

PROJECT SUMMARY

Human-Induced Landscape Change -- A Digital Image Archive Created by Students

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Human hands have changed dramatically the New England landscape over the past 250 years. Only 100 years ago, much of now-forested New England was cleared of trees as agriculture and development drove the rapid conversion of forest to farmland. The bare hills of post-colonial Vermont eroded rapidly and sediment surged down hillslopes, choking the region's rivers. Just as importantly, landscape response to natural events including floods and windstorms affected post-colonial settlers and their livelihood.

Currently, geologic archives of landscape response to climate change and human impact (pond and alluvial fans sediments) are being read by NSF CAREER-funded graduate and undergraduate students pursuing a variety of research projects at the University of Vermont. Now, we wish to integrate this funded research with the hands-on education of high school students and explore another archive, one that preserves evidence of human-induced landscape change at an instant of time.

In an integrated research and education program designed to involve high school science students and their teachers directly in active, on-going geologic research, we propose to build a digital library of photographs documenting two centuries of landscape change. Specifically, students across Vermont will compile historic photographs that show first hand, human/landscape interaction in New England including: clear-cutting, gully erosion, storm damage, and landslides. Students will scour their own community and personal resources locating images that show Vermont landscapes as they were 75 to 150 years ago. Such photographs can be found in the student's homes, in the homes of their older relatives, in local historical societies, and in local libraries.

We will work directly with teachers and their classes in 18 different Vermont high schools. Using for guidance a standards-based manual that we will develop, teachers will assist students as they find at least two historic photographs clearly showing human/landscape interaction. The students will attempt to relocate the place from which each photo was taken. The site will be mapped using hand-held GPS and the scene rephotographed using a digital camera provided by our program. The students will caption their photographs in detail using local reference sources including interviews, library research, and field observations. All images will be brought to the students' schools and scanned using NSF-funded equipment that will be loaned to each school for 6 to 8 weeks. The final result will be a pair of photographs, new and old, georeferenced and captioned by the student to explain the historic impact and the landscape response.

As each class finishes its town, our state-wide database, housed and available publicly on the Web, will grow. Created by students involved in on-going research using modern technology, this photo archive will be a digital resource for people around the world. The impact will be long-lasting in terms of both formal and informal science education. Our long-term goal is for our archive to include photographs from every town in Vermont showing human-induced geologic change -- we anticipate that such an effort will be supported by the University and local foundations interested in education reform after we develop our approach with NSF support.

We view this as a pilot project that will begin to bridge the gaps both between University research and high-school education and between history and science. Our program will involve high-school students, their teachers, University of Vermont faculty, staff, and students, and the Education Specialist for the Perkins Geology Museum at the University. Over the course of 18 months, University personnel will work intensively with students in 18 classrooms around the state. Teachers and students will continually share their findings on the web and in a culminating conference of high school teachers, students, and University scientists.

PROJECT DESCRIPTION

Results of Prior NSF Support

Bierman is currently supported by a four-year CAREER award from NSF-Hydrologic Sciences. This grant integrates research, research training, and education for Masters level and undergraduate students. The research identifies major hydrologic events during the Holocene, in particular, defining the spatial and temporal distributions of large storms over the last 10,000 years through the trenching of alluvial fans and the coring of lakes. In < 2 years, the grant has supported the research of 4 Masters candidates, provided impetus for an Advanced Geomorphology Field Class, and resulted in the 5 abstracts, 2 publications, and a thesis:

- Gran, S. Nichols, K., and Bierman, P. R., (in review). Teaching winter Geohydrology at the University of Vermont using frozen lakes and snowy mountains, **Journal of Geoscience Education**.
- Brown, S., (1999). Terrestrial sediment deposition in Ritterbush Pond: Implications for Holocene storm frequency in northern Vermont, **Geology Masters Thesis**, University of Vermont.
- Bierman, P. R. (1998). Catastrophic Results of Colonial Clearcutting, **American Association for the Advancement of Science National Meeting**, Philadelphia
- Brown, S., Bierman, P., Mehrtens, C., and Lini, A. (1998). Terrigenous layers in lake cores document fluctuations in New England's Holocene climate, **Geological Society of America Abstracts with Programs**, v.30, n. 7, A-114.
- Lini, A., Levine, S., Bierman, P., (1998). The birth of post-glacial lakes: a tale of stable isotopes, **Geological Society of America Abstracts with Programs**. v. 30, n.7, A-164.
- Bierman, P. R., Lini, A., Brown, S., Davis, P.T., and Zehfuss, P. (1997). Fans and pond sediments record concurrent episodes of hillslope erosion **Geological Society of America Abstracts with Programs**, v.29, n.7, A-411.
- Brown, S. L., Bierman, P. R., Mehrtens, C. J. and Lini, A. (1997). Episodic inputs of terrestrial sediment to a post-glacial mountain lake, **Geological Society of America Abstracts with Programs**, v.29, n. 7, A-36.
- Bierman, P., Lini, A., Davis, P.T., Southon, J., Baldwin, L., Church, A. and Zehfuss, P. (1997). Post-glacial ponds and alluvial fans: recorders of Holocene landscape history, **GSA Today**. 7 (10) p. 1-8.

In addition to the CAREER grant, Bierman has received NSF funding for several projects related to the measurement and interpretation of cosmogenic nuclide abundances in rock and sediment. These grants have supported several hundred isotopic analyses, a laboratory technician, student research, and research training of Masters students. They have resulted in the preparation and publication of 44 abstracts and 19 papers by Bierman and his students. Bierman is Co-PI with Lini on an NSF-MRI grant that brought automated Carbon/Nitrogen analysis and core logging instrumentation to the University of Vermont Stable Isotope and Lake laboratories and provided high-level GPS equipment for mapping. All of this equipment has been used extensively in support of CAREER grant field activities.

Massey directs several externally funded science education programs at the Perkins Museum of Geology, including programs for high school, middle school, and elementary school students, as well as elementary educators. The NSF provides funding for her programs for elementary educators (pre-service and in-service) and elementary students through Vermont's NSF State Systemic Initiative (SSI) grant. The Vermont Institute for Science, Math, and Technology (VISMT) administers the SSI program in Vermont and funds *Science in Vermont--Environmental Science & Technology for Elementary Educators* and the associated *Grades 1-6 Environmental Science Day Camp*.

NSF-VISMT funding has resulted in the following abstracts:

- Massey, C. A., (1997). Environmental Science and Technology Institute for Elementary Teachers and Education Majors in Vermont. **Geological Society of America--1997 National Meeting Abstracts with Programs**, 29, 6, A-301.
- Massey, C. A., (1996). Thrust faults, plankton tows, wastewater, and SEMs: Vermont Earth and Environmental Science for K-12 students and teachers. **Geological Society of America--1996 National Meeting Abstracts with Programs**, 28, 7, A-476.

Project Goals

This project has several highly inter-related goals that in their entirety will involve students at different levels directly in active research and research training, advance the state of geologic knowledge, and contribute, in the state of Vermont, to systemic change in science education (e.g., Rutherford and Ahlgren, 1990). We will:

- involve directly high school students and teachers in an extension of on-going, NSF-funded research that is gathering geologic and historic data to determine the effect of humans on the New England landscape. This research is particularly germane to the management of resources in New England as pressures to develop land and exploit timber resources increase (Zehfuss, 1996; Bierman et al., 1997; Bierman, 1998).
- create a unique, digital library of images documenting human impact on the landscape,
- train students and teachers in the use of modern technology to acquire and store images,
- provide a link between science and history at the local level, directly involving the students, their families, and communities,
- form a research and learning partnership between active University researchers (undergraduate students, graduate students, and faculty) and high school students,
- catalyze awareness, through individual student discovery of historical images, that by understanding the past we can better predict the future, and
- provide the opportunity for students to learn for themselves that human actions have distinct and significant environmental consequences.

Project Outcome and Benefits

The project will produce a unique data set of georeferenced, historic, and modern photographs of landscape change (Figure 1). This archive will be produced primarily by students and will be widely accessible through the World Wide Web. Generation of this archive will benefit different groups in different ways having a focused impact on the students and teachers in the program but much broader impact on the community at large.

Researchers -- Images collected by the students will be useful immediately to University of Vermont Geoscience researchers working under CAREER funding to understand better human-induced landscape change.

Student Summer Interns-- These interns will benefit by working closely with active University researchers and within the superb University collections of historical images.

High School Students -- The process of collecting images, working within their community, using technology, and interacting with University Scientists will enrich the educational experience and historical perspective for 350 to 450 students.

High School Teachers -- By working with this program, teachers will incorporate numerous the state education standards into their curriculum and will have unique access to technology and University expertise. The project-specific, standards-based Teacher's Manual we develop will be available for others at the close of the project.

Systemic Reform of Vermont Science Education -- Ours is part of a systemic effort to improve science learning in Vermont and to make higher education science expertise available to Vermont students and teachers.

Informal Science Education -- Images and information collected by this project will serve the wider public as they are incorporated in Perkins Geology Museum displays and accessed by anyone from our web-based digital image library.

Relevance to Program Announcement

Our proposed project is directly relevant to Element 1 (Awards to Facilitate Geoscience Education) and partially relevant to Element 2 (Digital Libraries). Specifically, our proposal involves secondary education, education outside the classroom, teacher training, and undergraduate education. It includes the following activities called out in the RFP and follows from ideas laid out in NSF97-171, Geoscience Education: A recommended Strategy:

- bringing cutting edge research to the classroom and public,
- implementation of National Science Standards (Project 2061, 1993; National Research Council, 1996),
- development of web-based pedagogy,
- opportunities for teachers to work with scientists,
- partnering for initiation of museum exhibits, and
- initiation of state-based alliances of Geoscience researchers and educators.

Relationship to On-Going Projects

The proposed project is closely tied to several existing, funded initiatives at the University of Vermont including: an NSF CAREER grant to Bierman, Perkins Geology Museum outreach activities directed by Massey, and the Statewide Systemic Initiative (SSI) for Science education reform in Vermont (VISMT).

NSF-CAREER Grant

With support from the NSF Hydrologic Sciences and EPSCoR programs, Bierman has been funded over four years to study the geologic record of New England landscape change, in particular the record of human impact and mega-storms. This CAREER grant specifically integrates graduate and undergraduate researchers and their research into the undergraduate curriculum with both strong field and web-based components. As part of this research, Bierman and his students collect lake sediments and trench alluvial fans and river terraces with backhoes (Brown, 1999; Li, 1996, Zehfuss, 1996, Brown et al., 1997, 1998). Although the grant is only in its second year, the related web page is beginning to mature. In particular, a Masters in Education student at the University of Vermont (Ms. Kristine Bryan) has developed a module on Vermont landforms, an interactive approach to communicate our research findings and methodology to the general public: (<http://geology.uvm.edu/vtlandforms/main.htm>). The web-based photo archive that will result from the project proposed here will greatly enhance the CAREER-based research by providing primary data. Conversely, students and faculty involved in CAREER -funded research will bring their expertise to the proposed high-school outreach program. CAREER funds have purchased a computer that will be used as a public web terminal in the Perkins Geology Museum.

Perkins Geology Museum Outreach

Science educational programming at the Perkins Geology Museum compliments the efforts of statewide systemic change by offering science and technology content and methods skills to students, teachers and the general public. In addition, students, teachers, and the general public rely on the Perkins Geology Museum as a resource for general Earth Science information and a source of geologic materials for educational borrowing.

The Perkins Geology Museum will act a center of operations for the proposed project, displaying student-made posters, and housing the public web terminal that contains the database of images in a permanent exhibit. Participants and the general public will have free access to the historical image database on-line at the museum as well as from any web terminal in the world. The proposed project will further the Perkins Geology Museum’s ability to provide science education resources to Vermont students and teachers.

Table 1 lists the ongoing science education activities hosted at the Perkins Geology Museum.

TABLE 1. Science Education Activities at the Perkins Geology Museum

Program Name	Program Description	Audience
<i>Governor’s Institute on Science & Technology (Summer)</i>	The Perkins Geology Museum hosts the non-profit organization, Governor’s Institutes of Vermont (GIV), during this 8-day, residential natural science program for capable and motivated Vermont high school students and high school science teachers (Lead Learners). Students design field and laboratory investigations of local geology, soils, botany, water chemistry, wildlife biology, and hydrology, and create interpretive web sites and printed materials for the public.	Grades 10-11 And Lead Learner Teachers (1 Week)
<i>Governor’s Institute on Science & Technology (Weekend Snow Studies)</i>	Faculty from the Governor’s Institute on Science & Technology Summer program introduce avalanche forecasting, snow studies, and web page creation to additional motivated high school students in a mid-winter program.	Grades 9-11 (3 days)
<i>Science in Vermont-- Environmental Science & Technology for Elementary Educators</i>	This NSF-VISMT funded program pairs elementary teachers with undergraduate education majors and provides environmental science content and standards-based curriculum development instruction.	Pre-service and In-service Elementary Educators (2 to 3 weeks)
<i>Environmental Science Day Camp</i>	Elementary educators involved in the <i>Science in Vermont</i> program develop and teach a week-long environmental science curriculum for grades 1-2, 3-4, and 5-6 students at the Perkins Geology Museum following the teacher program.	Grades 1-6 (1 week)
<i>Summer Science Adventure</i>	Using external funds, university faculty and local middle school teachers facilitate outdoor natural science inquiry and landscape interpretation during middle school “Girls”, “Boys”, and “Coed” week-long programs.	Grades 5-9 (3 weeks)
<i>Classroom/Public Tours</i>	Pre K-16 Professors, teachers, students, youth, parents, and the general public visit the Perkins Geology Museum for formalized science tours and informal visits. About 2000 people visit the museum on an annual basis.	All Ages
<i>Additional Outreach Events</i>	The Perkins Geology Museum sponsors public lectures, an annual <i>Earth Science in Vermont</i> Poster Contest, Teacher Open-House sessions, and Geology Department receptions.	All Ages

Systemic Reform in Vermont

The Statewide Systemic Initiative organization in Vermont, the Vermont Institute for Science, Math, and Technology (VISMT), provides resources and expertise to promote sustained high-level student performance in science, math, and technology. VISMT also spearheaded the development and use of *Vermont’s Framework of Standards and Learning Opportunities* for science, math, and technology in Vermont schools (Vermont Dept. of Education, 1996 a,b).

VISMT will help recruit teachers and schools for the proposed project. VISMT coordinates a successful Teacher Associates program and maintains an extensive database on science education in Vermont schools. These resources will allow VISMT to assist us as we recruit teachers and schools across Vermont.

The proposed project furthers Vermont's systemic change goals by: increasing the use of standards-based science and technology curricula, addressing both content and process standards (Table 2), creating opportunities for student-led investigations, training teachers to facilitate better student learning in science and technology, and connecting high school science and technology curricula with other disciplines such as history and social studies.

Project Management and Responsibilities

Project responsibilities will be shared between the two co-investigators, one full-time staff person (*Outreach Assistant*), a master teacher, and the two interns -- an undergraduate student and a high school student. Day to day operation of the project will be directed by the *Outreach Assistant*. PI Bierman will administer the grant and take responsibility for technology-related aspects of the project. Co-I Massey will oversee education activities. Table 3 outlines staff responsibilities more fully.

Project Approach

We have designed a project that simultaneously integrates research and education while at the same time developing standards-based instructional material and creating a web-based public access data library. A schematic plan for the project is presented in Figure 2.

Student Experience

At the core of the project is the student experience. Over the course of 18 months, University of Vermont staff and faculty will work with 20 to 25 students and their teachers in each of 18 Vermont high school class rooms -- intensive contact with 350 to 450 students. In each of these classrooms, students will be introduced to the project over several days by a University of Vermont staff person, the *Outreach Assistant*. The introduction will include hands-on activities with historic photographs of landscape change, geologic materials, and technology, including computers, scanners, GPS, and digital cameras.

For several weeks after the introduction, students will work on their own and with their teacher. Each student will find at least two historic images showing human-impacted landscapes in their town. Images might be found in their homes, in the homes of their relatives, in the local library or the local historical society. These images will be 75 to 150 years old and will show landscape change including gully erosion, clearcutting, landslides, storm damage, shifting river channels, and mining activities.

As they find the images, the students will bring the photographs to school and scan them at high resolution. The students will then head out into the community to learn more about their images and relocate the sites from which the images were taken. We anticipate that the students will need to work with the town clerk, local historians, and older members of their community in order to locate the sites. After the sites have been located, their coordinates will be measured by the students using GPS and the location recorded on a data sheet. At the same time, the students will rephotograph the site using a digital camera and print the image for field work and research.

With both the modern and older photographs in hand, the students will search for information to caption their images. Data collection will start with field work, walking over the site looking for evidence of the impact noted in the photograph. Students might ask and answer such questions as: What does the soil look and feel like? Is there evidence of clear-cutting? Are gullies or landslides still visible (Figure 1)? Site visits will lead to interviews with landowners that could be supplemented by time tracing deed records at the town office, visits to the local historical society, and to the University library. Most Vermont towns have been incorporated for almost 200 years. A strong tradition of locally-based government means

that land records are usually complete and accessible to the public. Historic photographs are easy to find everywhere!

After completing their research and compiling their findings, we anticipate that the students will present their findings to their peers in both oral and written (poster) formats. Many of these presentations will be attended by University of Vermont staff who will retrieve the posters, electronic data, and equipment. Within weeks of completing their work, the students' data will be posted to the web site and become part of the larger collection. Many of their posters will be displayed in the Perkins Geology Museum in a rotating display. With web terminals in most Vermont high schools, students will be able to see their own work on the web soon after it is completed.

Student Intern Experience

Two student interns (one high school, one undergraduate) will spend a summer working together and with the *Outreach Coordinator* to gather images and work in the field to learn more about the images. The interns will benefit from working closely with the project staff and faculty on an active research project. The high school student will have a unique opportunity to work with college students, faculty, and image curators at the University of Vermont.

Teacher Experience

A *Master Teacher* will be involved in the initial piloting of the project and the creation of a teacher's manual with assessment tools. During the proposed project, the *Master Teacher* will explore new methods in her own classroom by piloting the project, will develop better leadership skills by guiding other teachers, and will benefit from professional contacts at the University of Vermont.

Classroom teachers in our program will have significant and on-going contact with project personnel. Such contact will start with initial recruitment that will be done by letters and phone calls from the *Master Teacher* and *Outreach Assistant*. After a teacher has agreed to work with us, the *Outreach Assistant* will spend a day with the teacher instructing her or him in the use of relevant project technology and introducing the teacher to the structure of the program, the results of earlier classroom efforts, and the teacher manual. The teacher manual will lay out in detail successful methods for implementing the program.

When the students first begin the project, the *Outreach Assistant* will work with the teacher in the classroom to introduce the material and explain the goals of the project. The *Outreach Assistant* will be available for consultation by phone and email for the duration of the project.

At the conclusion of the project in each classroom, the *Outreach Assistant* will work with the teacher to pull together all of the data and coordinate the final presentation of the student work. As the data are added to the web site, we will maintain contact with the teacher, and act as a continued resource. When the project concludes in June, 2001 all of the teachers will be invited to participate along with their students in the culminating conference at the University of Vermont. We anticipate that opening the doors of the University of Vermont for such a conference will empower local teachers to continue accessing our resources and expertise.

Informal Science Experience

People not directly related to this project will benefit from the student and faculty efforts. The digital library will be accessible over the web to anyone; it will be used by lay people and researchers in a variety of disciplines. Parents will likely feel an intimate connection to the local landscape and family histories depicted in the digital library and connect with their children's research efforts.

The rotating displays in the Perkins Geology Museum will be seen by both informal visitors and the many students who each year tour the Museum as part of organized groups (1500-2000 visitors). Natural scientists, historians, rural studies researchers, and environmental policy makers from the University of Vermont community will view the culminating database and poster display as a valuable research archive for “Vermont Studies” of all kinds. The students' work will provide visual evidence to compliment more traditionally based geologic investigations of human impact on sediment yield and erosion (Costa, 1975; Trimble, 1977, and 1997)

Work Plan

We have developed a project work plan and time line for the 18 months over which this project will be active (Figure 3). The project will be accomplished in several stages designed to allow incremental revision of our didactic approach and the educational materials we produce as well as the continuous growth of our digital library.

Initial Development and Recruiting (January to May, 2000)

We will begin the project by hiring an *Outreach Assistant*. This person will have responsibility for day to day operation of the project and will most likely be a combined Education/Science degree holder, quite likely trained at the University of Vermont. Over the next several months, the *Outreach Assistant* will develop a draft teacher manual and assessment tools with the assistance of the *Master Teacher*, Snyder, and under the supervision of Massey. Bierman will assist the *Outreach Assistant* in selecting and purchasing computer equipment. In the late spring, we will work closely with two teachers, one of whom will be Snyder, and try our approach in two pilot classrooms. From our experience in these classrooms, we will modify our approach and our teacher manual. Late in the spring, before schools close for the summer, the *Outreach Assistant* will recruit 8 additional teachers to participate in the program during the fall. From the two pilot classrooms, we will recruit a student to work as an intern at the University over the summer along with a Geology undergraduate with an interest in surface process and landscape change.

Database Enrichment (June to August, 2000)

We will use the summer to make revisions to our project materials and to incorporate images from the University of Vermont Special collections into our data base. In this collection, Bierman has already found over 50 images clearly showing geologic impact of human activities and he has searched only a small part of the archive. The *Outreach Assistant* will work with Bierman, Massey, and the two summer interns to bring the new server and web site on-line and to fill the site with data gathered during the spring and summer.

Core Project Activities (August, 2000 to May, 2001)

During the last 12 months of the project, we will serve 16 schools. The *Outreach Assistant* will alternate between working in the schools and uploading data to the web site. During this time, we will continually reassess the program and revise our teaching materials as we learn more from different classes. The web site will grow quickly, covering nearly a third of the state by May 2001. During the last few months of the project, we will begin to seek additional funding from other sources to complete the project over the next three to five years.

Culminating Conference (June, 2001)

We plan to invite all the students and teachers involved in the project to the University of Vermont for a culminating day-long conference at the end of the project. The conference

will include poster sessions for the students to display their work as well as talks by landscape historians and scientists from the University of Vermont. University of Vermont president Judith Ramaley and provost Geoffrey Gamble, an anthropologist, will be invited to speak to the assembled group. We will provide lunch and organize an afternoon of science lab open houses. The conference will be open to the community as well. Such a conference will expose several hundred Vermont high school students to University level science and scientists. It will be a capstone activity and a way to acknowledge publicly the students' contribution to an on-going research project. This conference will be supported entirely by the University of Vermont's Provost's Office as one of the institutional commitments to this project.

Dissemination of Results

The teacher's manual and general program model will be accessible on the Web to other students and educators, and thus, disseminated to other areas nationally (or internationally) through informal means. A down-loadable version of the teacher's manual will be available on-line.

Massey, Bierman, and/or the *Outreach Assistant* will present project results at National Geologic Education forums such as the Geological Society of America or American Geophysical Union national meetings. In addition, Massey will have the opportunity to disseminate program information at the Vermont Science Teacher's Association meetings and professional development workshops in Vermont.

Project Products

The project will produce several tangible products including a teacher manual, a digital library of images and data, and paper (poster) copies of the same information.

Teacher Manual

The project will produce a detailed teacher manual that will be used and revised through the project period. This manual will include sample lesson plans, ideas for student assignments, simple well-tested instructions for operating and troubleshooting the technology involved, sample assessment tools, and examples of outstanding student efforts. The manual will provide detailed suggestions on the most likely places to find historic photographs and the information needed to interpret them. Both paper and web versions of the manual will be available.

Digital Library

The project will produce a digital library of several thousand images. Many of these images will be georeferenced and captioned in detail by students involved in the project. Each photo will be presented along with a modern view of the same location. A database will be developed that allows for photographs to be located by users both graphically and with an index search by town. The database will be freely available on the World Wide Web; the site will be hosted on our server at the University of Vermont. Figure 4 is an example of such data.

Posters

Students will produce posters as one of the culminating experiences of this project. These posters will include the same information as the digital database and will be submitted to the Perkins Geology Museum for rotating display. The posters will be displayed at the culminating conference and donated to the historical society in the town where photographs were taken.

Assessment

Three kinds of assessment will be an integral part of this pilot study. 1) Materials and methods assessment will address the implementation of the project; 2) student learning assessment will address our pedagogical efforts, and 3) impact assessment will evaluate how the digital database is used and how participants perceived the project.

- 1) The pilot study and feedback from teachers and students will refine our project methods, resource materials (teacher's manual), and our equipment resources (specific technologies) so that we offer the most effective and user-friendly program.
- 2) We will develop, with the *Outreach Assistant* and *Master Teacher*, pre- and post-assessment tools to gauge student learning. These may include tools for assessing:
student content knowledge of land-use history, natural-vs. human-induced landscape change, geologic change, and Vermont geologic history,
student research ability to formulate questions, collect and interpret data, synthesize and present information, evaluate scientific and social information,
personal student values about the role of people in the environment, the use of resources, the relative importance of history, the sense of personal history, and,
student use of technology in terms of relative ease of use, modes of access, personal feelings, and types of technology used.
- 3) Student and teacher evaluations at the end of the project will provide information about general interest and usefulness of the program as an integrated research and education program. In addition, we will monitor use of the *Landscape Image Project* web site using counters to evaluate the public interest and research potential. Use intensity of the computer terminal exhibit in the Perkins Geology Museum will become part of general use data for this facility.

Institutional Commitment (Cost Sharing)

The University of Vermont is committed to the success of this project. To that end, 5% of Bierman's academic year time and 5% of Massey's academic year time will be dedicated to the project. Furthermore, the Provost's Office of the University will sponsor the culminating student conference in its entirety because such a conference directly addresses President Ramaley's stated goal of University engagement in the broader community (see attached letter of support from J. Burke).

The Perkins Geology Building and Museum are scheduled for renovation over the next three years. This > 4 million dollar project (funded by the State of Vermont) will provide much additional space in which to display the work of students supported by this project.

Diversity of Populations Served

Our project will serve socioeconomically and culturally diverse populations. Vermont is a rural state with only a few small cities. Much of the state is heavily dependent on agriculture and tourism; only a few communities are dominated by high technology industry. In many communities, schools include students of widely varying socioeconomic backgrounds. When selecting schools to participate in our project, we will seek a mixture of venues including schools that represent different parts of the state, different income levels, and different cultures such as the logging-dominated economy of the far north, the agricultural economy of the southwest, and the more urban schools of the Burlington area. VISMT will assist in recruiting a diverse population of participants through their existing network of statewide Teacher Associates.

Future Plans

We view NSF funding of this project as a means by which to begin what could be five to seven years of work. Our long-term goal is to compile a digital database that includes historic photographs of every town in Vermont. NSF funding will allow us to demonstrate that our approach is feasible, develop and refine instructional materials and methods, and complete up to 30% of the state-wide database. At the conclusion of NSF funding, we will have developed the expertise to continue our work efficiently. We will have developed a teacher manual that can be used by others for similar work and we will have the equipment we need to continue collecting images. Using the results of this pilot study to demonstrate the feasibility of our approach, we will seek funding to continue this project from several Vermont foundations interested in education reform. In the absence of funding, Massey can continue to work with schools to collect images at a much reduced rate using NSF-provided equipment.

Qualifications of Project Personnel

Bierman and Massey are both geologist-educators; they are full-time employees of the University Vermont with complimentary skills. Bierman is a geomorphologist who supervises graduate and undergraduate research. Massey directs the Perkins Geology Museum and a variety of K-12 outreach programs. Together, they have the combination of experience and expertise to ensure that the project will succeed.

Bierman is an Associate Professor with six years of experience studying Vermont landscapes. He and his students are currently integrating research and education in a variety of ways, the most visible being an NSF-supported CAREER project that is searching for records of mega-storms and human impact in the geologic records of New England ponds and alluvial fans.

Bierman has extensive experience doing science with high school students. Over the past five years, Bierman has worked with high school students in an eight day residential science program at the University of Vermont - The Governor's Institute for Science & Technology (<http://geology.uvm.edu/geowww/morphwww/giv>).

Bierman uses web-based resources extensively and has developed web pages for all of his classes and research (<http://geology.uvm.edu/geowww/morphwww/paulbierman>). He designed, secured funds for, and recently installed a 21-seat, state-of-the-art, Macintosh-based computer teaching laboratory in the Geology Department. Bierman has advised 11 graduate students and 4 undergraduates in research. He and his students have published more than 20 papers and presented more than fifty abstracts including several dedicated to the integration of research and teaching.

Massey is Museum Education Specialist for the Perkins Geology Museum. She provides Earth and Environmental science expertise to the general public and coordinates K-12 outreach for local teachers and students. In addition, Massey oversees museum exhibits and collections, and manages museum student workers.

Massey directs summer science education programs for students and teachers as part of the public service mission of the University of Vermont's Departments of Geology and Education. She hires and administers University faculty, teachers, graduate students, and high school students as staff in her programs, as well as designs curricula for these programs. Massey's five formal science education programs are outlined in Table 1 and include students and teachers from grades 1 to 12. Work with students, teachers, and University administrators in Massey's science education programs prepares her well for work with high school students and teachers in the proposed project. She has the supervisory experience to work with the *Outreach Assistant* and *Master Teacher*.

In addition to Museum programs, Massey works with science education reform efforts in the State of Vermont. She acts as a higher education representative to science education initiatives in the State of Vermont including working with science educators and VISMT personnel to develop science professional development for teachers. She is a member of the Vermont Science Teachers Association. Massey also creates standards-based science curricula to accompany science exhibits at the new Barre Granite Museum in Vermont.

Snyder, the *Master Teacher*, is a high school earth science and biology teacher at Mount Abraham Union High School in Bristol, Vermont. In 1994, she received recognition from the National Science Foundation Research Program for outstanding collaborative efforts to enhance science education. She has helped develop the *Vermont Science Assessment* for assessing Vermont students statewide. Snyder develops standards-based science curricula for her students and ensures inquiry-style investigations in her field-based science courses. She uses interdisciplinary approaches to study a landscape with students and may combine such activities as wildlife tracking, water chemistry, tree identification, map making, art, and writing in nature in an outdoor session.

Snyder provides a wealth of experience and educational service to the proposed project. She volunteers for the Geological Society of America's *Partners for Education Program (PEP)*, is involved in professional endeavors such as the National Science Teacher's Association and the Vermont Science Teachers Association, serves as Education Chair and was past president of the Vermont Geological Society, works as an instructor in the UVM Department of Education, and serves as school coordinator for a student thespian group and coach of her school's *Odyssey of the Mind* program.

Snyder is committed to piloting the proposed project and has received enthusiastic support from her high school administration (see attached support letters).

Infrastructure Available to Support this Project

The Geology Department has the much of the intellectual and physical infrastructure needed to support this project. Funds available through the CAREER grant have been used to acquire several computers including one that will be used by the *Outreach Assistant* and one that will be permanently installed as a web terminal in the Perkins Geology Museum. Vans operated by the Geology Department will be used to transport staff, faculty and equipment to and from schools (see attached support letter). The University of Vermont Library Special Collections holds many thousands of Vermont images that we may freely access (see attached support letter).

REFERENCES CITED

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- Brown, S., (1999). Terrestrial sediment deposition in Ritterbush Pond: Implications for Holocene storm frequency in northern Vermont, Geology Masters Thesis, University of Vermont.
- Brown, S. L., Bierman, P. R., Mehrrens, C. J. and Lini, A. (1997). Episodic inputs of terrestrial sediment to a post-glacial mountain lake. *Geological Society of America Abstracts with Programs*, 29(7), A-36. (National)
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- Li, Lin (1996) Pollen Analysis of sediments from post-glacial ponds in Vermont, unpublished Geology Masters Thesis, University of Vermont.
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- Vermont Department of Education. (1996a). *Core connections: A how-to guide for using Vermont's Framework*, Montpelier, Vt.: Vermont Department of Education.
- Vermont Department of Education. (1996b). *Vermont's framework of standards and learning opportunities*, Montpelier, Vt.: Vermont Department of Education.
- Zehfuss, P. (1996). Alluvial fans in Vermont as recorders of changes in sedimentation rates due to deforestation: *Geological Society of America Abstracts with Programs*. (Northeastern)
- Trimble, S., (1977). The fallacy of stream equilibrium in contemporary denudation studies, *AJS*, v 277, p.876-887.
- Trimble, S. (1997). Contribution of stream channel erosion to sediment yield from an urbanizing watershed, *SCIENCE*, v. 278, p. 1442-1444.

**Paul R. Bierman, Associate Professor of Geology
Department of Geology, University of Vermont, Burlington, VT 05405**

Research and Teaching Interests

Geomorphology, Isotope and Low-temperature Geochemistry, Geohydrology, Environmental Geology, Glacial Geology, Human Impact on the Landscape

Academic Training

Ph.D., 1993, Geology, University of Washington, Seattle, WA with A. Gillespie

"Cosmogenic Isotopes and the Evolution of Granitic Landforms"

MS, 1990, Geology, University of Washington, Seattle, WA with A. Gillespie

"Accuracy and Precision of Rock Varnish Cation Ratio Dating"

BA, 1985, Geology and Environmental Studies, Williams College, Williamstown, MA

"Deglaciation of Northwestern Massachusetts," (cum laude and senior thesis)

Professional Experience

1998- present Associate Professor University of Vermont

1993-1998 Assistant Professor University of Vermont

1992-1993 Lecturer University of Washington

1987-1992 Research and Teaching Assistant University of Washington

1985-1987 Hydrogeologist and Project Manager Alliance Tech., Bedford, MA

1985-1987 Instructor Museum of Science, Boston

Honors and Accomplishments

NSF Waterman Award nomination, AGI, 1996

Donath Medal for Research by Young Scientist, Geological Society of America, 1996

Presidential Faculty Fellowship nomination, UVM, 1995

Faculty Fellowship, University of Washington, 1992

Fuller Fellowship, University of Washington, 1991

Honorable Mention, NSF Graduate Fellowship, 1987 and 1988

Other Training and Skills

Designed, set-up and manage cosmogenic isotope extraction laboratory and technician

Experienced operator, scanning electron microprobe, AMS, and ICP

Global Positioning Systems, GSA Short Course, 1996

Ground Water Flow and Contaminant Transport, GSA Short Course, 1986

Geology Field Camp, University of Montana, Bozeman, 1983

Professional Service

Associate Editor, Geological Society of America Bulletin, 1997-present

Panelist, National Science Foundation, *Water and Watersheds* competition, 1995

Session Chair, Geological Society of America National Meeting, 1994, 1997

Instructor, Geological Society of America National Meeting, *Cosmogenic Isotopes and Geomorphology* Short-course, 1994 and 1995

Leader and Organizer, Geological Society of America Fieldtrip, Owens Valley, 1991

Leader, NAGT Fieldtrip, Williamstown Glacial Geology, 1986

Manuscript and Book Reviews for *GEOLOGY*, *Geological Society of America Bulletin*, *American Antiquity*, *Quaternary Research*, *Quaternary International*, *SCIENCE*, *GSA Today*, *Chemical Geology*, *Nature*, *Biogeochemical Cycles*, *Geochimica et Cosmochimica Acta*

Personal Information

Born October 24, 1961; raised in Baltimore, Maryland; married 1994

Enjoy hiking, running, cross-country skiing, photography, home renovation

Relevant and Important Publications

- Bierman, P.R. and Robison, J. (in press) Henry's Land, in **Geology's Gaze**, J. Schniederma, ed., Freeman. (book chapter)
- Gran, S. Nichols, K., and Bierman, P. R., (in review), Teaching winter Geohydrology at the University of Vermont using frozen lakes and snowy mountains, **Journal of Geoscience Education**. (paper)
- Bierman, P. R., Marsella, K. A., Davis, P. T., Patterson, C. and Caffee, M., (1999), Mid-Pleistocene cosmogenic minimum-age limits for pre-Wisconsinan glacial surfaces in southwestern Minnesota and southern Baffin Island -- a multiple nuclide approach. **Geomorphology**, 27, 1/2, 25-40. (paper)
- Bierman, P., Lini, A., Davis, P.T., Southon, J., Baldwin, L., Church, A. and Zehfuss, P. (1997) Post-glacial ponds and alluvial fans: recorders of Holocene landscape history. **GSA Today**. 7 (10) p. 1-8. (paper)
- Clapp, E., Bierman, P., Church, A. B., Larsen, P. L., Schuck, R. A. and Hanzas, J. P. (1996). Teaching Geohydrology through analysis of groundwater resources and glacial geology, northwestern Vermont. **Journal of Geoscience Education**. 44, 45-51. (paper)
- Bierman, P. & Steig, E. (1996). Estimating rates of denudation and sediment transport using cosmogenic isotope abundances in sediment. **Earth Surface Processes and Landforms**, 21, 125-139. (paper)
- Bierman, P., Gillespie, A., Caffee, M. (1995). Cosmogenic Ages for Earthquake Recurrence Intervals and Debris-Flow Fan Deposition, Owens Valley, CA. **Science**, 270, 447-450. (paper)
- Bierman, P. (1994). Using in situ cosmogenic isotopes to estimate rates of landscape evolution: A review from the geomorphic perspective. **Journal of Geophysical Research** (special issue on Tectonics and Topography), 99, B-7, 13,885-13,896. (paper)
- Bierman, P. R. (1998), Catastrophic Results of Colonial Clearcutting:, **American Association for the Advancement of Science** National Meeting, Philadelphia. (abs)
- Bierman, P. R., Lini, A., Brown, S., Davis, P.T., and Zehfuss, P. (1997) Fans and pond sediments record concurrent episodes of hillslope erosion **Geological Society of America Abstracts with Programs**. (abs)

Graduate and Undergraduate Thesis Students

- Erik Clapp, Natural Resources Ph.D., Models of land surface evolution using ^{10}Be
- Darrin Santos, Environmental Science BS w/honors, Desert channel initiation
- Kristine Bryant, Education M.Ed., Development of Vermont Landforms web page
- Anders Noren, Geology MS, Holocene pond records of hillslope erosion
- Kyle Nichols, Geology MS, Geomorphic process rates, Patton Camps, Mojave Desert
- Karen Jennings, Geology MS, New England Alluvial fans
- Sara Gran, Geology MS, Fault offset rates in the northern Galilee, Israel
- Sarah Brown, Geology MS, Episodic Holocene sedimentation from extreme storms, 1999
- Timothy Whalen, Geology MS, Post-glacial response of the Champlain Basin, 1998
- Mike Abbott, Geology MS, Isotopic characterization of Mt. Mansfield groundwater, 1997
- Kim Marsella, Geology MS, Deglacial chronology of Baffin Island, 1997
- Amy Church, Geology MS, Holocene rates of surface change in northern Vermont, 1997
- Lin Li, Geology MS, Vermont Holocene history deduced from lake cores, 1996
- Paul Zehfuss, Geology BS, Vermont alluvial fan morphology and stratigraphy, 1996
- Patrick Larsen, Geology MS, ^{10}Be and ^{26}Al production rates from moraines, 1995
- Kristine Bryant, Geology BS w/honors, Glacial lake levels in the Winooski Basin, 1995

List of Collaborators and Advisors

- Alan Gillespie, David Dethier, Douglas Clark, P. Thompson Davis, Minze Stuiver, Bruce Nelson, David Elmore, Marc Caffee, Scott Kuehner, Eric Steig, John Southon, Lou Derry, Mark Johnson

Christine A. Massey, Museum Education Specialist
Department of Education, University of Vermont, Burlington, VT 05405

Research and Teaching Interests

K-12 Science Education, Introductory Earth and Environmental Science, Glacial Geology, Geology of National Parks, Stable Isotope Geochemistry

Academic Training

MS, 1995, Geology, University of Washington, Seattle, WA (with M. Stuiver)
“Development of Hydrogen Mass Spectrometry Methods for Testing Stable Isotopic Interactions of Water Vapor at the Snowpack-Air Interface, Summit, Greenland”

BA, 1986, Geology with Natural History & German, Carleton College, Northfield, MN
“Sodium Content of Overburden Sediments, Beulah Zap Lignite Formation, North Dakota” (cum laude and senior thesis with C. E. Buchwald)

Professional Experience

1998-present Museum Education Specialist University of Vermont
1995-present Adjunct Lecturer University of Vermont
1995-present Director Science & Technology Governor’s Institute for Vermont High School Students
1996-1998 K-12 Outreach Coordinator University of Vermont
1993-1995 Environmental Consulting Geologist WH&N, Burlington, VT
1989-1993 Research and Teaching Assistant (Geology/Chemistry/Environmental Sciences/Northwest Center for Research on Women)
University of Washington
1988-1989 Hydrologic Field Assistant U. S. Geological Survey, Menlo Park, CA
1986-1987 Naturalist Intern Foothill Horizons Outdoor Ed. Center, Sonora, CA

Honors and Accomplishments

American Western Universities (AWU) Student Research Fellow--Coal Science Division of the Energy Research Center, University of North Dakota, 1985

Other Training and Skills

Engaging Middle School Girls in Science and Math, WEEA On-line course, 1999
Lead-Scientist Institute on Systemic Reform of Elementary Science Education, American Physical Society (APS), Washington, DC, 1999
Writing in the Classroom and Grant Writing Techniques, University of Vermont, 1998
Educational funding (NSF), Obtaining Educational Materials from the USGS, and Using GIS in Educational Settings, GSA Short Courses, 1997
Learning from the Fossil Record, GSA Short Course, 1996
Isotopes in Hydrology, GSA Short Course, 1995
40-Hour OSHA Hazardous Materials & 8-Hour Refresher courses, 1993-1994
Greenland and Antarctica Ice Core Research and Cold Weather Training, 1990-1991
Back-Country Ski Patrol, Pinecrest, CA, 1987-1989
Geology Field Camp, California State University--Bakersfield, Bakersfield, CA, 1987
Carleton Death Valley Field Seminar, 1986
Gemstone, Mining, and Crystallography Research, Sri Lanka, 1984
Languages: English, German, and French

Personal Information

Born: Minneapolis, Minnesota: February 27, 1963.
Lived: Minnesota, Germany, Sri Lanka, California, South Korea, Washington, Greenland, Antarctica, Australia, and Vermont

Professional Service

Volunteer Scientist, Science-By-Mail, Boston Museum of Science, 1992-present
Reviewer, SUGR/FAME student research proposals, University of Vermont, 1998
Curriculum Committee, Barre Granite Museum, Barre, VT, 1997-present

Professional Memberships: *Sigma Xi, The Scientific Research Society, American Geophysical Union, Geological Society of America, Association for Women in Science, American Association of University Women, National Association of Geoscience Teachers, and Vermont Science Teachers Association*
Children's International Summer Village (CISV) Adult leader for U.S. delegation of four eleven year old children to Seoul, South Korea, 1989

Relevant and Important Publications

- Massey, C. A., (1998). Earth Science Week. **Connect: Teacher's Innovations in K-8 Science, Math and Technology**, 12, 1, 26.
- Massey, C. A., (1998). Learning through inquiry and community service--The Science & Technology Institute for Vermont high school students. **Geological Society of America--1998 National Meeting Abstracts with Programs**, 30, 7, A-350.
- Massey, C. A., (1997). Environmental Science and Technology Institute for Elementary Teachers and Education Majors in Vermont. **Geological Society of America--1997 National Meeting Abstracts with Programs**, 29, 6, A-301.
- Massey, C. A., (1996). Thrust faults, plankton tows, wastewater, and SEMs: Vermont Earth and Environmental Science for K-12 students and teachers. **Geological Society of America--1996 National Meeting Abstracts with Programs**, 28, 7, A-476.

Undergraduate and High School Student Advisees

- Katherine Meyer, Senior Graduation Challenge, Champlain Valley Union High School, "*Differences in Science Learning for Middle School Girls and Boys*," 1999
- Jill Wagner, Environmental Studies BA., University of Vermont, "*Environmental Education at Burlington High School*," 1997

List of Collaborators and Advisors

Russell Agne (UVM Education), Barry Doolan (UVM Geology), Mike Strauss (UVM Chemistry), Walter Poleman (UVM Field Naturalist Program), Aimee Stephenson (VISMT), Minze Stuiver (UW Quaternary Research Center/Geology), and Pieter Grootes (UW Quaternary Research)

BUDGET JUSTIFICATION

Costs associated with this project are primarily for personnel and equipment. As a community service project, our activities qualify for an overhead rate of 26.4%.

Salary and Benefits

Most salary costs will support the *Outreach Assistant*, most likely a Science Education student (either graduate or undergraduate) who has recently completed their degree and who is familiar with both the University of Vermont and the State of Vermont. As PI, Bierman will dedicate two summer weeks to the project primarily implementing technology and setting up the web server. Massey has a 12-month position at the University so requests no salary support although she will work 5% time on the project (see Institutional Commitment). University benefits are assigned at standard rates for different personnel.

Master Teacher Salary

Participation of the Master Teacher is an important part of the proposed project. Funds for the *Master Teacher* will support her work with curriculum and assessment development in the Teacher's Manual, piloting the project, and recruitment of other teachers.

Student Stipends

Funding requested in this proposal will support two student interns over the summer of 2000, a high school student and a University of Vermont undergraduate. During this summer, the students will select and scan the most relevant images from the University of Vermont's Special Collections Library which houses over 20,000 historical photographs including stereo views and post cards. In pairs, the students will then go to the field and attempt to relocate the sites from which these images were taken using GPS and digital cameras.

Supplies

We request funding for supplies needed to complete the project. Each school will be provided a kit to make posters that includes pre-cut poster board, glue, and ink jet paper for printing photos. Data storage media are needed to transfer information and back up all data. We request funds to prepare copies of the teacher manual, for postage, and for copying.

Travel

There is extensive local travel associated with this project. During the school year, the *Outreach Assistant* will travel to the schools involved in the project. He or she will use Geology Department vans whenever possible. Use of these vans requires reimbursement and the cost of gasoline. Use of the vans in the summer by the undergraduate will also require support.

Travel to national geologic meetings by project staff will allow further dissemination of project results in scientific sessions and approaches in education sessions. Funds requested will cover airfare, registration, and per diem for Massey and perhaps the Outreach Assistant.

Equipment

In order to expose students to modern digital technology and to archive images digitally, we will need to acquire four sets of image acquisition tools including: the lowest-cost Macintosh Powerbook computers, low-priced image scanners (Microtek), digital cameras (Kodak), small ink-jet printers, and hand held GPS (Garmin). We prefer the Macintosh platform because the University of Vermont Geology Department recently added a 21-seat Macintosh computer laboratory dedicated to the integration of active, computer-based learning into our curriculum. The equipment we purchase will be issued as a package to schools for use

by teachers and students over a 4 to 6 week period. After this time, the equipment will be returned to the University of Vermont, cleaned, repaired as necessary and reissued to the next school.

We request funds for a fast, new web server to house and distribute all the images collected by this project, including both the low resolution images for display on the web site and the high resolution images available for selective down loading. The current Geology Department server is heavily used and cannot bear the increased burden of thousands of additional files and web users. The purchased server will include mirrored hard drives as well as tape back-ups to ensure data preservation.

Culminating Conference (UNIVERSITY OF VERMONT, COST SHARING)

At the conclusion of the project, participating teachers and their students will come together at the University of Vermont to present their findings in a poster session and attend presentations on the Vermont landscape. University faculty and administrators will be invited to attend. The Provost's Office at University of Vermont will sponsor the conference and will be responsible for all associated costs, a cost sharing of \$4000 plus indirect.