a short distance north and west of that contour.

The elevation of the delta surface approximates the former shoreline of Lake Hitchcock which today rises to the north because of isostatic rebound at a slope of 0.9 m/km. Jahns (1967) noted that the shoreline of Lake Hitchcock in the Hanover area was about 655 ft ASL. A north-south projected profile of the Lake Hitchcock shoreline in Massachusetts extended to the Hanover area coincides with the top of the Quechee gorge ice-contact delta.

As the margin of ice tongue retreated upvalley a small lake formed between the ice margin and the north side of the delta. Drainage from this small lake was across the west side of the delta into Lake Hitchcock. With time Lake Hitchcock drained and the stream flowing south across the delta cut down first through deltaic sediments and then into the bedrock now exposed in the wall of Quechee Gorge. The preglacial channel of the Ottauquechee River lies buried somewhere under the ice-contact delta east of the gorge.

The usual form for streams is curved or meandering and straight reaches like the Quechee gorge section of the Ottauquechee are relatively rare. Why are straight streams rare and meandering streams so common? The usual answer is that meandering represents the most efficient way for the stream to carry its load and do its geologic work. Engineers familiar with straight canals have noted that deposits tend to accumulate on alternate sides of a new canal. In other words, the stream tries to develop small bends in a straight channel so that it can be more efficient.

Are there alternating sediment accumulations in Quechee Gorge? No, the gorge has a steep gradient and most sediments have been flushed out during floods and are not replenished because of a dam at the north end of the gorge. Sediments that normally would come down the stream are trapped in the reservoir above the dam. Lacking sediments to create bends what does a straight stream do? It forms deep pools and rapids (riffles) that create an undulatory motion similar to meandering in a vertical plane. The view south from the U.S. Route 4 bridge is a great spot to observe the riffles and pools of Quechee Gorge.

Frederick D. Larsen
Norwich University

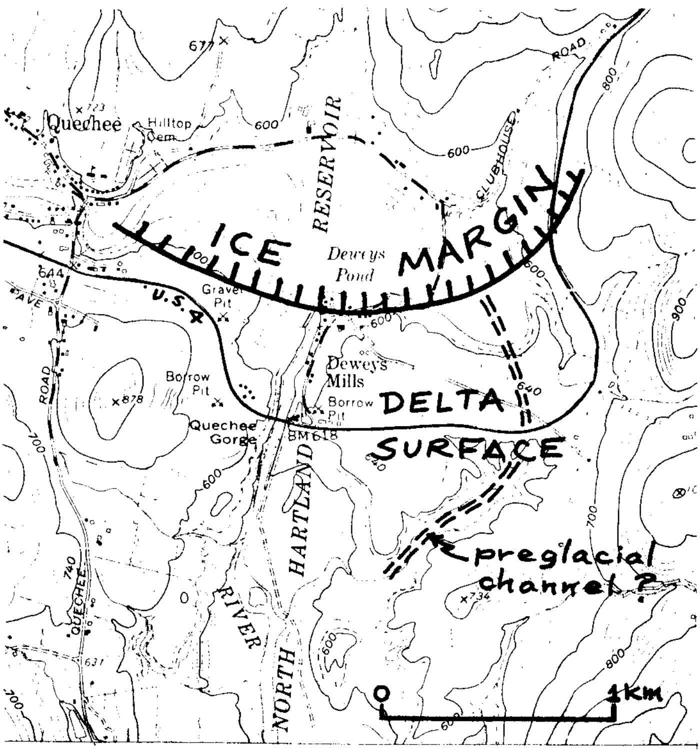


Figure 1. Map of Quechee Gorge area (from U.S.Geol. Survey 7-1/2' Quechee, Vermont, quadrangle, contour interval-20').

MINERAL OF THE QUARTER

KYANITE Al_2SiO_5

Hardness: 5.5 along length of crystal, 7 across the crystal
Specific Gravity: 3.7
Crystal System: Triclinic
Crystal Habit: Flat blades or radiating bladed aggregates
Color: Mottled, uneven coloration bluish, greenish, white to grey or even black
Luster: Transparent to translucent
Cleavage: Two good cleavages
Distinguishing Characteristics: Blue, uneven color, bladed habit, good cleavages and variable hardness

Kyanite gets its name from the Greek word for blue - kyan. It occurs in schists and gneisses, formed from clay-rich deposits by metamorphism. It is the densest of the three polymorphs which share the same chemical composition. Andalusite (specific gravity, 3.1) is formed under low pressure metamorphic conditions. Sillimanite (specific gravity, 3.3) forms under moderate pressure conditions, and kyanite (specific gravity, 3.7) is formed as a result of high pressure metamorphism.

Kyanite is common in New England schists and gneisses, but does not occur in commercial quantities. Mineable quantities are exploited in Virginia, North Carolina and Georgia. These are used in the production of high-temperature-resistant ceramics and porcelains, such as furnace bricks and spark plugs. The large, clear crystals mined in Kenya, Africa, and water-worn, clear pebbles found in Sao Paulo, Brazil, are cut into gem stones.

Vermont Locations

A large outcrop of mica schist containing muscovite and paragonite, quartz, garnet, staurolite and kyanite can be found to the east side of Route 103, where the road crosses the Williams River, just north of the Village of Gassetts. This deposit was mined for the garnet it contains at one time to make abrasives. Light blue-green prisms of kyanite of gemmy quality can be found in the mica schist.

Another reported location for kyanite, which needs to be checked out in better rockhounding weather, is in the Peacham area. Take the Peacham Road south from Danville for seven miles. Just before South Peacham, at the base of a downtrending, steep hill, is a bridge over South Peacham Brook. Turn right onto a dirt road that follows the brook to its outlet at Foster's Pond. Park near the dam-like structure by the outlet and look under the footbridge on the right side of the road. Blue kyanite has been reported in the brook, as well as black staurolite crystals of various sizes.

Submitted by Ethel Schuele

STATE GEOLOGIST'S REPORT

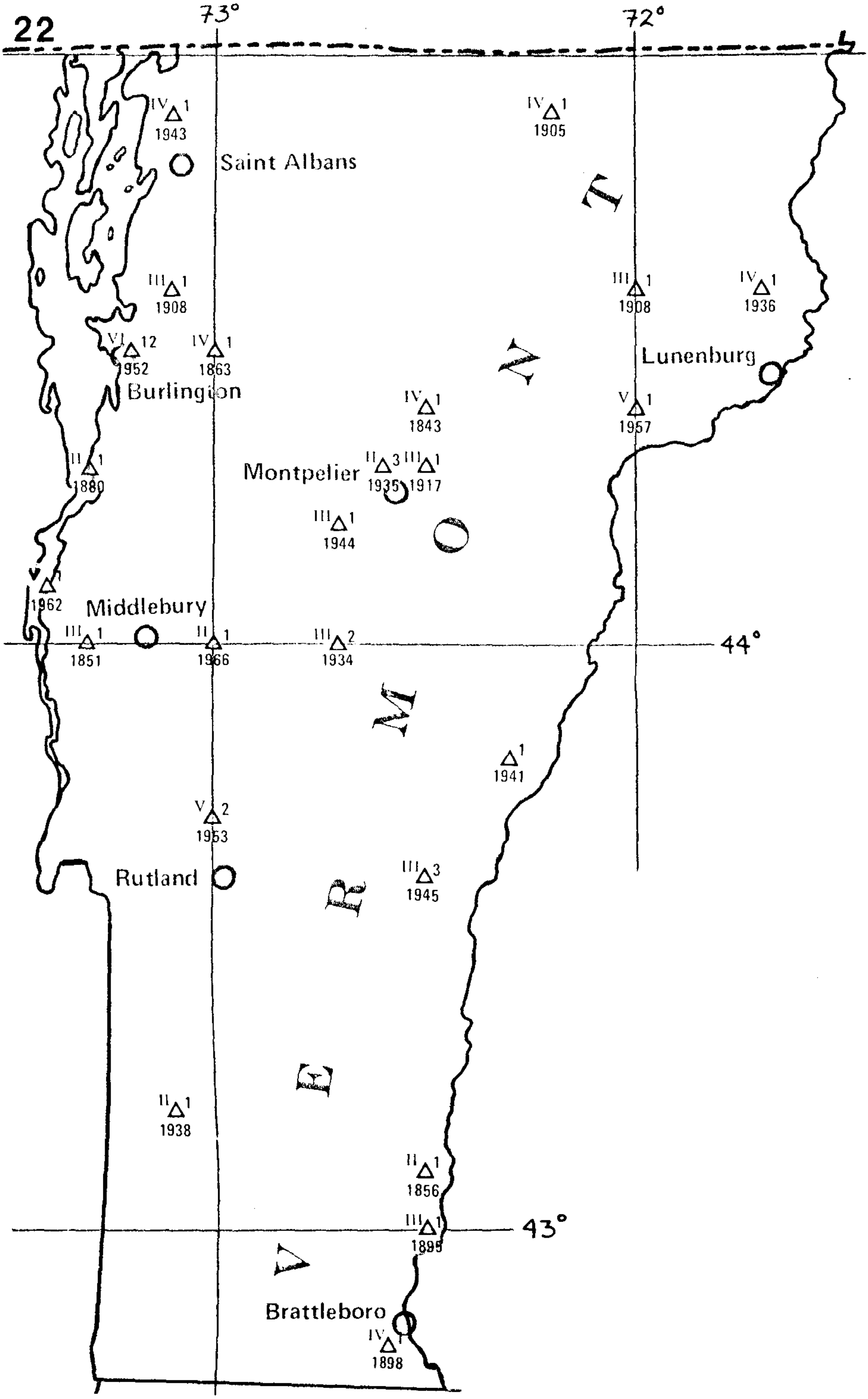
Oil and Gas Legislation

I have been working with the Vermont Natural Gas and Oil Resources Board to get legislation ready for this session. The bill is in the House Natural Resources Committee (H.602). Mr. Solomon's concerns [See Letter from Canada elsewhere in this issue of the GMG. Editor] are addressed. I am working with a committee made up of Environmental Agency personnel that is reviewing the bill for specific environmental jurisdiction concerns, plus I am personally working on the aspect of having geological, geophysical, hydrological, etc. information made available to the state geologist as well as the Oil and Gas Board. If the Vermont Geological Society has concerns about this, I would encourage Fred Larsen to appoint a committee to revies the bill and perhaps request to give testimony before the House committee. I should not be on that committee since I am working on the bill already through the Oil and Gas Board and the Environmental Agency.

Two Recent Northeastern Earthquakes

The following data about two seismic events felt in Vermont in January was provided by the Weston Geophysical Laboratory at Weston, Mass. Lamont-Doherty Geophysical Observatory (into whose network all seismic stations in Vermont are tied) sends a quarterly report to me. There are always reports of several low magnitude events which are recorded by not felt throughout New England and New York State. Perhaps the only real significance of the January 9 and 18 events was that they were large enough to be felt. The people at both labs mentioned above feel that this is not unusual and to be expected once in awhile. The map accompanying this report shows locations of historic earthquakes in Vermont. Any quake with a value of V or more on the Modified Mercalli scale was a felt quake. Triangles locate each quake, showing the year of the event, the number of separate events felt and the Modified Mercalli value in Roman numerals. The map is taken from the U.S.G.S. publication, Miscellaneous Field Studies Map MF 1262 Seismicity, Vt. by Carl Stover.

Location: New Brunswick, Canada 47^{o}N, $66^{o}5'$W
Time: January 9, 1982 7:54 AM, Aftershock 11:38 AM
Magnitude: 5.8-5.9, Aftershock 5.0
Comments: This quake was felt all over New England and New York State. Some slight damage was unconfirmed in Northern Maine. This is generally a very quiet area, and this was an unexpected event.


22
73°
72°
44°
43°
VERMONT
Saint Albans
Burlington
Montpelier
Lunenburg
Middlebury
Rutland
Brattleboro
IV 1 1943
IV 1 1905
III 1 1908
III 1 1908
IV 1 1936
VI 12 1952
IV 1 1863
IV 1 1843
V 1 1957
II 1 1880
II 3 1935
III 1 1917
III 1 1944
1962
III 1 1851
II 1 1966
III 2 1934
1 1941
V 2 1953
III 3 1945
II 1 1938
II 1 1856
III 1 1895
IV 1 1898

Location: near Laconia, New Hampshire 43.5°N, 71.6°W
Time: January 18, 1982 7:14:42 PM
Magnitude: 4.7
Comments: Depth of focus was 4-6 miles. This quake was probably only coincidental to the New Brunswick one. Only minor damage was sustained. This area is known to be seismically active and there have been several small quakes in the past 4-5 years with magnitude 1.5-2.5. The last significant quake was in 1959 at 4.0 on the Richter scale.

MEETINGS

FEB 20 VERMONT GEOLOGICAL SOCIETY Winter Meeting see the program on page 3 of this issue for details.

MAR 9-10, 11-12 VGS is co-sponsor with the Agency of Environmental Conservation's Division of Protection of a two-day course "Wisconsin on-site treatment and disposal of waste water" in Montpelier. The second session (Mar 11-12) is still open and anyone interested should contact Stephan Syz, Agency of Environmental Conservation, State Office Building, Montpelier, Vermont 05602. (802/ 828-2761) Registration cost is $125.

MAR 25-27 Northeastern and Southeastern Sections of the GSA, annual meeting in Washington, D.C. (Jean M. Latulippe, GSA Headquarters, Box 9140, Boulder, Colorado. (303/ 447-2020)

MAY 21 Deadline for abstracts for the GSA 1982 Annual Meeting to be held October 18-21 in New Orleans, Louisiana. VGS members who wish to have copies of the announcement and abstract form, write to the VGS editor, c/o the Society's P.O. Box. We have a supply of these.

LAST MINUTE ADDITION

MAR 13 Fourth Annual Water Well Driller's Workshop at Vermont Technical College in Randolph, Vermont. A number of speakers are scheduled to discuss water quality (pollution of wells by road salt, and removal of hydrocarbons from wells), and licensing and construction requirements for the industry. For more details contact James Ashley at Water Resources, 802-828-2761.

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

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

FIRST CLASS

Charles A. Ratte'
4 Chestnut Hill
Montpelier, Vermont
05602