Strategic Plan for Stony Brook's Department of Geosciences – 2011

Overview

The Department of Geosciences at Stony Brook University, with a faculty of 17, has established itself as a leading department in the earth science/geoscience discipline, both nationally and internationally. The National Research Council's 2010 survey of doctoral programs ranks our research activity among the top 15 earth science departments at public research universities throughout the US, and in the top three within the Northeast. *U.S. News and World Report*'s 2010 survey of graduate programs ranks our Department in the top third of earth science departments among both public and private universities. With a small faculty size relative to peer departments, our strategy has been to focus efforts into a few key sub-disciplines, rather than try to cover all or even most fields within the earth sciences. Our expertise encompasses mineral and rock physics, geochemistry, mineralogy/crystallography, petrology, planetary geology, sedimentary geology, seismology, tectonics, and environmental geology. The Department is home to the Mineral Physics Institute, which has established itself as a leader in high-pressure research focusing on processes in the deep earth. Collectively, with the Mineral Physics Institute, our external funding level exceeds $6M, among the highest per capita levels on west campus. Our faculty have been particularly successful in developing multidisciplinary research and training centers, several of which involve major research initiatives at Brookhaven National Laboratory and utilize other national user facilities. All of our faculty are active in teaching as well as research. We offer BS, BA, MS, and PhD degrees, as well as an MAT program for earth science teaching. The Department offers two majors (a BS in Geosciences and a BA in Earth and Space Sciences), with combined undergraduate enrollment of approximately 80, continuing a steady increase over the past several years. Our 40+ graduate students are supported primarily by external funding from research grants, with first-year students supported by TAs.

The Geosciences Faculty

Our faculty of 17 enjoys an international reputation for excellence and leadership in research. Four of our faculty hold the rank of Distinguished Professor (Parise, Weidner) or Distinguished Service Professor (Hanson, Liebermann). Many others have been recognized by professional societies for their significant contributions. Over the past several years, several of our faculty have been re-assigned to administrative roles. Prof. Robert Liebermann served for 8 years as President of the Consortium for Materials Properties Research in Earth Sciences (CoMPRES), completing this assignment only last year. Prof. Donald Weidner serves as Director of the Mineral Physics Institute. Prof. Martin Schoonen is Director of the Sustainability Studies Program at Stony Brook, having previously served as Interim Dean of Stony Brook Southampton. All have (or had) reduced Departmental responsibilities as a result of these additional duties. However, continued excellence and leadership within a department depend on an influx of new ideas, typically from younger scholars. The age distribution of faculty in the Geosciences Department is skewed toward senior members, with only two at the Associate Professor level and two at the Assistant Professor level. Within ten years, nearly one-half of the current faculty will be approaching retirement age. Whereas this presents an opportunity for bringing in outstanding junior faculty over the longer term, there is an urgent need to expand into key areas that are currently developing and which will define the future of the geosciences.

The latest review of the Geosciences Department by an external committee of distinguished faculty from MIT, Virginia Tech, and UC Santa Cruz noted the high impact of our faculty's research, as well as the high quality and effectiveness of our undergraduate and graduate programs, stating: *"The Department of Geosciences has, with a small faculty complement,*

generated superlative research, teaching, and service enterprises." They particularly noted that such accomplishments were made with a relatively small faculty size. Nearly all of the earth science/geoscience departments having higher rankings in *U.S. News & World Report*'s 2010 survey have larger faculty size (some by a factor of two). The review committee warned that the loss of just one or two faculty could severely harm a relatively small department already impacted by assignment of several faculty to university service. At the same time, the external committee also recognized the timely opportunity to strengthen the Department and elevate its stature and effectiveness with a relatively small investment from the University. Our highest priority is to bring in outstanding young scientists who will help to define future challenges and expand through vigorous research and graduate training programs.

Leadership in Establishing Interdisciplinary Programs

Geoscience faculty have been successful in establishing and leading interdisciplinary research centers, including the NSF Center for High Pressure Research (CHiPR), the NSF Consortium for Materials Properties Research in Earth Sciences (COMPRES), the Mineral Physics Institute (MPI), the NSF-funded Center for Environmental Molecular Science (CEMS), and the NSF IGERT Metals, Metalloids, Minerals and Toxicity (3MT). Geosciences faculty have served in a principal leadership role in each of these collaborative centers. The Department's close connection with these centers, including Stony Brook's Consortium for Interdisciplinary Environmental Research (CIDER) and the New York Center for Computational Science (NYCCS), has allowed unique research and graduate student training opportunities and has also created novel outreach initiatives that are recognized nationally. The Department has been very successful in developing campus-wide and community involvement in current earth science topics and faculty research through a public lecture series and sponsorship of local geological societies.

Mission and Vision

The Department of Geosciences is committed to providing the best possible intellectual environment for the education and training of students and for the discovery of earth-related knowledge for the benefit of humanity. With programs in mineral and rock physics, geochemistry, seismology, geodynamics, and planetary science that are already highly regarded, the Department is poised to become a world-leading center of learning. We also serve as a valuable resource for advanced educational needs for the campus, local community, and local schools. By strategically building on existing strengths and leveraging federal funding initiatives and user facilities, we aspire to become the leading Geosciences department among public research universities on the East Coast and among the top 10 departments nationally.

Emerging Opportunities in the Geosciences

Within the last decade earth's processes and their impacts on society have taken center stage in world and even political affairs. Public awareness of the important role of geosciences has been heightened by the wide range of critical issues facing humanity. These concerns are not limited to developing countries, but affect modern societies like our own. Among the most noteworthy examples are:

- Water resources and pollution (surface and ground water)

- Fossil fuel energy resources and impacts of recovery and use
- Geologic (subsurface) sequestration and mineralization of CO_2 emissions
- Uranium resources, the nuclear fuel cycle, and geologic storage of nuclear waste
- Climate change, the global carbon cycle, and environmental impacts
- Earthquake and tsunami hazard and prediction
- Seismic monitoring of nuclear testing and arms control
- River flooding
- Coastal erosion
- Environmental pollutants and human health

Renewed public awareness of geosciences has stimulated demand for advanced training needed to meet future challenges. ***At no other time in human history has Geosciences figured so importantly in assessment and planning at all levels throughout the world's governments*.** Among the most serious challenges facing humanity, nearly all require an understanding of earth processes. Climate change is altering river flow and groundwater recharge patterns, accelerating retreat of glaciers and ice sheets, and raising sea level, the latter exacerbating coastal erosion and threatening coastal communities. Increased reliance on nuclear power also raises a host of unanswered geologic questions, ranging from the long-term fate of uranium released into groundwaters underlying mining operations to the permanent geologic storage of spent nuclear fuel. Chemical pollutants continue to plague natural waters and soils, which represent critical resources for communities and agriculture and pose threats to human health. As the core discipline for study of our planet, the geosciences are uniquely positioned to address fundamental problems that face society. Within US funding agencies, the need for increased graduate training in geosciences has been recognized through new initiatives focusing on carbon sequestration, water quality and resources, earthquake and deep earth processes, biogeochemical processes, and underground storage of radioactive waste. In New York State, our location within an environmentally sensitive area with a large population brings with it the responsibility for providing scientific and environmental leadership. Already the leading Geoscience Department among SUNY schools, we intend to extend our educational, training, and research missions to meet these challenges.

Projected Job Growth in Geosciences Fields

The U.S. Bureau of Labor Statistics has projected a 19% increase in jobs in the geosciences through 2016. This rate of job growth far exceeds that projected for most other science disciplines. Much of the expected demand comes from the private sector with growing needs for energy, water resources, natural hazards, and environmental workers. Research-related job growth is expected in fields involving energy, natural hazards (especially earthquakes), environmental pollution and water quality, as well as many areas related to global change. New initiatives at NSF and DOE have targeted geological challenges involving energy, water resources, climate change, and the environment. Most recently, funding agencies have given a high priority to studies of geological sequestration of carbon dioxide.

Employers continue to tell us that in-depth training in a specific topic leads to superior problem solving abilities. For this reason, the training provided in our undergraduate and graduate geoscience programs is clearly favored over broadly distributed programs encompassing divers environmental topics. Our programs emphasize this approach, and we have been very successful in placing our undergraduate and graduate students across all sectors.

Expanding Collaborations Within and Beyond the University

Owing to the inherently multidisciplinary nature of geosciences, we have been very effective in forging collaborations beyond our discipline. On campus, our faculty have close connections to Chemistry, Physics & Astronomy, the School of Marine and Atmospheric Science, and Materials Science. Prof. John Parise has a joint appointment in Chemistry, and Prof. Artem Oganov as an affiliated appointment in Physics & Astronomy. Prof. Martin Schoonen has established close ties to the Department of Pharmacology in the University Medical Center, as part of an NSF-funded IGERT for training graduate students in a medical geology and also as a joint research program. In addition, a number of faculty in other departments have affiliated appointments in Geosciences. Furthermore, Geoscience faculty participate in several campus-wide initiatives (e.g., Consortium for Integrated Environmental Research, Interdepartmental Doctoral Program in Anthropological Sciences, Turkana Basin Institute).

Geoscience faculty have also forged collaborations beyond Stony Brook. These range from formal joint appointments to informal research efforts. One of the most important opportunities for collaboration has been at National Laboratories, including Brookhaven, Argonne, Oak Ridge, and Lawrence Berkeley Labs. At Brookhaven National Lab a number of our faculty (Parise, Rasbury, Reeder, Weidner, Wong) have established programs involving research and/or development of instruments for use by the broader community at the National Synchrotron Light Source (NSLS). Prof. Don Weidner and other members of the Mineral Physics Institute have designed, constructed, and continue to operate a beamline at NSLS for high pressure research. Other Geoscience faculty are PRT members for spectroscopy beamlines at NSLS. Important new opportunities will be presenting themselves with the construction of NSLS II, which will replace NSLS and become operational in 2015. Geoscience faculty John Parise, Richard Reeder, and Don Weidner serve on beamline advisory teams (BATs) for design and construction of beamlines at NSLS II. Prof. Parise has a joint appointment at NSLS II. He is also co-Director of the Joint Photon Science Institute, a partnership between New York State, Stony Brook University, and Brookhaven National Lab supporting research initiatives at synchrotron facilities. Participation in the design and development of beamlines suited for our research is a high priority for a number of Geoscience faculty. This will position us to be major users of this unique facility in the future.

Geoscience faculty also have significant roles in other national user facilities. Prof. John Parise participated in design and development of a beamline at the Spallation Neutron Source at Oak Ridge National Lab, and his research group continues to be a major user of this unique instrument. Our faculty also use the Blue Gene/L supercomputer and the leading facilities at the Center for Functional Nanomaterials, both at BNL. Several faculty participate in the NSF EarthScope program, in the Plate Boundary Observatory, and in the Incorporated Research Institutions for Seismology as members and in leadership roles. As described below, new opportunities for research are continually emerging and provide us with new challenges.

Strategy Outline

For a relatively small department, the path toward greater prominence lies in identifying emerging areas and integrating them with existing strengths. The Department of Geosciences has clear strengths in a number of areas, and we expect to maintain these. Yet, we lack expertise in several areas that are likely to become increasingly influential in steering the direction of learning and research in geosciences and related fields. If we do not invest in several or all of these areas at this time, our Department risks missing opportunities that will effectively define the future of our discipline. The Department has identified seven specific areas that build on existing strengths

but also identify emerging topics in which we can make a major impact with modest investment. Strategic growth in several of the following areas would help to elevate our Department to a new level of prominence, both nationally and internationally:

- Computational/observational seismology
- Computational/theoretical geodynamics
- Computational/theoretical earth materials science
- Energy geoscience
- Biogeochemistry and environmental geochemistry
- Earth systems sciences
- Planetary science

The first three areas have great potential for leveraging the new computational capabilities of the New York Center for Computational Sciences (NYCCS). Launched jointly by Stony Brook University and Brookhaven National Laboratory (BNL) in 2007, NYCCS takes advantage of the powerful IBM Blue Gene/L supercomputer located at BNL. As part of this initiative Stony Brook University hired six faculty whose research was linked to computational science. One of these lines came to Geosciences. Prof. Artem Oganov is a world-leading mineral physicist focusing on structure, energetics and transformation of solids at the high temperatures and pressures experienced in earth's deep interior. Dr. Oganov fills an important gap in the area of computational mineral physics. Our strategy for expanding to include computational methods in geodynamics, seismology, and earth materials reflects a 'sea change' within the geosciences toward more computationally intensive research. The fields of energy geoscience and biogeochemistry/environmental geochemistry are both rapidly growing, and each leverages existing strengths to address growing societal concerns. The last three areas also build on our strengths in experimental and field studies, and could effectively leverage new capabilities that will become available at NSLS II at Brookhaven National Laboratory.

1. Computational/theoretical geodynamics.

Geodynamics, the integrative study of the dynamic systems of earth's interior, is undergoing rapid growth within the earth sciences. Driven by new observational data and unprecedented computational capabilities, unique opportunities are emerging that would take advantage of existing strengths in our department and allow us to become world-leading in geodynamics. The Department has strong, highly regarded research programs in mineral physics (Weidner, Parise, Liebermann), seismology (Wen) and geodynamics (Wen, Holt, Davis). The mineral physics group focuses on studying material properties under the extreme conditions in the earth's interior; the seismology group probes the seismic structure in the earth's interior; and the geodynamics group studies dynamic system of the present-day earth. The faculty members in these groups are all internationally recognized leaders in these sub-fields. Collaborations are on-going between the mineral physics and seismology groups (Weidner and Wen) and between the large-scale mantle dynamics and lithospheric dynamics groups (Wen and Holt). Larger impacts of research and graduate education, however, lie in the interdisciplinary research integrating the results from these sub-disciplines. The interdisciplinary research would require leading experts in each of the sub-disciplines. A key element that is lacking in the department is an expert studying the evolution of the dynamic system of the earth and its relationship with the seismic structures in the earth's interior imaged by the seismology group, the elastic properties and rheology of the earth's materials measured by the mineral physics group, and the present-day geodynamic models constrained by the

current geodynamics group in the department. Such faculty expertise could also establish collaborative research programs with the planetary science group (McLenann, Glotch, Nekvasil, Davis), with studies of dynamics and evolution of other planets. By establishing such interdisciplinary programs the Department can distinguish itself from peer institutions, including top Ivy-league universities. With the collaborative spirit and existing strengths in the Department, the addition of new expertise in computational or theoretical geodynamics would establish the Department as a world-leading multidisciplinary center for studying the composition, dynamics and evolution of earth's interior.

Recent developments in observational and computational geodynamics provide unique opportunities for growth in this area. Observationally, the Plate Boundary Observatory (PBO), a component of NSF's EarthScope program (http://www.earthscope.org/), is supplying unprecedented, dense geodetic data across the plate boundary zones in the United States. Two core components in NASA's strategic plan for solid earth research over the next 25 years are InSAR (http://solidearth.jpl.nasa.gov/insar/info.html) and the Gravity Recovery and Climate Experiment (http://www.csr.utexas.edu/grace/). They will provide a new generation of geodetic observations of changes in earth's gravity and movements of its surface, providing new insights into the dynamic evolution in the earth's interior, as well as natural hazards, terrestrial hydrology, and climate change. On the computational front, advanced numerical methods are being developed in the geodynamics community through the Computational Infrastructure for Geodynamics (CIG) (http://geodynamics.org/). Future leaders in the field of geodynamics will require a strong collaborative link with the CIG community, with the ability to perform full three-dimensional, time-dependent calculations, while integrating constraints from mineral physics, seismology, geodesy, and rock mechanics. With the foundation provided by our existing strengths, our direct involvement in CIG, and our access to Blue Gene/L (NYCCS), a strategic hire in computational geodynamics would allow us to become a world-leading interdisciplinary center for studying dynamics, composition and evolution of the earth's interior. Furthermore, with a corresponding investment in seismology discussed below, the quantitative geodynamicist that we seek would provide the missing expertise to cement the world-class components of geophysics together, thereby providing opportunities for cutting edge integrative science that few graduate programs in the country can offer. Without this key and vital component, however, the graduates from Stony Brook in the area encompassing the dynamics of the earth's surface and interior will find it difficult to compete at the national level.

2. Computational/observational seismology.

Seismology covers a wide spectrum of research activities within the Earth Sciences, ranging from studies of the media through which seismic waves propagate to the sources of the seismic waves themselves. This sub-discipline has been at center stage for solid earth geophysics, with its ability to directly probe the earth's interior and its role in evaluating societal and economical impacts such as earthquake studies and oil exploration. Currently, our Department has only one full-time seismologist (Wen), a fact that hinders development of our seismology program and creates a deficiency in graduate training. Of the top 28 ranking Geosciences graduate programs in the US only Johns Hopkins and Stony Brook have fewer than two seismologists on their faculty (Johns Hopkins has none). Our most serious need is for expertise in studying seismic sources and the earth's interior using long-period data. Addition of a faculty member in this area

would provide the necessary breadth for a seismology program with adequate expertise for research and graduate training.

Recent developments in observational and computational areas of earthquake seismology provide exciting opportunities never before seen. Observationally, the USArray, one of the components of the NSF EarthScope program (http://www.earthscope.org/), is supplying unprecedentedly dense data coverage across the United States. On the computation front, the ever-increasing power of supercomputers has propelled development of advanced numerical methods for simulation of seismic wave propagation in complex media and for study of the complexities of earthquake sources through the CIG (http://geodynamics.org/). Many of our peer departments have already identified earthquake seismology as a key area for development to make significant impacts in their Geoscience programs, and are currently competing for young talent. At the present time, searches are underway at Princeton, UCLA, UT Austin, Michigan, and USC. With NSF's EarthScope program in full swing, Stony Brook needs to join the competition immediately in order to avoid lagging behind our peer departments. We can take immediate advantage of the Blue Jean/L supercomputer associated with NYCCS to achieve advances in this area.

An investment in a new seismologist would also serve long-term interests of the department by building up a top solid earth geophysics program among our peer institutions. A new seismology hire would complement the research programs in mineral physics, geodynamics, and rock physics. The mineral physics group (Weidner, Liebermann) has made major advances in the understanding of elastic and rheological properties of mantle materials under the extreme conditions of the earth's interior. The rock physics group (Wong) has developed expertise in the brittle failure of rocks in the laboratory. The geodynamics group (Holt, Davis, Wen) has developed models for high-resolution images of the earth's interior. These research activities would have greater impacts by collaboration with studies of seismic structure and earthquake sources. Adding new expertise in seismology would also allow us to offer advanced training to graduate students planning careers in the energy industry. Strengthening seismology in the Department is a foremost concern.

3. <u>Computational/theoretical earth materials science</u>.

The Geosciences Department has strong, highly regarded programs in experimental earth materials science, with the research of several faculty (Hanson, Liebermann, Parise, Phillips, Rasbury, Reeder, Schoonen, Weidner) and associated institutes (CEMS, CIDER, 3MT IGERT, MPI) focusing on issues ranging from the deep earth to environmental concerns. The basis for much of the understanding in this research is molecular-scale processes, including reaction mechanisms and kinetics, stability, structure-function relationships, and mechanical properties. The accomplishments of our faculty's experimental programs demonstrate their importance in characterizing complex systems of interest to a broad range of earth science. Yet in many instances experiments or limitations in experimental design raise questions that require a different approach. Modern computational methods, utilizing molecular dynamics, Monte Carlo techniques, and density functional theory, have become essential tools for studying many aspects of molecular-scale structure and processes. Furthermore, these studies often complement experiment results, thereby increasing the value of both. Computational methods have become so important in current research in molecular-scale geochemistry that graduate students are increasingly expected to have some familiarity or expertise with them. The

recent DOE-BES survey *Basic Research Needs for Geosciences: Facilitating 21st Century Energy Systems* (2007) identified such computational approaches, and their alignment with experimental approaches, as one of three grand challenges in our discipline.

At present, the Geosciences Department has limited faculty expertise in the application of such methods to the materials focus areas in which we are active, although Oganov is helping to fill this void. Nor does such expertise exist elsewhere on campus. This hinders our graduate training and research enterprise. A poignant example is seen in the need for Stony Brook faculty (three from Geosciences) in the newly established Collaborative Research in Chemistry (CRC) center to engage computational expertise at U. Wisconsin, Penn State U., and U. Cambridge to provide essential computational support for their research program. The lack of expertise in modern computational approaches that focus on environmental (aquatic and terrestrial) geochemistry presents a limitation on our graduate-level training. This encompasses aqueous complexation, mineral-water interface geochemistry, and poorly crystalline solids. Several peer geoscience departments have made major commitments to their computational programs. For example, Penn State, Wisconsin, Berkeley, Michigan, and UC Davis have all hired faculty whose primary teaching and research approach involves computational methods. Stanford is currently conducting a faculty search in this area.

A new faculty hire in this area would elevate the level of graduate training and raise the visibility of our geochemistry and mineral physics programs. New expertise would directly complement the experimental programs of Professors Nekvasil, Parise, Phillips, Reeder, Schoonen, and Weidner. Moreover, by combining strong experimental and computational programs we would become one of just a handful of Geoscience departments able to train students and conduct research on the most complex problems in molecular-scale earth sciences. New faculty in this area, as well as the previous two focus area, could leverage the computation capabilities available in NYCCS and provide new opportunities for collaboration across the campus.

4. Energy Geoscience

Heightened awareness of the complex relation between energy resources and societal needs has focused attention on the geosciences. The recovery and development of energy, in every form, have impacts on earth's environment, ranging from coal mining accidents to emissions of greenhouse gases. Climate change is altering river flow and groundwater recharge patterns, accelerating retreat of glaciers and ice sheets, and raising sea level, the latter exacerbating coastal erosion and threatening coastal communities. Geologic (subsurface) sequestration of CO_2 has emerged as the leading candidate for mitigation of industrial CO_2 emissions, and research on this topic is identifying new challenges that require focused research programs. Among the outstanding questions are interactions of supercritical CO_2 with reservoir rocks and fluids and the long-term integrity of reservoirs to prevent release of CO_2 back to the atmosphere. Emerging science reveals that the answers to the key questions lie in studies of candidate rock units over a range of length scales. Among the most promising techniques for study of subsurface materials are synchrotron-based X-ray methods that permit in situ studies at elevated pressures and temperatures appropriate to intended injections conditions. Similar experimental approaches are applicable to studying "hydrofracking", which has emerged as a potentially game-changing technology for extracting methane from so-called gas shales. Key questions relate to the mobilization of methane and transport of potentially hazardous additives to the hydrofracking solutions. Several Geoscience

faculty (Parise, Rasbury, Reeder, Weidner, Wong) have active research programs at the nearby National Synchrotron Light Source at Brookhaven National Lab, and are planning to develop research initiatives specifically relating to energy geoscience. However, new expertise would greatly enhance these initiatives.

Energy Geoscience also encompasses the design and characterization of advanced materials for specific energy applications, ranging from host storage materials for radionuclides to next-generation battery materials. Prof. Artem Oganov has developed a research program using computational methods for design and prediction of potential materials useful for energy applications. This work takes advantage of the Blue Gene/L supercomputer at BNL. Minerals commonly serve as analogs for developing novel materials that can withstand extreme conditions. The focus of MPI on high-pressure and high-temperature minerals can be transferred to design of solid suited for specific applications, such within reactors. Again, in situ characterization is essential, and neutron and synchrotron X-ray techniques have proven to be invaluable.

A particularly exciting opportunity presents itself with the construction of NSLS II, which will become available in 2015. A joint appointment between Geosciences and NSLS II would strengthen the current ties, and it would also position us to become a leading player in energy geosciences research in the next decade.

5. Biogeochemistry and Environmental Geochemistry

A number of faculty in the Geosciences Department have made major contributions to education, training, and research relating to environmental geochemistry, including aspects that directly impact human health. Encompassing the complex system of biological, physical, and geochemical processes at earth's surface, the National Research Council report (NRC, 2001) referred to this realm as earth's *Critical Zone* and identified it as one of several important growth areas in the geosciences. Human habitation is directly impacted by natural and anthropogenic processes within the Critical Zone, as demonstrated by examples as diverse as contaminant transport in aquatic and soil systems, carbon cycling, and inhalation of mineral dusts. Distinguishing characteristics of these systems include the heterogeneity of earth materials, their complexity, and interactions among systems over a range of length and temporal scales. The geosciences lie at the heart of this multidisciplinary field of study, and young geoscientists are already being called on to address increasingly complex problems for which traditional solutions may not be applicable. A major funding initiative was subsequently launched by NSF in support of research studies in the Critical Zone. We consider it a high priority to begin training students in problem-solving in these complex systems that are essential for human habitation.

Several faculty in Geosciences have active research programs addressing various aspects of this growing field. However, the main expertise of current Department faculty in this area involves experimental studies of model systems or systems focusing on individual processes. Geoscience faculty were instrumental in developing several multidisciplinary initiatives at Stony Brook. Among these is the Center for Environmental Molecular Science (CEMS), created in 2001 with approximately $6 M in funding from NSF. Several of the participating CEMS faculty (Parise, Phillips, Reeder, Schoonen) are from Geosciences. This collaborative effort also involves Stony Brook faculty in Chemistry, Marine Sciences, Physics, and Materials Science, as well as researchers at Brookhaven National Lab, Penn State, and Temple University, and emphasizes molecular-scale aspects of environmental contaminants. An important component of CEMS is direct

involvement at several beamlines at NSLS, where unique experimental techniques are available. Another initiative is the NSF-funded IGERT, named "3MT" (Minerals, Metals, Metalloids, and Toxicity), led by faculty in Geosciences and Pharmacology. This innovative graduate training program links the geochemical behavior of metals and minerals with human health, and bridges physical sciences and health sciences on the Stony Brook campus. In 2007, the Consortium of Interdisciplinary Environmental Research (CIDER) was created to enhance interchange among researchers on the SB campus interested in environmental topics. Geoscience faculty are founding members of this initiative.

Despite such expertise, we have limited programs in complex systems approaches or those involving biogeochemical processes. Our formal courses and advanced training are therefore limited in scope. In order to provide the breadth and depth of training that is essential, we need to expand our expertise to include faculty who address the complex materials and processes in earth's Critical Zone. Biogeochemistry is now emerging as an important focus area that links geoscience with biological processes in the Critical Zone and has specific funding programs within NSF and DOE.

New faculty in this area could benefit from ready access to synchrotron radiation techniques at NSLS and participate in development of scientific capabilities at NSLS II. A new faculty member with such expertise would also directly complement research activities in the planetary science group in areas related to astrobiology and the search for life in the universe. Two Geosciences faculty (Schoonen, Parise) are currently involved in the NASA-funded Astrobiology Institute at Montana State University, and several more (Glotch, McLennan, Parise), as well as research faculty and education/public outreach specialists, are presently pursuing funding for an Astrobiology Institute in collaboration with researchers at the University of Tennessee. NASA has designated several funding programs for the study of astrobiology, evolutionary biology, biogeochemistry and development of instrument packages to detect life and biomarkers on other planets (http://nspires.nasaprs.com). A new biogeochemistry faculty member would help to focus these efforts and complement the geochemistry and mineralogy expertise of current faculty.

A related area that holds great potential for growth is medical geology. A newly created discipline that is closely allied to health programs, this field examines the relationship between earth materials and human health. Several faculty in our department have already established programs in this area, including the NSF-funded 3MT IGERT training program for graduate students. With growing societal concerns about the health risks posed by natural and contaminated materials, there is increasing demand for expertise that links geosciences with fields such as environmental epidemiology and toxicology. This focus area, like biogeochemistry, would consolidate existing strength with an area of future national need.

6. Earth Systems Sciences

Geologists use all of the sciences to understand the processes operating on and within the earth. It is increasingly apparent that it is impossible to consider systems separately because changes in one system force changes in others. These feedbacks are thought to be critical for self-regulation of earth processes and cycles. For example, the carbon cycle, which plays a fundamental role in climate and impacts future energy strategies, is interconnected with processes in the hydrosphere, the atmosphere, the biosphere (including humans), the lithosphere, and very likely to processes in the mantle, which

control plate tectonics. Yet, the controls and connections between systems are still not understood sufficiently well to allow confidence in predictions. As a result, geosciences is increasingly turning to "deep-time", which is uniquely recorded in sedimentary rocks, to unravel the controls and interrelations between these systems. NSF has recently established a new program in Global Change, namely Paleo Perspectives on Climate Change (P2C2). *The earth has been the crucible in a 4.6 billion year experiment, and the results are recorded in the rocks and in related earth materials. Geosciences is the only discipline that can de-code this record.* Of current Geosciences faculty, Rasbury, Sperazza, and Hanson have research programs that train students to focus on the geologic record of climate change and to use geochemical approaches to date and characterize these changes. There is a particular need for new expertise in extracting sea level and climate information from the deep-time sedimentary rock record, a challenge that is distinct from well established studies of the marine sediment record. This would complement the programs of existing faculty who use trace element and isotope geochemistry approaches to test global models of climate change. It would also provide the basis for developing collaboration with climate change programs in SoMAS.

Although the Department has an international reputation for isotope geochemistry, only one faculty member (Rasbury) currently has an active research program in this area, specifically focusing on dating methods applied to sedimentary rocks. New expertise would also benefit collaborations of Geoscience faculty with other departments both on and off campus. Our mass spectrometry lab is used by graduate students from SoMAS (mentored by Kirk Cochran and Bob Aller) and from the Interdepartmental Doctoral Program in Anthropological Sciences (IDPAS) (mentored by Troy Rasbury and Elizabeth Stone), as well as by collaborating faculty at Queens College and Lamont Doherty. Technological advances in mass spectrometry over the last ten years have made possible higher precision measurements that would greatly accelerate application of dating in sedimentary systems, which would also expand applications to the anthropological studies of the IDPAS. In addition to an observational scientist, there is a need to add expertise in earth systems modeling. This would provide training and research opportunities for interpretation of geological climate proxy data and for testing climate models and their sensitivity. As oil companies search for remaining frontier oil (unexplored oil fields) they rely increasingly on geologically-based climate models because of their potential for understanding sequestration of carbon in earth's crust. Such a modeler could interact with NYCCS and take advantage of new computing resources. Growth in this area would complement ongoing research efforts to establish rates and directions of climate change in the geologic past, which are crucial for predicting future changes. New expertise in this area could also complement the planetary geology program, with an emphasis on Mars, and provide a temporal and spatial framework to complement studies of Critical Zone processes.

7. <u>Planetary Geology</u>

Planetary geology has experienced unprecedented growth in the past several years. This has been coupled to much-publicized NASA-sponsored space missions and the exciting findings that have followed. Beyond manned spacecraft missions, however, a new generation of remote-sensing instrumentation has revolutionized observational planetary science and is now providing data of unprecedented quality for planetary nearby bodies (including earth!). Our Department has taken advantage of recent science programs aimed at advanced characterization of Mars and the Moon. We have a particularly strong and highly visible program in Martian geology, which has placed us in a position to participate in future Lunar missions and other planetary, including sample return

missions. Geosciences faculty are currently seeking external funding to create a planetary sample environment laboratory that would allow simulation of planetary environments. This unique facility could best be utilized by adding new faculty and collaborating with NASA scientists. Furthermore, a partnership with NSLS II at BNL would offer a unique capability for characterization of samples returned to Earth, which again would greatly complement the initiatives developed in our Strategic Plan. To fully take advantage of emerging opportunities in this field, we need to grow in the field of remote sensing.

Commitment to Diversity

The Geoscience Department has a demonstrated commitment to encouraging participation from all walks of life. Surveys of diversity by professional societies have consistently shown that minority groups are under-represented in geosciences, both as students and as faculty. Geosciences has adopted several approaches to address this concern. Prof. Gilbert Hanson has taken the lead in establishing a program aimed at enhancing diversity in our discipline. Prof. Hanson has obtained an award from the NSF program "Opportunities for Enhancing Diversity in the Geosciences" to further this goal. This education/outreach program focuses on pre-college minority students and develops approaches to encourage careers in geosciences. The Department has supported this initiative by making classroom and lab space available for training and education programs, and by making a range of geological and geophysical field equipment available for use by the students and their instructors. Several other outreach programs within the Department have similarly focused on inclusion of minority students. For many years, CEMS and MPI have offered summer REU programs that have actively recruited minority students, relying in part of local contacts at historically black universities and colleges. The Department continues to make efforts to expand opportunities for identifying highly qualified individuals who contribute to a goal of broadening diversity.

Graduate Student Recruitment and Support

The Department has been successful in maintaining a vigorous graduate program. Historically, we have been able to support nearly all PhD and MS students. We have also been very successful in placing our graduate students, with nearly 70% of our PhD recipients finding placement in university research and teaching, or in research in national or industrial laboratories. Continued success depends critically on our ability to recruit graduate students and provide competitive stipends for the entire duration of their graduate study. Increasingly, we find the competition with top-rated schools to be fierce. Graduate student stipends continue to rise in order to remain competitive, but we commonly find that competitor departments offer higher stipends. Furthermore, we appear to be unique among leading geoscience departments in that we lack the option to provide university TA lines to any but first-year students. Because our competitors all have the option of using TA lines as a backstop, we are unable to match their multi-year support offers. This places us at a severe recruiting disadvantage. With most stipends provided through individual faculty grants, this puts a heavy burden on faculty. Stipends provided through CEMS and MPI research faculty also contribute, but the scheduled ramp down for CEMS shows that more stable funding is needed.

Since 1997, the Department has been proactive in recruiting a higher percentage of US national students. We have twice been successful in obtaining GAANN awards, which makes it possible to focus on recruitment and retention of US students. Geoscience faculty were also successful in obtaining Stony Brook's first NSF IGERT award (jointly with Pharmacology), which provides

additional resources for attracting top graduate students in medical geology. Although these awards have greatly benefited the Department, we cannot rely on their availability in the future.

Graduate student recruitment is strongly tied to TA allocations (typically 7-8 TA packages); most incoming students are funded from TA packages. With typical acceptance rates of 40–60% it becomes a difficult balancing act to garner a reasonable number of students without over-committing ourselves. Although the Graduate School will back-stop us if more students than predicted accept, this cuts into allocations in the following year, thus making growth difficult. To alleviate this perennial problem, we would like to work with the Graduate School and the College of Arts and Sciences to obtain greater flexibility in allocation of TA resources that will allow growth in graduate student numbers in parallel with growth of the Department. Such growth will still carry a burden on us as the level of TA support from the University is roughly $10 K less than our stipend level, requiring the Department to supply the differential.

Undergraduate Education and Research Opportunities

The Geosciences Department has a rich history of including undergraduates in the research enterprise. Two major REU (research experience for undergraduates) programs tied to major centers (CEMS and MPI) bring in 10-15 undergraduates from across the nation annually. Additionally all of our faculty have worked with Stony Brook undergrads on research projects of various scales. In fact, a large percentage of our students have benefited from this. We have recently submitted a change of curriculum for Geology majors, which reflects new opportunities afforded by recent hires in Planetary Geology and Computational Geochemistry. We expect to expand horizons even more effectively with the new hires and with increased TA numbers. Not only are we offering different courses, we have reorganized the required courses such that students have the opportunity to specialize in any of the fields that our faculty represent. Those students will work with a faculty mentor and the GEO advisor to tailor a curriculum that will best meets their career goals.

Building and Facilities

The Geosciences Department currently occupies approximately ¾ of the Earth and Space Sciences Building on the west side of the main academic mall. This building, now 40 years old, shows much evidence of deterioration, both inside and out. Renovation of the leak-prone roof is planned for 2011. A major landscaping project for the front courtyard, originally planned for 2011, has been delayed for at least one year. The interior classrooms and labs suffer from structural, operational, and aesthetic problems that are well known to faculty, staff, and students. The physical environment now presented by the ESS building detracts from the classroom experience of thousands of students daily and adversely impacts research and graduate student training. The Geosciences Department intends to work closely with University officials to identify a cost-effective course of action and a timetable for improving the physical environment for students, faculty, and staff that benefits attainment of our goals, and enhances the overall appearance of this end of the main academic mall.

Outreach and Advancement

The Geosciences Department has taken great pride in our efforts to reach out to the campus and local communities. One of the most successful mechanisms of outreach has been our Geology Open Nights lecture series, offering monthly lectures by Geoscience Faculty on their research to members of the local and campus community. A new endeavor is “Our Environment”, a series of monthly lectures to the local and campus communities on environmental concerns regarding

Long Island and the Metropolitan New York. Geoscience faculty member Gilbert Hanson has served as coordinator for the Long Island Geologists, which sponsors geologic field trips and annual conferences on the Geology of Long Island and Metropolitan New York for the local science community. These outreach efforts also provide an opportunity for science teachers to receive in-service credit. Geoscience faculty members partner with staff in CEMS and MPI to offer summer REU programs, workshops for local high school teachers, and educational programs for minority high school students through the NYS STEP program. We continue to explore new avenues for interacting with students of all ages and community members alike.

Advancement and fund-raising are areas in which we have limited experience. Yet we recognize the importance of promoting such efforts in coordination with the College of Arts and Sciences and the University. We frequently hear from departmental alumni who share with us fond memories of their time spent in our Department. We would like to think this is a result of the collegial environment of learning that we have tried to maintain. Several years ago we were fortunate to receive a substantial endowment to establish a fund to support field work by graduate students. This was donated by a former graduate student, who benefited from funds made available for his field work. Encouraged by such gifts, we have created new gift-giving opportunities and will actively promote advancement to alumni. As an initial step, we have created an annual newsletter that for the past three years has been distributed to Geoscience alumni and friends. In addition to helping the departmental alumni community keep in contact, the newsletter provides a gift-giving option. We will also explore mechanisms for connecting directly with alumni, possibly using national/regional meetings as a venue.

Summary

Geosciences has emerged as one of the most dynamic disciplines in the sciences and has great societal relevance. Our Department has evolved to capitalize on new opportunities, and we continue to seek new areas for growth. We believe that expansion into several of the key areas described above would strengthen Stony Brook's leadership role in earth and environmental sciences, both throughout the Northeast and nationally. Our record has demonstrated an ability to maximize returns on investment, while partnering across campus and with national user facilities such as NSLS. Concurrent with our redirection in research, we have realigned course programs to suit the needs of undergraduate and graduate students. This includes developing programs and expanding course offerings for high school teachers and revising programs for professionals in the environmental consulting sector by developing courses on energy and water resources that are suited to their needs and those of Long Island.