



# THE GREEN MOUNTAIN GEOLOGIST

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## VERMONT GEOLOGICAL SOCIETY SPRING MEETING Presentation of Student Papers

April 20, 2002, 8:30 AM  
Middlebury College

### TABLE OF CONTENTS

SPRING MEETING PROGRAM .....	2
STUDENT ABSTRACTS.....	4
PRESIDENT'S LETTER .....	20
EXECUTIVE COMMITTEE MEETING MINUTES.....	21
DIRECTIONS TO SPRING MEETING .....	22
STATE GEOLOGIST'S REPORT .....	22
VGS TREASURER'S REPORT .....	23

**THE GREEN MOUNTAIN GEOLOGIST**  
 VERMONT GEOLOGICAL SOCIETY  
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**SPRING MEETING PROGRAM****VERMONT GEOLOGICAL SOCIETY**

**Annual Presentation of Student Papers  
Bicentennial Hall, Room 220  
Middlebury College, Middlebury, Vermont**

**April 20, 2002**

**8:30 AM**

8:30 Coffee

9:00 Susan Ludwick, Middlebury College: THE MERTZ DRIFT: A PALEOENVIRONMENTAL ARCHIVE IN EAST ANTARCTICA

9:15 Holly Carlson, Middlebury College: QUANTITATIVE XRD ANALYSIS AS A MEANS OF DETERMINING LAST GLACIAL MAXIMUM ICE FLOW DIRECTION IN VERMONT

9:30 Bradley Corr, Middlebury College: SOURCE IDENTIFICATION OF THE STARKSBORO RADIONUCLIDE ANOMALY: A FIELD, GEOCHEMICAL AND PETROGRAPHIC STUDY OF ANOMALOUSLY HIGH RADON LEVELS

9:45 Dayna Adelman, University of Vermont: AN ANALYSIS OF AN EIGHTEEN YEAR RECORD OF CARBON AND OXYGEN ISOTOPE RATIOS IN MONTASTREA ANNULARIS, ROATAN, BAY ISLANDS, HONDURAS

10:00 Alysa Snyder, University of Vermont: TRACE ELEMENT ANALYSIS OF STREAM SEDIMENTS AND THEIR RELATIONSHIP TO BEDROCK GEOLOGY, ROATAN, BAY ISLANDS, HONDURAS

10:15 Dana Drummond, Middlebury College: CHEMICAL WEATHERING OF THE EAST DOVER ULTRAMAFIC BODY, EAST DOVER, VERMONT

10:30 Parham P. Gardner, Middlebury College: GEOCHEMISTRY AND PETROLOGY OF A SERPENTINIZED ULTRAMAFIC UNIT IN EAST DOVER, VERMONT

10:45 BREAK

11:00 Jeff Polubinski, Middlebury College: A GEOCHEMICAL ANALYSIS OF GREENSTONES IN THE PINNACLE, UNDERHILL AND HAZENS NOTCH FORMATIONS NEAR BOLTON, VERMONT

11:15 Heather Beal, Middlebury College: A PETROLOGIC AND MICROSTRUCTURAL STUDY OF THE SCARBORO FORMATION, CASCO BAY SEQUENCE, SOUTH-CENTRAL MAINE

11:30 Nathan Toke, University of Vermont: TECTONICS AND TOPOGRAPHY: SOME NEW RELATIONSHIPS IDENTIFIED ALONG THE ALPINE FAULT IN NEW ZEALAND

11:45 Ben Cichanowski, University of Vermont: ISOTOPIC AND ELEMENTAL COMPOSITION OF LAKE BIOTA AND RECENT SEDIMENTS: A REGIONAL COMPARISON

12:00 Fred Coriell, Middlebury College: RECONSTRUCTION OF A PALEOFLOOD CHRONOLOGY FOR THE MIDDLEBURY RIVER GORGE USING TREE SCARS AS FLOOD STAGE INDICATORS

12:15 LUNCH BREAK

1:00 Anna Cotton, Middlebury College: STRATIGRAPHY AND SEDIMENTOLOGY OF A PARAGLACIAL FAN NEAR HANCOCK, VERMONT

1:15 Angela Rogers, University of Vermont: THE IMPORTANCE OF HAZARD MAPS IN THE THIRD BRANCH OF THE WHITE RIVER VALLEY, CENTRAL VERMONT

1:30 Jamie Laidlaw, Middlebury College: A MID TO LATE HOLOCENE RECORD OF FIRE FREQUENCY FOR THE NORTHWESTERN UINTA MOUNTAINS INTERPRETED FROM CHARRED PLANT REMAINS IN LACUSTRINE SEDIMENTS

1:45 Christopher Q. Kautz, Middlebury College: THE MINERALOGICAL RECORD OF EOCENE/OLIGOCENE CLIMATE CHANGE IN THE JOHN DAY FORMATION, CENTRAL OREGON

2:00 Robyn C. Cook, Middlebury College: DIFFERENTIATION OF TWO QUATERNARY MT. HOOD LAHARS BY CLAY MINERALOGICAL, QUANTITATIVE X-RAY DIFFRACTION AND PARTICLE SIZE ANALYSES

### STUDENT ABSTRACTS

#### THE MERTZ DRIFT: A PALEOENVIRONMENTAL ARCHIVE IN EAST ANTARCTICA

Susan Ludwick, Geology Department, Middlebury College, Middlebury, VT 05753

The Mertz Drift, located in the Mertz-Ninnis Trough of East Antarctica, is an area of high sedimentation and contains a high-resolution sedimentary record of paleoclimatic variability (Harris et al., 2001). This record was expanded during East Antarctic Cruise NBP0101, February 2001, when two Jumbo Piston Cores (JPC10, JPC11—21.24m and 23.98m respectively) were obtained from the drift. Physical property data was collected, along with p-wave velocity, electrical resistivity, and magnetic susceptibility data at 5cm intervals for each core. P-wave velocity and bulk density were used to generate synthetic seismograms to compare between sediment cores and PDR records. Grain size analysis, using the Malvern MastersizerE<sup>®</sup>, was conducted on 397 samples from JPC10, containing an expanded sediment record, and on 224 samples from JPC-11, containing a more condensed record with 1.06m of diamicton at the base.

These sites, verified by radiocarbon dating, contain a record of Holocene climate change. At approximately 5000 yrs BP (between 1500-1750cm core depth), there is a change in sedimentation rate for both cores. This corresponds to a lithology change from laminated and water saturated oozes to silty/muddy diatom oozes, according to electrical resistivity classifications created by Burgdorff (2002). This

change in deposition is reflected in the physical properties of electrical resistivity, porosity, and voids ratio.

JPC11 (sampled in a condensed stratigraphic section) recovered diamicton. The diamicton is the transition facies from ice-covered to open-marine conditions. Open marine conditions were sampled throughout JPC10. Spectral analyses of grain size, magnetic susceptibility, electrical resistivity and density all show variability indicating paleoproductivity trends. Paleoclimatic shifts are documented and a climate model is proposed to explain the variations in data, along with a proposed forcing mechanism for climate shifts.

#### QUANTITATIVE XRD ANALYSIS AS A MEANS OF DETERMINING LAST GLACIAL MAXIMUM ICE FLOW DIRECTION IN VERMONT

Holly Carlson, Geology Department, Middlebury College, Middlebury VT

Quantitative X-ray diffraction (QXRD) was used to examine directions of glacial ice flow for the late Wisconsinan advance, and to test Stewart and MacClintock's (1970) model suggesting a glacial advance derived from the northeast. Data from QXRD analysis from localities across Vermont universally indicate NW to SE ice flow and provide no evidence for a northeasterly advance. Till SE of the k-feldspar-rich Barre Granite contains 14.8% k-feldspar whereas till to the SW averaged just 2.5% and contained no k-feldspar at 1 m depth, clearly indicating glacial advance from NW to SE. A similar trend was observed near serpentine-rich ultramafic rocks in East Dover (southern Vermont), where serpentine was detected in elevated concentrations (5 - 10%) S SE of the serpentine-bearing outcrop, while only in trace amounts (<2%) were detected to the SW. In west-central Vermont, kaolinite is clearly detectable in the clay fraction of tills to the SE of the kaolinite-rich Brandon Residual Formation, but in the same area only traces magnetite are detected SW of the magnetite-rich Pinney Hollow Formation. Lastly, no k-feldspar was detected in pits SW of the k-feldspar-rich granitic plutons in the Northeast-Kingdom, suggesting no advance from NE to SW.

Three two-till sequences were also analyzed. These tills consist of oxidized sandy till over unweathered gray-green clay-rich till, and have been previously interpreted as indicative of ice advance from

both NE and NW. However, QXRD analysis reveals nearly identical mineralogical compositions between upper and lower tills in each case, suggesting both were derived from the same location. Oxidized till over unweathered till suggests that the two-till sequences may be lodgement overlain by ablation till.

QXRD analyses strongly suggest late Wisconsinan glacial ice advanced over Vermont from NW-SE. These results provide no evidence to support Stewart and MacClintock's (1969) claim of a NE-derived glacial advance and are supported by boulder train and indicator fan data as well as the predominant orientation of striations. The pattern of sediment redistribution by glacial action has implications for acid-buffering capacities of soils, potential identification of metals that could become environmentally available through weathering, and varying aquifer potential between various glacial till deposits.

SOURCE IDENTIFICATION OF THE STARKSBORO  
RADIONUCLIDE ANOMALY: A FIELD, GEOCHEMICAL, AND  
PETROGRAPHIC STUDY OF ANOMALOUSLY HIGH RADON  
LEVELS

Bradley Corr, Geology Department, Middlebury College, Middlebury, VT, 05753

Radon is a naturally occurring radioactive gas that forms through the decay of uranium and thorium isotopes. Airborne radionuclide studies focused on locating uranium deposits were conducted in the northeastern United States in the 1970's and early 1980's. These studies revealed an approximately 10 square kilometer anomaly near Starksboro, Vermont, but no field work or sampling has ever been conducted in the area to more precisely locate the source of the anomaly. A combination of field, petrologic, and geochemical studies were employed in this study to identify the source and impact of the radionuclide anomaly on the local community.

Gamma ray spectroscopic measurements conducted along a series of perpendicular to strike traverses within the anomalous zone revealed elevated radionuclide values associated with a highly foliated, phyllitic member of the Cheshire Quartzite. Uranium counts ranging from 15 to 27 ppm characterize this unit, while surrounding rocks have values that range from 1 to 12 ppm. Petrographic analysis of samples

collected from the phyllite unit reveal: (1) the presence of small amounts (< 1%) of uranium-bearing detrital minerals such as zircon and apatite, and (2) textures indicative of high ductile shear strain. Whole rock geochemical analysis of the highly strained phyllite unit is forthcoming, as are results of groundwater sampling in the field area. It is hypothesized that uranium-bearing minerals were concentrated in the phyllite unit during high-strain ductile deformation. The weak properties of the fine-grained foliation planes in this unit make them more susceptible to weathering and results in greater permeability. Radon, being an inert gas, is then easily transported along these foliation planes. It is believed the combination of small amounts of detrital uranium-bearing minerals, high degrees of ductile deformation, and greater permeability in this phyllitic member of the Cheshire Quartzite explain the observed radionuclide anomaly.

AN ANALYSIS OF AN EIGHTEEN YEAR RECORD OF CARBON  
AND OXYGEN ISOTOPE RATIOS IN MONTASTREA ANNULARIS,  
ROATAN, BAY ISLANDS, HONDURAS

Dayna Adelman, Department of Geology, University of Vermont, Burlington, VT 05405

A sample of the reef-building scleractinian coral *Montastrea annularis* from Roatan, Bay Islands, Honduras, was analyzed for variation in the carbon and oxygen isotopes. Variation in these stable isotopes can be used to identify changes in temperature and salinity. The sample site, Gibson Bight, is located in a partially enclosed bay on a portion of the island which is experiencing rapid land use change. Ocean water exchange is limited, and much of the water affecting the reef is susceptible to anthropogenic influences. Rosenheim (1999) examined a shorter record of oxygen isotope values for coral collected around Roatan. He suggested that these data reflected freshwater dilution and attributed it to land use change.

The coral head in this study was slabbed, X-rayed and eighteen annual growth bands identified. From each growth band we collected multiple samples of  $\text{CaCO}_3$  and analyzed this material in the mass spectrophotometer. After statistical analysis of the data I found no correlation between carbon and oxygen isotopic composition. There does not appear to be a trend in oxygen isotope fractionation; carbon

isotope values vary widely due to the complexity of carbon fixing mechanisms in coral.

#### TRACE ELEMENT ANALYSIS OF STREAM SEDIMENTS AND THEIR RELATIONSHIP TO BEDROCK GEOLOGY, ROATAN, BAY ISLANDS, HONDURAS

Alysa Snyder, Department of Geology, University of Vermont, Burlington, VT 05405

The distribution of trace elements within fluvial sediment has been shown to be an effective way of identifying source area in a watershed. The small island of Roatan (Bay Islands, Honduras) is experiencing increased terrigenous runoff as a result of changing land use patterns. The approximately 160km<sup>2</sup> island has over 80 small watersheds. Analysis of the sediment currently being deposited on the reef around Roatan indicates that some terrigenous sediment is making its way across the lagoon to the reef. I analyzed the trace element composition of bedload sediment from stream channels around the island in order to determine if it differed and was related to the gross bedrock composition. If the trace elements do reflect difference in the bedrock geology, then this technique might be an effective way to correlate the sediment composition to a specific watershed. Eleven samples were collected and sieved for grain size and the fine silt and clay fraction was subsequently analyzed for 14 trace elements on an ICP. Statistical analysis was then used to see if significant differences exist between samples.

#### CHEMICAL WEATHERING OF THE EAST DOVER ULTRAMAFIC BODY, EAST DOVER, VERMONT

Dana Drummond, Geology Department, Middlebury College, Middlebury, VT 05753

The East Dover Ultramafic Body is an ophiolite sequence that is believed to have been emplaced during the Taconic Orogeny and later metamorphosed during the Acadian orogeny (Hoffman and Walker, 1978). The soils and hydrosphere surrounding ophiolites are at a high risk of becoming enriched in trace metals such as Ni, Cr and Co due to the chemical weathering of the rock and subsequent release of these metals (Ryan, 2000). Ten rock samples with both fresh and weathered components were collected along a roadside outcrop in East Dover, VT

for analysis. Stream water and sediment was collected from 10 sites on several nearby streams that begin above and crosscut through the body.

A combination of ICAP, XRD and optical microscopic analysis has been done on highly weathered rinds, fresh ultramafics, stream sediment and surface water to determine trace metal concentrations in this area. Both Ni and Cr concentrations remain at a constant 1:1 ratio for both fresh rock and weathered rock in 3 of the rock samples. A ratio of 1:3 between the fresh rock and the weathered rock occurs in the other 2 rock samples analyzed. The fresh rock samples (at each location) are nearly identical in chemical but not in mineralogical composition, which has resulted in different weathering patterns.

Analysis of the sediment shows a Ni:Cr ratio of 1:3. This may be the result of the different resistances to weathering that the minerals in which these metals are found. Cr is limited to the stable chrome spinel mineral, while Ni is found in the unstable olivine mineral. Solubility of each of these metal ions differs as well. The pH of the surface water sampled was 7.1-7.3, a level that allows Ni to enter solution but is too high for Cr to enter solution (Faure, 1998). For these reasons it is likely that Cr will be found at a constant concentration and not be mobile, while Ni will be found in decreasing concentrations along the weathering process and will be fairly mobile.

#### GEOCHEMISTRY AND PETROLOGY OF A SERPENTINIZED ULTRAMAFIC UNIT IN EAST DOVER VERMONT

Parham P. Gardner, Geology Department, Middlebury College, Middlebury, VT 05753

The texture and geochemistry of ultramafic rocks exposed at the Earth's surface can be used to distinguish their origin as either magmatic or tectonic. Tectonite ultramafics can be indisputably linked to ophiolite sequences and are interpreted as uplifted sections of the upper mantle, while cumulate ultramafics are interpreted as either part of an ophiolite sequence or as the lower "strata" of a layered intrusion.

Preliminary investigation of the petrology and geochemistry of the East Dover ultramafic unit in south central Vermont indicates that the serpentinitized dunitic body formed as residual mantle emplaced

tectonically, rather than ultramafic cumulate formed by a magmatic intrusion. The East Dover ultramafic body consists of serpentine surrounding islands of olivine, with accessory chrome spinel, and minor pyroxene and secondary calcite. Plots of  $Al_2O_3$  vs.  $TiO_2$  for the East Dover ultramafic body classify it within the dunite field. Because chrome spinels from throughout the unit contain  $Cr\# [(Cr)/(Cr+Al)] > 0.60$ , the rock can be classified according to Dick and Bullen (1984), as a Type III Alpine-Type peridotite. A mantle origin is widely accepted for Type III Alpine-Type peridotites (Dick and Bullen, 1984). Additional support for the interpretation of the East Dover ultramafic unit as a fragment of uplifted residual mantle is provided by compositional data from olivine and chrome spinel, using Ni (~2200-2700 ppm) vs. %Fo (~88-96%) in olivine grains (Leblanc, 1984), and Cr-Al-Fe+3 in chrome spinels (Barnes, 2001).

The interpretation of the East Dover ultramafic unit as the mantle tectonite section of an ophiolite sequence suggests that it can be correlated with the ophiolites and fragments thereof in northern Vermont, Quebec and Newfoundland.

#### A GEOCHEMICAL ANALYSIS OF GREENSTONES IN THE PINNACLE, UNDERHILL AND HAZENS NOTCH FORMATIONS NEAR BOLTON, VERMONT

Jeff Polubinski, Geology Department, Middlebury College, Middlebury, VT 05753

In spite of low-grade metamorphism during the Taconic Orogeny, metavolcanic units in the Pinnacle, Underhill and Hazens Notch formations of Vermont can be sorted by their chemistry. Furthermore, major and trace element geochemistry can be used to fingerprint their tectonic environment of formation. The metavolcanics occur as greenstone bodies interlayered with metasedimentary rocks formed in the Proterozoic to the Cambrian. The sedimentary units are generally schists, graywackes and phyllites while the metavolcanic units appear as epidote or albite-rich greenstones. In thin section, the epidote-rich greenstones typically consist of 60% epidote, 10% quartz, 10% plagioclase feldspar and 10% chlorite with minor inclusions of sphene, calcite, muscovite, biotite and magnetite. The albite-rich greenstones typically comprised of 30% chlorite, 30% plagioclase feldspar, 15%

quartz, and 10% sphene, with minor inclusions of calcite, muscovite, magnetite, epidote, and biotite.

Geochemically, the greenstones are characterized as transitional (alkaline to tholeiitic) basalts as shown by Al/Si versus Fe+Ca+Mg and Zr versus  $P_2O_5$  discriminant diagrams. Tectonic discriminant diagrams such as the Ti-Zr-Y diagram designate these greenstones as within plate basalts. These results fit in most regularly with other greenstones from the Underhill and Hazens Notch formations (Geochemical Zones 2 and 3 (Coish et al., 1991)), which have been characterized as basalts formed during the early and intermediate stages of continental rifting. At one site, the geochemical data of an apparent greenstone is highly variable and inconsistent with other greenstones in the area. This unit is interpreted as either a highly metasomatised volcanic rock or a volcanoclastic unit. The results from most greenstones in this study support the hypothesis that they were basalts formed in a rift valley during the break-up of the Laurentian continent and the subsequent formation of the Iapetus Ocean in the Late Proterozoic and Early Cambrian.

#### A PETROLOGIC AND MICROSTRUCTURAL STUDY OF THE SCARBORO FORMATION, CASCO BAY SEQUENCE, SOUTH-CENTRAL MAINE

Heather M. Beal, Department of Geology, Middlebury College, Middlebury, Vermont 05753

Ordovician rocks of the Liberty-Orrington belt in south-central Maine are flanked by younger rocks to the southeast (Fredericton belt) and northwest (central Maine belt) and thus occupy an important structural position in the region. This study focuses on detailed petrologic and microstructural analyses of Middle Ordovician (?) metapelitic rocks of the Scarboro Formation (upper part of the Casco Bay sequence) exposed within the Liberty-Orrington Belt. At least two phases of deformation are observed in these rocks: (1) An early phase of upright isoclinal folding with an associated axial planar foliation that trends N10-25 degrees E and dips steeply (> 60 degrees) to the southeast. (2) A later phase (based on cross-cutting relationships) of dextral shear deformational features.

Metamorphic mineral assemblages in these rocks indicate low-pressure metamorphism (< Al<sub>2</sub>SiO<sub>5</sub> triple point conditions) at lower sillimanite grade conditions. Typical AFM mineral assemblages in these rocks include garnet, biotite, andalusite and sillimanite. Local variations in bulk composition result in the presence of staurolite (Fe-rich) and cordierite (Mg-rich) porphyroblasts in some samples. Compositional data from garnets indicate high manganese concentrations (up to 30 mole % in cores) and patterns typical of growth zoning. Previously published Ar-Ar hornblende ages provide a Middle Devonian age for the timing of this metamorphism.

Microstructural analysis of porphyroblast-matrix relationships in these rocks provide information on the timing of metamorphic mineral growth relative to the deformational fabrics in the rocks. Complex, locally spiraled inclusion trails in garnet porphyroblasts are generally discordant to the matrix foliation. Caution should be taken in interpreting such relationships, but it is suggestive of growth during a deformational episode that preceded the development of the matrix foliation. Andalusite and staurolite porphyroblasts are often syntectonic with respect to the external foliation, although examples of post-tectonic growth can be found. This external foliation is parallel to the axial surfaces of upright isoclinal folds and thus peak metamorphic mineral growth appears to have been synchronous with this deformational episode. Localized, late dextral shear deformation of all porphyroblasts often accompanied by chlorite growth indicates this phase of deformation occurred after peak metamorphism (Middle Devonian).

**TECTONICS AND TOPOGRAPHY: SOME NEW RELATIONSHIPS IDENTIFIED ALONG THE ALPINE FAULT IN NEW ZEALAND**  
Nathan Toke, Dept. of Geology, University of Vermont, Burlington, VT 05405

Digital Elevation Map (DEM) imaging of the Fiordland Belt in Southwestern New Zealand shows unusual, asymmetric topographic features characterized by extremely high slopes (up to 87°) and deeply incised river networks. This mountain range is bounded on all sides by strike-slip and oblique-slip faults that form restraining bends east (outboard) of the present-day trace of the Australian-Pacific transform plate boundary. The western edge the range is characterized by

average and maximum elevations of 468 meters and 1467 meters, respectively. In contrast, the eastern side of the range is over 300 meters higher in both average and maximum elevations than the western side. This asymmetry contrasts with that exhibited by the rest of the Southern Alps in New Zealand where there is typically a steep, erosion-controlled, western edge with a gently eastward sloping outboard plateau.

Even more unusual, Fiordland contains a large, 2000 km<sup>2</sup> diamond-shaped topographic uplift in the northernmost part of the mountain range. The uplift mostly has slopes of 45° to 65°, with some reaching up to 87°. This uplift rises 300 to 1100 meters above the surrounding topography of Fiordland and ranges in elevation from 1877 to 2699 meters. The average elevation of the uplift is approximately 900 meters with the greatest elevations on the eastern side adjacent to curved traces of the Darran and Hollyford faults. These two oblique-slip faults from splays of the modern transform plate boundary. The eastern side of this uplift has an average elevation of nearly 1200 meters and contains the highest peaks in the region at 2699 meters. I have determined that the highest slopes and greatest elevations of this region coincide with the maximum curvature of the faults where they merge into the transform plate boundary. Our DEM and fault data indicate that a transpressional style of deformation in the region between the strike-slip faults is responsible for 300-1100 meters of uplift above the rest of the Fiordland range. These features illustrate the important role of strike-slip and oblique-slip tectonics in creating and modifying mountain topography.

**ISOTOPIC AND ELEMENTAL COMPOSITION OF LAKE BIOTA AND RECENT SEDIMENTS: A REGIONAL COMPARISON**  
Ben Cichanowski, Geology Department, University Of Vermont

Since first settlement in the northern New England region, both cultural and natural impacts have greatly influenced the trophic and chemical status of many lake ecosystems. Entire lake ecosystems are no longer nutrient balanced, many have become eutrophic, while some have become hypertrophic. Being able to quantify the level of deterioration using relatively simple chemical indicators such as stable isotopes of carbon and elemental ratios (e.g., C/N ratios) would be invaluable in determining type and scale of remediation measures. The

correlation between isotopic composition and productivity levels can also be used in studies of recent sediments to monitor the response of these lake ecosystems to documented increases and/or decreases in nutrient loads.

Lake sediments provide natural archives that record the response of the Earth's biota to environmental perturbations from the local to the global scale. Organic remains preserved in lacustrine sediments allow us to reconstruct the environmental histories of lakes and their watersheds because they reflect the biological communities found in and around lakes.

In summer 2001 samples of land and aquatic plants, and short (25-50 cm) sediment cores were collected from three NH lakes: South Pond, Crystal Lake, and Stinson Lake. These samples have been analyzed for C isotopic composition using the Department's stable isotope mass spectrometer. In addition, %C, %N, and C/N for each sample were determined using an Elemental Analyzer. The data collected so far has offered trends suggesting an up-core increase in algal remains in the sediments, possibly suggesting moderate eutrophication. The results of this study will be compared to similar data collected for numerous VT lakes as part of two previous undergraduate theses and one graduate thesis. A compilation of records from numerous lakes will give insight into the broader scale response of ecosystems to environmental change.

#### RECONSTRUCTION OF A PALEOFLOOD CHRONOLGY FOR THE MIDDLEBURY RIVER GORGE USING TREE SCARS AS FLOOD STAGE INDICATORS

Fred Coriell, Geology Department, Middlebury College, Middlebury, Vermont

Botanical evidence is commonly used in order to determine the stage past flood events. Most of these studies have been concerned with tree ring intervals, which depict years of high and low water. However, there has been little work done correlating flood frequency with flood magnitude on streams not gauged by the United States Geologic Survey. One must be a bit creative when trying to make this correlation on such streams. One feature that can both date and help determine discharge of a flood is the tree scar. This is direct evidence of the flood recording its year, its stage, and thus its magnitude.

The study site was the Middlebury River in East Middlebury, VT. Dates of scars were determined by using an increment borer. Seventeen scarred trees were sampled. Channel cross-sections were measured at seven different scars randomly selected throughout the study area in order to calculate discharge. Due to the nature of the river it would have been impossible to get cross sections at all scar locations. Manning's equation for stream discharge was used to make these calculations. The slope coefficient for the equation was determined as the average slope over the study area. The n coefficient was determined from USGS examples posted on their website. Data showed several instances in flooding over the last half century with past discharges ranging from 107 m<sup>3</sup>/sec to 366 m<sup>3</sup>/sec. These values show similarities with high water years over the last half-century on the Otter Creek, a USGS gauged stream in the same drainage basin. Actual flood years for the Middlebury River are still pending upon completion of tree ring analysis.

#### STRATIGRAPHY AND SEDIMENTOLOGY OF A PARAGLACIAL FAN NEAR HANCOCK, VERMONT

Anna Cotton, Geology Department, Middlebury College, Middlebury, VT 05753

The Bowen Fan is an anomalously large alluvial fan in the Third Branch of the White River Valley. This project involved investigation of the sedimentology, size, and physical characteristics of the Bowen Fan in an attempt to determine the processes responsible for its formation, and its anomalous size.

The internal stratigraphy of the Bowen Fan was studied in a large borrow pit excavated in the fan by the Bowen family. Interbedded coarse debris flow and finer fluvial deposits indicate that the fan formed through a combination of sedimentary mechanisms. Particle size distributions were determined for each major horizon through dry sieving (>0.063 mm). A Coulter counter was used to determine the particle size distribution for finer fractions. Age control for fan formation was provided by a core from the oldest living tree on the fan, and AMS radiocarbon dates on organic fragments recovered from 240 cm, 288 cm and 540 cm depths in the borrow pit. Based on historical reports, the presence of trees on the fan surface, and the



extent of incision of the modern stream, there has been no activity on the fan for at least 60 years

The working hypothesis is that the Bowen Fan is a paraglacial fan that formed soon after retreat of the Laurentide Ice Sheet from Vermont. At this time, large volumes of unconsolidated glacial sediment would have been available for transport from the unvegetated slopes in the fan catchment. This scenario explains the discordant size and volume of the fan relative to other fans in the White River Valley. To further evaluate this theory, a GIS analysis of fan volume and drainage basin area was completed for nineteen alluvial fans along the White River Valley, north and south of the Bowen Fan. This analysis revealed that within the total population of fans in the valley, there is a subset of paraglacial fans (including the Bowen Fan) that have extremely large volumes relative to their drainage basin area. These fans contrast strongly with the subset of smaller fans, many of which have been active during the post-settlement period.

#### THE IMPORTANCE OF HAZARD MAPS IN THE THIRD BRANCH OF THE WHITE RIVER VALLEY, CENTRAL VERMONT

Angela Rogers, University of Vermont, Burlington, VT

The Third Branch of the White River, which flows southerly from Roxbury to Bethel, Vermont, was assessed during the summer of 2001. The assessment involved examining the geomorphology and habitat of the mainstream and the tributaries. One component of the assessment involved determining areas of the stream that are undergoing degradation, aggradation, overwidening, or changing its planform. Mass failures, alluvial fans, channel avulsions, and cut off chutes were also identified. The data collected could be used to create hazard maps, which can be used as a planning tool to reduce costly flood damage to house, roads, and bridges. The mass failures identified in the Third Branch valley can be caused by the surficial geology, where lacustrine sands or gravel overlie glacial lake silts and clay. This stratigraphy can lead to failure from hydraulic loading, especially after a heavy storm or long periods of precipitation, which can create saturated conditions. Mass failures are also caused by the river actively cutting away the bank.

Channel avulsions and cut off chutes are indicators of potential hazards, since they denote a change in the channel's planform. Channel avulsions and cut off chutes are concerns where the channel is overwidening, because the river will change its planform to achieve adequate sediment and water flow.

Alluvial fans also present potential hazards due to their stratigraphy and general nature of deposition. The sudden change in topography causes energy to be transported to lower elevations. In these areas the river forms multiple channels and potentially changes its planform. Developers and planning commissions should be aware of these hazards before they build infrastructures. Mapping mass failures, channel avulsions, cut off chutes, and alluvial fans could assist in decreasing flood damage as well as maintaining the ecosystems viability.

#### A MID TO LATE HOLOCENE RECORD OF FIRE FREQUENCY FOR THE NORTHWESTERN UINTA MOUNTAINS INTERPRETED FROM CHARRED PLANT REMAINS IN LACUSTRINE SEDIMENTS

Jamie Laidlaw, Department of Geology, Middlebury College, Middlebury VT. 05753

Charred plant remains isolated from lake sediments were quantified in an attempt to construct a middle to late Holocene fire history of the northwestern Uinta Mountains. Lily Lake (surface area 57 ha, 2710 m asl) was targeted for this study because of its location within continuous *Pinus contorta* (Lodgepole pine) forest, and its small drainage basin (615 ha), which simplifies interpretation of the charcoal record. A 171-cm long core was retrieved from the lake during February 2000 with a modified Livingston corer. Charcoal and wood found in samples 66, 149, and 171 returned AMS dates of  $1970 \pm 40$ ,  $4040 \pm 50$ , and  $4760 \pm 50$  14C BP. Calibrated into years BP, these dates yield a near linear sedimentation rate in which 1 cm represents from 20 to 50 sidereal years (mean of 32). Samples were taken every centimeter (1.3 cm<sup>3</sup> volume), disaggregated in a 5% solution of sodium hexamataphosphate for three days, and wet-sieved to 125 microns. Charcoal fragments were identified, counted, and measured under a stereoscope. Results show CHAR (charcoal accumulation rate) background levels post 3250 years BP ranging from 0.002-0.03 fragments/cm<sup>2</sup>/yr with peaks (0.04-0.39 fragments/cm<sup>2</sup>/yr)

interpreted as fire events within the basin occurring with an average frequency of 320 years. Prior to 3250 BP CHAR values were much higher with background levels ranging from 0.1-0.9 fragments/cm<sup>2</sup>/yr and peaks ranging from 28.8-223.3 fragments/cm<sup>2</sup>/yr. The average fire frequency during this period was 236 years. Our preliminary interpretation is that this period prior to 3250 BP represents a period of water drawdown in excess of 5 m. Peaks indicate fires that burned both the surrounding forest and the surface of the wet meadow, which occupied the exposed lake floor.

THE MINERALOGICAL RECORD OF EOCENE/OLIGOCENE  
CLIMATE CHANGE IN THE JOHN DAY FORMATION, CENTRAL  
OREGON

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John Day Formation paleosols formed in volcanoclastic sediment under climatic conditions that changed from humid-subtropical to sub humid-temperate across the Eocene-Oligocene boundary. In this study, we seek to take advantage of the well-constrained paleoclimatic (Retallack et al., 2000) and zeolite (Hay, 1963) records of the John Day paleosols to examine (1) the mineralogical record of climate change and (2) the effects of burial diagenesis on pedogenic minerals. XRD analyses of 85 paleosols indicate clear distinction in clay mineral content between late Eocene (39 – 34 Ma) and early Oligocene (34 – 29 Ma) paleosols. Late Eocene paleosols contain abundant kaolinite (K) and lesser kaolinite/smectite (K/S). Early Oligocene paleosols are virtually devoid of kaolin minerals and are dominated by smectite. The kaolin in the lower John Day Formation reflects intense subtropical weathering of the late Eocene. Abrupt shift to smectitic soils across the Eocene-Oligocene boundary is attributed to step-like change to cooler, more arid climates of the early Oligocene as described by Bestland et al (1997). The presence of clinoptilolite in the Turtle Cove Member (30-29 Ma) constrains pre-uplift burial depth to approximately 1000 – 2000 m, an estimate that is consistent with the folded and faulted character of the John Day Formation.

DIFFERENTIATION OF TWO QUATERNARY MT. HOOD LAHARS  
BY CLAY MINERALOGICAL, QUANTITATIVE X-RAY  
DIFFRACTION AND PARTICLE SIZE ANALYSES

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Multiple analytical methods have successfully differentiated three similar Quaternary lahar deposits on the northern flank of Mount Hood and in downstream valleys. These methods include X-ray diffraction (XRD) of clay mineral content, quantitative XRD of bulk mineral content, and laser diffraction particle size analysis (LDPSA). The best differentiators are clay and bulk mineralogy. QXRD results of bulk samples indicate that the older lahar (older than 425 Ka) contains 16-24% plagioclase feldspar and 35-65% total dioctahedral clay (predominantly halloysite), whereas the younger lahar (40 to 80 Ka) contains 36-63% plagioclase feldspar and 25-36% total dioctahedral clay (predominantly expandable smectitic-vermiculitic clay). The intermediate unit (~130Ka) consists of 33-38% clay (more weathered than smectite) and 40-43% plagioclase. At most sites, the older lahar is relatively enriched in clay and sand-sized grains as compared to the more silt-rich younger lahar. These preliminary results will prove valuable in determining the spatial variability of lahars and may be used in remote sensing mapping by providing differentiating characteristics.

Previous work by the USGS Cascade Volcano Observatory (CVO), as part of their hazard assessment program, has identified at least two distinct Quaternary lahars based on field mapping and limiting K-Ar dates. The field area encompasses roughly 200km<sup>2</sup> from the northern flanks of Mt. Hood through the Hood River valley to across the Columbia River. This work provides the impetus for our current study because of speculation raised during mapping the lahars. Since it is apparent that field identifiers are not the most reliable indication of specific units, this study was undertaken to produce quantitative data that can then be applied to more accurate mapping and hazard analysis.

## PRESIDENT'S LETTER

April 5, 2002

Dear Members:

Since the last GMG, we had a very successful winter meeting at Norwich University. On behalf of the society, I'd like to thank all the participants for very interesting presentations. I want to especially thank Dave Westerman and Norwich University for doing a fine job of hosting. There was general agreement among the executive committee that we should re-instate the winter meeting as an annual event.

Following up on a discussion at the executive meeting in Norwich, Jeff Hoffer and I composed a letter in support of the Vermont Geological Survey for this spring's round of budget negotiations in Montpelier. I sent copies to key members of finance committees in both branches of the state legislature. The executive committee felt it was important to show state legislators that the Survey is well respected and supported by the geological community in Vermont.

What's in a name? After some heated debate, the executive committee decided to look into changing the name of our society to the Geological Society of Vermont. There are two main reasons: (1) the name Vermont Geological Society (VGS) is often confused with the Vermont Geological Survey and (2) the change would bring us in line with most other state societies such as Maine and New Hampshire. Steve Howe, Christine Massey and Jeff Hoffer are looking into the logistics of such a name change. In the meantime, if you have opinions on this proposal, please contact Steve, Christine, Jeff or me.

I look forward to seeing many of you at the spring meeting in Middlebury on April 20th.

Sincerely,  
Ray Coish  
coish@middlebury.edu

## EXECUTIVE COMMITTEE MEETING MINUTES

Saturday, Feb. 16, 2002: Meeting opened by President Ray Coish at 12:15 PM. Based on the success of the Winter meeting, it was decided to reinstate the Winter meeting on an annual basis, to be hosted by Norwich University. Treas. Kristen Underwood reported the financial status of the Society remains strong. A discussion followed regarding dues. Existing members receive dues statements in the GMG with no separate mailing. It was decided to send institutional members a separate statement. The publications committee discussed the frequency of publishing the GMG, particularly the summer issue, when there is not always enough material to justify publication. It was decided to let the publications committee determine publishing frequency. Steve Howe reported that the society website will be up and running shortly. A discussion followed as to what will be posted on the web site and whether or not to include the GMG as an electronic version. A decision was made not to include the entire GMG on the website, but only certain portions, to be decided by the web site and GMG editors.

State Geologist Larry Becker spoke of upcoming budget battles over the Vermont general fund, which funds the Survey. A discussion followed regarding a potential mailing (by e-mail) to Society members to elicit support letters to legislators regarding the funding of the Survey. The committee also decided to submit letters from the Society in support of the Survey.

The possibility of changing the Society's name to the Geological Society of Vermont was discussed. Committee members considered the name change to have merit, but that the ramifications of doing so needed to be evaluated and put to a general vote of the Society if desired. Christine Massey, Steve Howe, and Jeff Hoffer were requested to evaluate the ramifications and report back to the committee and board at the Spring meeting. The New Hampshire version of the Society recently went through a name change and will be contacted for information.

Potential field trips for the summer and fall of 2002 were discussed. Possibilities mentioned included a summer field trip led by Helen Mango and a fall field trip led by Peter Thomas. Meeting was adjourned at 1:15 PM.

Respectfully submitted,  
Jeff Hoffer

## DIRECTIONS TO SPRING MEETING

Middlebury College, April 20, 2002, 8:30 am

Take Rte 125 west, past the Catholic Church, up hill through the college. Go over the crest to bottom of the hill as it flattens to a valley; turn right onto the winding driveway (may have road sign saying Bicentennial Way by April). Continue up the driveway and park in the large parking lot on the west side of Bicentennial Hall. Don't worry about the sign saying faculty and staff only. Meeting is in Bicentennial Hall, Room 220. Come in the west door from the parking lot, go up the first stairs you see to the Great Hall; room 220 is first lecture room in the south wing off the Great Hall. Coffee and donuts at 8:30; meeting begins at 9:00 am.

## STATE GEOLOGIST'S REPORT

Thanks to Letter Writers

I want to thank the Society and others who have written letters in support of the Vermont Geological Survey during these times of budget uncertainty. Your letters show that the geological community has a direct interest in a vibrant state survey that provides framework information to address a variety of geoscience problems. Whether you work in the field or just have a curiosity about the earth, state surveys are intended to meet your needs. Those outside the community are not always aware of the usefulness of the information and how it influences their lives and your letter writing brings the importance of geology to light. It matters in Vermont when a community of 150 plus members speaks with one voice about the need for our science. Thanks again for your efforts.

Sincerely,

Laurence R. Becker, State Geologist  
Vermont Geological Survey, DEC  
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Waterbury, Vermont 05671-0301  
Phone - 802-241-3496  
Fax - 802-241-3273  
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<http://www.anr.state.vt.us/geology/vgshmpg.htm>

## VGS TREASURER'S REPORT

The financial condition of the Society remains strong. The checking account balance is \$3,685.92 as of March 31, 2002. Please see the attached Income Statement. All bills received by me have been paid and are reflected in the above balance. Within the next month, letters will be sent to individuals whose memberships have lapsed for one or more years. The status of lapsed memberships has been based on the Society's most current membership and treasurer records. Please call or email if it is felt that such letters have arrived in error.  
Kristen L. Underwood, March 31, 2002

### Income and Expenses, 1/1/02 through 3/31/02

#### INCOME

Total Dues	\$893.00
Dues-Family	\$80.00
Dues-Institution	\$70.00
Dues-Member	\$735.00
Dues-Student	\$8.00
Interest	\$0.57 **
Publications (UVM Geology)	\$30.00
Credit for Lost Student Check	\$30.00
Student Research Grant Contributions	\$270.00
<b>TOTAL INCOME</b>	<b>\$1,223.57</b>

#### EXPENSES

US Post Office (stamps, GMG Distribution)	\$0.00
GMG Publishing	\$96.39
Earth Science Week Poster Awards (reissue lost check)	\$30.00
Expense Reimbursement (UVM Geology)	\$30.00
Research Grant Awards	\$0.00
Student Awards (VGS Spring Mtg)	\$0.00
<b>TOTAL EXPENSES</b>	<b>\$156.39</b>
<b>TOTAL INCOME - EXPENSES</b>	<b>\$1,067.18</b>

\*\* Does not reflect interest from February or March.

The Society gratefully acknowledges the generous contributions to the Student Research Grant funds received from the following members during the first quarter of 2002: Alexis P. Nason, John Cotton, Arthur W. Gilbert, Jr., Lawrence W. Gatto, Christine Massey, Paul Bierman, Jeff Hoffer, Cassie Major, Peter and Thelma Thompson, Sue Hadden, Barbara L. Hennig, Sharon Strassner, and Bill Norland.