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The Vermont Geological Society
Spring Meeting
April 29, 2006, 8:30AM
McCardell Bicentennial Hall, Room 220
Middlebury College, Middlebury, Vermont

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ABSTRACTS

SEDIMENT BEDFORMS: CAUSES AND HISTORY WITHIN LAKE CHAMPLAIN

Kathryn Hayo, Geology Department, Middlebury College, Middlebury, VT 05753

A high-resolution CHIRP seismic survey of the main lake region of Lake Champlain revealed the presence of sediment bedforms located within the Juniper Deep. Primarily of interest are two north-south trending sediment mounds disrupting the pattern of otherwise normal drape sedimentation that characterizes deposition throughout the main lake. Flanking these mounds are moats to the east and west as well as north-south trending furrows indicating sedimentation controlled by bottom current activity. As such these mounds have been interpreted to be small scale lacustrine sediment drifts. The goal of this study is to determine the bottom current patterns that control the deposition of the two drifts, as well as determining when and how they began to form.

Two basic drift geometries have been identified. Drift A, the eastern deposit, is a confined elongate drift, while Drift B, the western deposit, is a detached elongate drift. The drifts are comprised of highly laminated sediments that can be traced through both drifts. The southern portion of Drift A overlies a series of acoustically transparent in-fill trough sediments. Northern portions of Drift A, as well as the sediments of Drift B, overlie normally depositing, acoustically transparent, drape sediments.

In the north, Drift A is mantled by northward migrating mudwaves, suggesting the bottom currents responsible for the deposition of this drift are flowing in a southerly direction. This is supported by the presence of a deep moat located along the western side of the drift. Drift B is flanked by several north-south trending, sedimentary furrows, suggesting a parallel bottom current flow. The basal reflector for both drifts has been correlated to the known Champlain Sea-Lake Champlain sediment interface. This indicates an age correlation between the Champlain Sea-Lake Champlain boundary and the start of drift formation. On-going analyses will identify the sediment source(s) responsible for the formation of both drifts.

CIRCULATION AND HYPERPYCNAL PLUME DYNAMICS WITHIN SHELBURNE BAY, VERMONT; FOR USE BY CHAMPLAIN WATER DISTRICT

D. D. Dums, Geology Department, Middlebury College, Middlebury, Vermont 05753

One and a half years of temperature, current, and turbidity data were obtained from long-term moorings near the neck of Shelburne Bay, on the eastern margin of Lake Champlain just south of Burlington, Vermont. Meteorological data at the Burlington International Airport and LaPlatte River turbidity and flow rates were obtained from the National Weather Service and USGS, respectively. During wintertime periods, water temperatures reached isothermal conditions, the coldest temperatures being 0.5^{o}C during March. Summertime periods resulted in a stratified water column with water temperatures reaching 26.0^{o}C in August.

Bimodal circulation within the bay existed during stratified periods, while primarily uniform flow existed during non-stratified periods. Counter clockwise flow was present throughout the entire study, with a second recirculated filament found at the neck of the bay. Water primarily flowed south on the western side of the bay, while west/northwest flow was found in the center of the neck.

Increased stream levels of the LaPlatte River occurred after the majority of precipitation events and the largest stream levels occurred during the annual spring runoff. As this water entered Shelburne Bay, it created a hyperpycnal plume that flowed along the bottom and apparently trapped within the thalweg of the bay. Its northern extent was at least six kilometers from the mouth where it was observed at the Central mooring. Plume dynamics were strong enough to override the pre-existing circulation within the bay with speeds upwards of 10 cm/s at the deepest depths within Central mooring while at the Western mooring the deepest depths produced speeds only upwards of 5 cm/s. Turbidity levels were found to be on the order of three times larger in the central thalweg than on the eastern margin.

Correlating temperatures between the Western, Central, and CWD moorings indicate that the epilimnic waters affect the deepest portions of the CWD mooring most, while the Central mooring is least affected. Turbidity spikes occurred at all of the moorings but the most spikes existed at the Central mooring, while the fewest number existed at the Western mooring.

GEOCHEMICAL AND MINERALOGICAL ANALYSIS OF POTENTIAL K-BENTONITES IN THE CHAMPLAIN VALLEY OF WESTERN VERMONT

Kristiaan Joseph, Geology Department, Middlebury College, Middlebury, VT, 05753

Shaly beds showing lateral continuity, sharp basal and upper contacts, absence of sedimentary layering, and thicknesses ranging from 1-60 cm are found locally interbedded with Ordovician carbonate rocks of the ~460 Ma Beldons and Bridport Formations in the Champlain Valley. These field indicators are consistent with characteristics of K-bentonites, and given the extensive record of Ordovician metavolcanic rocks associated with the Taconian Orogeny, this study was carried out to determine if these distinctive beds are K-bentonites, i.e., beds originally deposited as volcanic ash. 38 samples were collected from 3 localities in Addison County—Kingsland Bay in Ferrisburgh and Pike Quarry and Huntington Falls in New Haven.

Thin-section analysis reveals that these beds are dominated by fine-grained illitic clay with little or no detrital quartz, and rare teardrop-shaped grains that are suggestive of glass spherules. One Kingsland Bay bed revealed fossil fragments suggestive of a detrital component. Samples from Huntington Falls and Pike Quarry contained illite, minor amounts of chlorite and rhombohedral dolomite. Zircon, apatite and biotite were not identified in any samples. Preliminary X-ray diffraction analysis confirms the predominance of illite—future work will include detailed XRD analyses to determine illite polytypism and mixed layering in order to determine burial and diagenetic history.

Major element data document compositions similar to K-bentonites from Ordovician and Silurian strata elsewhere in North America—compositions that are consistent with beds dominated by illite plus minor amounts of authigenic carbonate and chlorite. Zr/TiO_2 vs. Nb/Y plots indicate sub-alkaline to andesitic source magma. Future work will attempt to better elucidate the tectonic setting based on discriminant diagrams. Additional analyses of geochemical data combined with SEM and XRD will reveal more on the geological origin of these beds, as well as the burial diagenetic history of clay-rich strata from the Middlebury Synclinorium (Pike and Huntington) and less deformed rocks further to the west (Kingsland Bay).

AN EVALUATION OF SOIL CHEMISTRY FOR ACID DEPOSITION ON BOLTON MOUNTAIN, VERMONT

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Studies of acid deposition on soils reveal that it can cause changes in the soil geochemistry through increased leaching of essential base cations and that the deposition of these acids increases over an elevation gradient. Increased acidification and decreased base saturation of nutrients can in turn be detrimental to forest health and water chemistry, particularly at higher elevations due to orographic effects. The objective for this study is to analyze soil geochemistry (particularly base cation saturation, pH, and Ca to Al ratios) and soil mineralogy of soils at three different elevation sites (548.64m, 731.52m and 914.4m) on the western and southern sides of Bolton Mountain, Vermont.

Overall eighteen soil pits were excavated at six sites with three pits at each site to account for local variability. Samples were taken from each soil horizon and tested for pH, bulk density, ion concentrations, base saturation, bulk and clay mineralogy. The results found that pH becomes more acidic with increased elevation as the pH ranges from 5.3 at the lowest elevation to 3.2 at the highest elevation. Meanwhile, the percent base saturation declines with elevation from 90% at the lowest elevation to 10% at the highest as mmol Al:Ca ratios increase with elevation.

The results indicate that base saturation levels and pH levels decrease at greater elevations. This is possibly due to higher levels of soluble aluminum, which is mobilized in soil due to acidification from acid rain, replaces base cations and causes these nutrients to be leached from the soil. The parent material of mica and chlorite weathering into vermiculite may buffer some of the effects of acid deposition. High variability in soil properties between the west and south side sites may indicate local as well as elevation differences in the results. These south and west aspect differences could be the result of anthropogenic factors more than geologic factors. In conclusion, the results generally support the hypothesis that higher elevations receive more acid rain which in turn affects soil geochemistry and forest health. More sampling will be done in the future to confirm these findings.

ACIDIC DEPOSITION AND ITS EFFECTS ON THE SOILS OF A FORESTED ECOSYSTEM: WHITE MOUNTAINS, NEW HAMPSHIRE

Lynne Zummo, Geology Department, Middlebury College, Middlebury, VT 05753

This study examined the spodosols of Bartlett Experiment Forest (BEF), a low- to mid-elevation, sub-alpine forest that lies within White Mountain National Forest. Given the documented occurrence of acidic deposition in the region, the purpose of the study was to identify any effects of acid influx apparent in BEF soils, and to ultimately ascertain forest health.

Soils were sampled from 6 different sites that fell along an elevational gradient extending from 250 m to 570 m. The site was a continuously forested ecosystem, dominated by a mix of coniferous and deciduous species, and underlain by granite bedrock. All soils were derived from granitic parent material, assumed to be till deposited during the last glacial period. Soil pH ranged from 2.6 to 5.1, but showed no relationship with elevation. Samples analyzed for exchangeable cation concentration were found to be generally low in Ca^{+2} and high in Al^{+3}, once again, with no relationship to elevation. High molar Al:Ca ratios affected nearly all sites, ranging from 1.0 to 18.7, excluding A-horizon values. Low percent base saturation (%BS) affected most sites as well, and ranged from 9.0% to 60.4%, excluding A-horizons. Both pH and %BS showed distinct correlation with soil depth and horizon. Soil mineral weathering was most apparent in the E and Bs-horizons, and less apparent in the B and C-horizons. Evidence for vermiculite formation, as a product of weathering, exists in many of the upper mineral horizons, whereas clay-sized parent materials dominate the <2 μm fraction of lower mineral horizons.

Analysis of BEF soils showed severe nutrient depletion in mineral horizons, likely the result of acidic deposition to granite-derived soils with low buffering capacities. The effect of cloud deposition on BEF could explain the lack of correlation with elevation. Mobilized by acid influx, Al^{+3} appears to be playing a role in the displacement and leaching of crucial base cations, such as Ca^{+2}, processes which could ultimately endanger forest health by shrinking pools of available nutrients. Continued monitoring of BEF for dieback and decline is recommended, especially in instances of severe climatic events.

SYNTHETIC SEISMOGRAMS AND PHYSICAL PROPERTIES GENERATED FROM SEDIMENTS IN MAXWELL BAY, ANTARCTICA—A STUDY OF CLIMATE VARIABILITY

Bradley Michalchuk, Geology Department, Middlebury College, Middlebury Vermont, 05753

A 108-m push core of Holocene sediment was retrieved from Maxwell Bay, Antarctica to better understand the depositional history, climate cycles, and climate variability. During the coring process, disruption and gas expansion within the sediment affected the cores depth profile that was generated on board the *Nathaniel B. Palmer*. In this study, synthetic seismograms were created to adjust for the sedimentation disruption and to determine a more accurate depth profile for the core. Multiple synthetic seismograms were constructed as a control to ensure that the proper variables (used in creating a synthetic seismogram including: bulk density and velocity) were used. By aligning the reflective layers in the Bathy 2000 seismic profile with the synthetic seismograms, the expanded core sections needed to be compressed and a modified velocity profile gave the best results.

Using the new depth profile, physical property data, radiocarbon dates, sedimentation rates, and climate patterns are determined. At 5 cm intervals downcore, electric resistivity was determined, bulk density and porosity was calculated from discrete samples, and grain size was determined using a Horiba laser spectrometer. Spectral analysis on electric resistivity, bulk density, porosity, void ratio, mean grain size, and sand, silt, and clay composition (determined by grain size percentages) provided various results. The electric resistivity, bulk density, void ratio and porosity all yielded the highest spectral peaks at 2560 and 1462 years. High spectral peaks at 1137 and 853 are also observed in both the bulk density and porosity variables. The grain size variables yielded sporadic spectral peaks. Previous studies in the Antarctic Peninsula region suggest there are climate cycles at 200 years, but this study does not effectively corroborate those findings. The determined cycles are most likely caused by changes in the depositional setting which are caused by climate changes in the sup-polar regions.

A TEPHROSTRATIGRAPHIC INVESTIGATION OF MARINE SEDIMENTS FROM MAXWELL BAY AND BRANSFIELD STRAIT, ANTARCTICA

Katherine Kirsch, Geology Department, Middlebury College, Middlebury VT 05753

The age control on glacial and climatic events since the Last Glacial Maximum in Antarctica is primarily through radiocarbon dating. This technique, however, often yields anomalously old ages due to the marine reservoir effect. A more reliable technique is tephrostratigraphy in which ash layers in marine cores are correlated with dated mainland eruptive events based on geochemistry. This study aims to refine and extend the tephrostratigraphy in the northern Antarctic Peninsula region by re-examining five ash samples from sediment cores taken in the Bransfield Strait, and examining one ash sample from a sediment core taken in Maxwell Bay.

Petrographic examination of bulk samples from the selected ash layers reveals varying proportions of volcanic glass, lithic fragments, and minerals. Major element oxide abundances were determined for individual volcanic glass fragments using the electron microprobe. Three of the samples contain a single, basaltic andesite glass population, while the other three samples contain multiple glass populations, ranging in composition from basalts to rhyodacites. Most samples have high Na_2O and TiO_2 and low K_2O, which is characteristic of rock compositions on Deception Island, a young stratavolcano at the southwestern end of the South Shetland Islands. Deception Island has therefore been identified as the most probable source of all ash samples analyzed.

Previous studies have also attributed the five ash samples from Bransfield Strait to Deception Island volcanism. However, the glass analyzed in these studies was limited to the dominant basaltic andesite population, suggesting that the traditional sample preparation technique of handpicking glass fragments prior to analysis biases the data. Instead of handpicking, this study utilized representative samples of the entire population of grains from individual ash layers. These samples were made into polished grain mounts which through petrography and electron backscatter imaging allowed for the easy identification of multiple populations of glass. This alternative method of sample preparation, while more expensive, is less time intensive and allows for a more complete assessment of the range of volcanic glass compositions. This may ultimately provide a more diagnostic fingerprint of volcanic rich horizons in marine cores and allow for more precise correlations with eruptions of known age.

SEISMIC AND CORE STRATIGRAPHY FOR YOUNGER DRYAS FRESHWATER FLOODING AND EROSION IN SOUTHERN LAKE CHAMPLAIN

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From 12,800–11,500 years B.P., the North American continent underwent an abrupt climatic oscillation where temperatures dropped to near glacial conditions. The onset and end of this cold episode are generally accepted to correlate to the incursion of the Champlain Sea. As the Laurentide Ice sheet receded northward and exposed the St. Lawrence River Valley, a large amount of cold freshwater rushed into the North Atlantic and offset the North Atlantic Deep Water circulation enough to disrupt global climatic conditions. After isostatic rebound, the marine water that had inundated both the St. Lawrence and Champlain Valley lowlands began to decrease, initiating the transition to the freshwater stage of present day Lake Champlain. This study uses seismic data to analyze sediment deposition related to the possible floods into the North Atlantic and their subsequent erosional events occurring near the Younger Dryas period.

Seismic data was collected over a three-year period by the United States Geological Society, professors and students from Middlebury College. The study area extends from just north of the Champlain Bridge to Basin Harbor. Key sediment horizons have been dated and appear to be coincident with the regional erosional events. These were picked from the seismic profiles, and the softwares DelphMap, SonarWeb, and earthVision were used to digitize the lines and create 3D images of these layers and of the general depositional events in the study area.

Initial data suggests that the transition between the Champlain Sea and Lake Champlain may have occurred later than previously suspected. The 3D models indicate a variation in thickness between key sediment horizons throughout the study area. The most significant variation occurs between the Champlain Sea/Lake Champlain interface and the two major reflectors above and below it. The change between acoustically transparent and laminated sediment further suggests that sediment deposition in the Champlain Valley was affected by these erosional events that occurred both at the beginning and throughout the Younger Dryas period.

A GEOCHEMICAL, PETROLOGIC, AND HYDROLOGIC INVESTIGATION OF TWO BEDROCK ARSENIC SOURCES, SOUTH-CENTRAL MAINE

Nellie Barnard, Geology Department, Middlebury College, Middlebury, VT 05753

Previous reconnaissance geochemical studies in south-central Maine revealed anomalously high concentrations of arsenic (>200 ppm) in two thin iron-rich metamorphic units (Wilson Cove and Muzzy Ridge units). The discovery of a natural arsenic source presents a rare opportunity to study the extent to which groundwater is acquiring arsenic as a result of contact with these units. The purpose of this research is twofold: 1) to complete a whole rock geochemical and mineralogical study of the Wilson Cove and Muzzy Ridge units to determine the nature and extent of arsenic in these units, and 2) to investigate the extent to which groundwater in contact with these units is contaminated with arsenic.

Wilson Cove samples are generally characterized by a combination of garnet, grunerite, biotite, apatite, and opaque minerals. Muzzy Ridge samples contain varying amounts of garnet, grunerite/cummingtonite, quartz, and opaque minerals. Energy dispersive spectrometry on both units identified three main arsenic-bearing minerals: arsenopyrite (FeAsS), cobaltite (CoAsS), and loellingite ($FeAs_2$). Whole-rock major element chemistry from both units reveals anomalously high concentrations of iron (up to 43 wt. %) and manganese (up to 11 wt. %). Similarly, trace element chemistry reveals both units are significant sources of naturally occurring arsenic (up to 1161 ppm) and other trace metals. With the exception of one sample (44 μg/L As), all water samples obtained from these units tested below the EPA maximum contaminant levels for arsenic (10 μg/L).

The results of this study indicate that the Wilson Cove and the Muzzy Ridge units may be classified as metamorphosed manganiferous ironstones, but speculation on their protoliths is difficult due to amphibolite facies metamorphism. The whole rock geochemistry clearly reveals the presence of two major natural point sources of arsenic in this region. However, water chemistry in the vicinity of these units generally does not reflect the unusual chemistry of these rocks. Reasons for this include: (1) groundwater flow directions perpendicular to the strike of the thin units, (2) joint orientations parallel to groundwater flow direction facilitate rapid water movement through the thin units, and (3) conditions allowing the mobilization of arsenic are either absent or offset by other processes.

GEOLOGY AND GEOCHEMISTRY OF ARCHEAN, METAMORPHOSED MAFIC ROCKS IN SOUTHWESTERN MONTANA

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Laramide uplift in southwestern Montana has unroofed and exposed Precambrian, metamorphic basement rocks in the cores of several mountain belts. Three mountain ranges along the northwestern margin of the Archean Wyoming Province form the geographic focus of this study. The purpose of this study is to examine the mineralogy and whole-rock geochemistry of metamorphosed mafic rocks from these exposures in order to determine their protoliths and the geologic setting in which they originally were formed.

Rock samples are subdivided by the mountain ranges in which they are found, from north to south: the Highland, Greenhorn, central Gravelly, and southern Gravelly Ranges. In the Greenhorn and Highland Ranges, amphibolite bodies occur within suites of quartzofeldspathic gneiss as lenses or layers, and in the Highland Range are further subdivided by the gneiss units in which they occur. Fine-grained metabasalts occur as small outcrops within metasupracrustal rocks of the central Gravelly Range, and in the southern Gravelly Range regionally metamorphosed mafic intrusions into metasupracrustal rocks take the form of small plutons, sills, and dikes. All rocks have undergone at least one regional metamorphic event, though the degree of deformation and the presence of foliation vary between and within these four regions. Samples from the Highland Range typically show the highest degree of deformation, while those from the southern Gravelly Range display little or no evidence of deformation.

Geochemical analyses classify all samples as tholeiitic basalts, based on Nb/Y vs. Zr/TiO_2 and AFM diagrams. Samples from the Greenhorn, central Gravelly and southern Gravelly Ranges are enriched in LREE, while samples from the Highland Range show flat REE patterns or slight LREE enrichment. Spider diagrams for all samples show significant negative Nb-Ta anomalies, indicative of formation in a subduction environment. Tectonic discrimination diagrams are consistent with this pattern, and suggest that samples from the Greenhorn, southern and central Gravelly Ranges were formed in arc settings. Most samples from the Highland Range have MORB signatures on these diagrams, and are interpreted as back-arc basin basalts.

USING GEOCHEMISTRY TO CHARACTERIZE METASEDIMENTARY ROCKS AROUND WATERBURY, VERMONT

Claire J. Vaughan-Anderson, Geology Department, Middlebury College, Middlebury, VT 05753

The north-central region of Vermont, near the town of Waterbury, is characterized by metamorphosed sedimentary rocks deposited during the Cambrian and Ordovician. Little geochemical data has been gathered from sedimentary rocks in this region so studies here provide significant findings. The purpose of this study is to use geochemistry: 1) to compare rock types between and within recently re-mapped formations in the region. Of particular interest is a tectonic slice within the Stowe Formation that has been correlated with the Hazen’s Notch Formation (Gale et al., 2006), 2) to determine the provenance(s) of metasedimentary samples, and 3) to identify the tectonic environments where the formations were deposited.

The four formations from west to east include: 1) Hazen’s Notch dominated by albitic schists with abundant quartz, albite and muscovite as well as graphitic phyllites with interbeds of dark quartzite, 2) Ottauquechee Fm. with graphitic phyllites and quartzite/quartz-sericite schists with epidote-chlorite-albite and calcite, biotite and magnetite, 3) Stowe Fm. containing sericite-quartzite-chlorite phyllitic schists and Worchester schists that contain chlorite-muscovite-quartz with garnet clasts, 4) Moretown Fm. consisting of black phyllites, light greenish to gray phyllitic quartzites, and quartzites.

Overall, geochemistry findings indicate REE patterns are similar for the Ottauqueechee, Stowe and Moretown Fms. In general, the Moretown displays a higher absolute abundance of REEs. All formations are distinguished by slightly enriched LREE (La/Sm ratios range from 2.43-3.7), slightly negative Eu anomalies and relatively flat HREE (Gd/Yb ratios range from 0.79-2.45). Worchester Schist in the Stowe Fm. plots identically to phyllite lithologies in the formation. All quartzite samples are depleted in REE abundance when compared with the schists and phyllite samples. On REE diagrams, albitic schist from the tectonic slice within the Stowe Fm. plots identically to albitic schist in the Hazen's Notch Fm.

Tectonic discriminant diagrams seem contradictory at this point. However, trace element data namely, Eu/Eu* and La/Y ratios, Sc, Th, U, Cr and Ni concentrations, are characteristic of post-Archean upper-continental crust with some mafic input. Concentrations of these elements are similar to those in rocks from a passive margin tectonic setting.

THE PETROLOGY AND GEOCHEMISTRY OF AN INTRUSIVE COMPLEX NEAR LAKE MEMPHREMAGOG, VERMONT

Hillary I. T. Brooks, Geology Department, Middlebury College, Middlebury, VT 05753

Adjacent to Lake Memphremagog in northern Vermont, a north-south trending complex of intrusive rocks previously correlated with the New Hampshire Plutonic Series is exposed just to the west of the boundary between the Connecticut Valley and Green Mountain sequences. A large quarry in the northeastern corner of the Irasburg 7.5' quadrangle has recently exposed a variety of plutonic rocks along the eastern margin of this larger intrusive complex. The purpose of this study is to petrographically and geochemically characterize the rocks at this locality. These results can then be compared with available data from the larger intrusive complex and with rocks of similar age and composition in the region.

Twenty-three samples were collected from the Calkins Quarry near Coventry, Vermont. Amongst these rocks, there is great compositional and deformational variability. Compositionally, the rocks in the quarry can generally be divided into the following types: (1) relatively massive zones dominated by felsic rocks (2) massive zones dominated by intermediate to mafic rocks, and (3) zones characterized by mafic and felsic rocks mingled together. Petrographically, most of the rocks show strong evidence for post-magmatic foliation and/or recrystallization. However, the degree of foliation varies tremendously within the quarry with more massive rock types showing little foliation, while other rocks exhibit phyllitic textures.

Whole rock geochemistry reveals SiO_2 concentrations that range from 47 to 75 wt. % (gabbros to granites) with few large compositional gaps. A Zr vs. P_2O_5 diagram reveals that the low-silica rocks are sub-alkaline basalt in composition and the AFM diagram shows a calc-alkaline trend. Harker variation diagrams display strong linear trends between SiO_2 and other major elements. The range of rock compositions exhibits little variability in REE distributions with all rocks characterized by enrichment in LREEs. Spider diagrams exhibit variability in LILEs, and Ti and Nb show distinct negative anomalies.

The whole rock geochemistry is suggestive of a co-magmatic origin for the variety of plutonic rocks exposed in the quarry. Tectonic discrimination diagrams suggest both a within plate and volcanic arc tectonic environment for the magma generation. Subsequent to crystallization, the rocks were variably affected by deformation and recrystallization.

THE GEOCHEMISTRY OF THE METAVOLCANIC ROCKS OF THE SOUTHERN WORCESTER MOUNTAIN AREA, VERMONT

Nate Morris, Geology Department, Middlebury College, Middlebury, VT 05753

Recent 1:24,000 scale bedrock mapping by the Vermont Geological Survey shows many elongate Cambro-Ordovician? greenstone and amphibolite bodies in the southern Worcester mountain area (Gale et al., 2006). The purpose of this study is to use geochemistry to understand the origin of the bodies and to correlate them with other bodies in Vermont and southern Quebec.

Thirty-seven samples were collected from the greenstone and amphibolite units of the southern Worcester mountain area. Twelve thin sections were used to determine representative mineralogy and basic petrographic characteristics of each of the metavolcanic bodies. Thirty-one samples were analyzed for major and trace element content using ICP-MS. Analysis of the geochemical data shows two distinct geochemical groups within the region. Twenty-four of the thirty-one samples classify as tholeiitic series basalt. Tholeiitic series samples exhibit TiO_2 content ranging from ~0.59 to 1.47 wt %, Zr from 25 to 92 ppm, Sr from 67 to 222 ppm, Sc from 40 to 51 ppm, and rare earth elements at about 10x chondrite with flat to slightly LREE-depleted patterns. Furthermore, trace element variation diagrams suggest that the tholeiitic series may have formed as ocean floor basalts in the Iapetus Ocean. Seven of the thirty-one samples classify as alkaline series basalts with higher TiO_2 content (2.66 to 3.87 wt %), higher Zr content (153 to 223 ppm), Sr from 243 to 494 ppm, Sc from 27 to 32 ppm and rare earth elements at about 10x chondrite with LREE-enriched patterns similar to those of some rift and ocean island volcanics. On trace element discriminant diagrams and N-MORB normalized spider diagrams, the alkaline series samples plot in fields of rift or ocean island basalts.

Analysis of this full suite of samples places the newly mapped metavolcanics of the southern Worcester mountain area within the larger framework of the whole plate tectonic history of Vermont. Specifically we address the question: Were all of the volcanics part of the rift and ocean spreading sequence associated with the opening of the Iapetus ocean in the Late Proterozoic-Early Paleozoic or were some formed near an Ordovician magmatic arc? In this study, we conclude that the metavolcanic rocks of the southern Worcester mountain area formed in a late rift environment, much like the Afar region in East Africa.

PRESIDENT'S LETTER

Dear VGS Members,

Spring seems to be here to stay and I'm sure you are getting ready for fieldwork or some general wandering. We had a great VGS Winter Meeting at Norwich, including an unveiling of several draft bedrock maps, cross sections and correlation charts from the Vermont Geological Survey. That project is really coming along and it was nice to get a preliminary look and give some feedback. Special thanks to Marjie Gale for her introductory remarks on the project.

The summer field trip is still not set and if you would like to lead a trip please let one of the Executive Committee members know as soon as possible. The fall field trip is planned for Highgate Falls Gorge with Adam Schoonmaker, but the date is still in the works.

We would like to continue the VGS Lecturer Program. Last year I was the Lecturer, visiting universities and high schools, and I had a great time. The VGS will cover your travel expenses and it's a great way to get your work out to the public. The main function is to provide a lecturer for smaller colleges and high schools. Please consider volunteering for this program. You can contact me for further information.

At the Winter Meeting, the Executive Committee discussed ways that the VGS can become more involved in Earth Science Week (October 8-14). There will be an open house at OMYA's Middlebury Quarry, and they are hosting the student posters, but we are looking for ways to advertise and promote Vermont earth sciences and we need your input. If you have any ideas on this please pass them along.

I'm looking forward to the student research at the Spring Meeting, April 29. Hope to see you all there.

Best wishes,
Rick Dunn, President

WINTER MEETING MINUTES

Saturday, February 18, 2006

The meeting of the Executive Committee followed five professional presentations during the Winter Meeting held at Norwich University. The Winter Meeting was well attended (about 30 people) and culminated with a progress report delivered by Marjorie Gale on the new Bedrock Geologic Map of Vermont. After the presentations, participants had an opportunity to view drafts of maps, cross-sections, and correlation charts associated with the new map and discuss them with two of the editors (Gale and Peter Thompson).

Following the map discussions, President Rick Dunn called the Executive Committee Meeting to order. It should be noted that a quorum was not present at the meeting as only three members of the Executive Committee were in attendance. However, Stephen Howe (Treasurer, Advancement of Science and

Publishing Committees), in anticipation of his absence, did circulate information electronically to the members of the Executive Committee and this material was presented and discussed.

Steve indicates the financial condition of the Society remains sound. He did indicate that donations to the Research Grant Program are running a little behind last year's pace, although as of this date about 10% of the membership has yet to pay their 2006 dues. Steve also reported for the Publishing Committee and indicated that all went well with the new Publishing Committee structure and the printing and distribution of the newly formatted Green Mountain Geologist. Approximately 50% of the membership has chosen to receive the GMG electronically as a pdf file. The Winter 2005 GMG will be archived on the Society's website.

The status of the 2006 Summer Field Trip was discussed but not resolved. Members of the Executive Committee will be contacting potential leaders and it is hoped that an announcement will be made on the trip in the Spring GMG (to be published in mid-April). A Summer edition of the GMG is planned and will contain a description and road log of the Summer Field Trip, the annual membership directory, results of the Spring Meeting student awards, minutes from the Spring Executive Committee Meeting, and the State Geologist's Report. The Fall Field Trip appears to be set, with Adam Schoonmaker leading a trip to the Highgate Falls Gorge and vicinity (this trip was cancelled last fall due to high water).

The Committee discussed continuing the VGS Lecturer program. Rick Dunn's tenure as last year's VGS Lecturer was very successful and the Committee discussed several possibilities for the next lecturer. There was also discussion on how to better publicize the program and the availability of a lecturer, perhaps by e-mail announcements to colleges and high school science teachers. This discussion will be continued electronically with the full Executive Committee and potential speakers will be contacted.

Marjie Gale requested that the Vermont Geological Society consider playing a larger role in this year's Earth Science Week (October 8-14, 2006). OMYA will again be handling all aspects of the student posters, in addition to hosting its annual open house at the Middlebury Quarry. The Vermont Geological Survey will also play a role in the week's activities (details to be provided in the Fall GMG). The Committee briefly discussed having the Fall Field Trip coincide with Earth Science week, but this is a bit earlier than normal for this trip and potential conflicts will need to be addressed. It was agreed that one or more VGS members will need to "take the lead" on this and the topic would be discussed further at the Spring Meeting.

The Committee briefly discussed VGS officer nominations for the fall. Both Rick Dunn and George Springston agreed to hold their offices for an additional year if the Nominating Committee were to make that recommendation. This topic will be discussed further at the Spring Meeting.

Finally, the Committee discussed whether the Vermont Geological Society should officially endorse the Geological Society of America's statement on evolution. This statement is posted on GSA's website. This topic will also be discussed further at the Spring Meeting when hopefully a quorum of Executive Committee members will be present. The meeting was adjourned.

Respectfully submitted,
David West, Secretary

TREASURER'S REPORT

The financial condition of the Society continues to be very strong. As of March 24, 2006, the Society's checking account balance was $5,258.85. To my knowledge, there are no outstanding bills.

The following members have been approved for membership in the Society since the last report: Matthew Guerino, Saint Albans, VT; Andrew McIntosh, Middlebury, VT; and Brendan O'Shea, Franklin, VT.

Respectfully submitted,
Stephen S. Howe, Treasurer

ADVANCEMENT OF SCIENCE COMMITTEE REPORT

The Society's Winter Meeting, with its "mineral resource" theme, was well attended and informative. An additional highlight of the Meeting was the presentation by Marjorie Gale about the progress being made on the new Bedrock Geologic Map of Vermont. As always, members are encouraged to contact me with any suggestions they may have for topics or presenters for next year's meeting.

The Committee received one application to the Society's Research Grant Program by the deadline of April 1, 2006. Applications for the second round are due October 1, 2006. Please see the Society's website for details.

The Committee gratefully acknowledges the contributions to the Society's Research Grant Program by the following members:

Laurence R. Becker
E. Stanley Corneille, Jr.
Jeanne C. Detenbeck
Albert W. Gilbert, Jr.
Barbara L. Hennig
Jefferson P. Hoffer
Jon Kim
Carl Koteff
Frederick D. Larsen
Alexis P. Nason
George Springston
Sharon Strassner
Peter J. and Thelma B. Thompson
Roger and Terry Thompson
David West
Stephen F. Wright

Respectfully submitted,
Stephen S. Howe, Chair

VERMONT STATE GEOLOGIST'S REPORT

Testimony before the U.S. Senate and Vermont Legislature

The State Geologist testified for Vermont in Washington, D.C. on March 30, 2006 before the U.S. Senate Energy and Natural Resources Subcommittee on Water and Power chaired by Senator Lisa Murkowski of Alaska. S.2054 submitted by Senator Jeffords is to perform a "Vermont Water Resources Study." The United States Geological Survey (USGS) also testified concerning the bill that calls for USGS participation in coordination with Vermont. The State Geologist testified that both the Vermont Geological Survey and the USGS would bring expertise necessary to perform the proposed study that focuses on groundwater. On April 7th, in the Vermont Senate Natural Resources Committee, the State Geologist spoke of the congressional testimony to indicate that a provision that passed the Vermont House in a groundwater bill (H294) is already underway that seeks USGS cooperation.

The Jeffords bill directs the USGS in coordination with the State of Vermont to conduct a study of water resources in Vermont with an emphasis on groundwater. The focus is on aquifers, availability, existing and potential future supplies, potability, potential recharge, and the interaction of groundwater with surface water. A component of the study is the characterization of surface and bedrock geology, including the effect of that geology on groundwater yield and quality.

The State Geologist testified that the reasons to conduct the study are that sixty-six percent of Vermont's population depends on groundwater for their drinking water supply including municipalities, fire districts, agricultural, industrial, and commercial users, and homeowners. Fisheries habitat is supported by groundwater discharge to surface waters. For future supplies, the State has little knowledge of the location of potential high yield aquifers. Natural contamination in well water from uranium, radium, and arsenic that exceeds public health standards has also been an issue in a number of geologic settings in Vermont. Information on where the contaminants can be found is needed statewide. Vermont has seen well interference problems in tight geologic formations made worse by periods of drought. These areas need characterization. Resource vulnerability can vary depending on the nature of the geology overlying groundwater resources and this has been little characterized in relation to aquifers.

As Vermont Geological Society members we can applaud the U.S. Senate language that puts a focus on bedrock and surficial geology as it relates to groundwater. Often in groundwater studies the details of the geology, the vessel that contains the water resource, does not get the attention it deserves.

Respectfully submitted,
Laurence R. Becker, State Geologist

ANNOUNCEMENTS

STUDENT RESEARCH GRANT APPLICATIONS DUE SEPTEMBER 30, 2006

Students and secondary school teachers are encouraged to apply to the VGS Research Grant Program by September 30, 2006. Downloadable Research Grant Program Applications are available from the Society's website at www.uvm.org/vtgeologicalsociety/. For those without Internet access, forms may be obtained by writing to Stephen Howe at the Dept. of Earth and Atmospheric Sciences, University at Albany, ES-351, 1400 Washington Avenue, Albany, NY 12222-0001. Tel: (518) 442-5053; e-mail: showe@albany.edu

COMMUNICATIONS DIFFICULTIES WITH AOL E-MAIL ADDRESSES

The Society wishes to alert VGS members that Stephen Howe, who normally sends out all Society e-mail correspondence, is presently unable to communicate with those members having AOL e-mail addresses. Until further notice, Kathleen Howe will send pertinent e-mail notices to AOL members instead. We remind all members to also check the Society's website frequently for updated calendar announcements.

VERMONT GEOLOGICAL SOCIETY CALENDAR

4/29/06	Spring Meeting, Middlebury College
Summer 06	VGS Summer Field Trip
Fall 06	VGS Fall Field Trip and Annual Meeting
9/29-10/1/06	NEIGC 98th Annual Meeting, Rangely, Maine
9/30/06	Student Research Grant Program Applications due
10/6-8/06	NYSGA Annual Meeting, Buffalo, New York
10/22-25/06	GSA Annual Meeting and Exhibition, Philadelphia
10/30-11/4/06	AEG Annual Meeting, Boston

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Saint Albans, VT 05478-1224

ADDRESS CHANGE?
Please send it to the Treasurer at the above address

Vermont Geological Society
Spring Meeting
April 29, 2006, 8:30 AM
McCardell Bicentennial Hall, Room 220
Middlebury College, Middlebury, Vermont

Directions to Middlebury College:

From the town green in Middlebury, take Route 125 west, past the Catholic Church, and up the hill through the College. Go over the crest to the bottom of the hill as it flattens to a valley. Turn right onto Bicentennial Drive and follow the winding driveway to the large parking lot on the west side of McCardell Bicentennial Hall. The meeting will be held in Room 220.