

1. Mission

Describe specific objectives and measurable contributions the program will make to the university's mission, paying particular attention to the program's consistency with the university's focus statement and priorities. Such objectives and contributions may include:

- serving a distinct student population;
- occupational and student demand for the program;
- meeting the needs of business, employers, and/or society;
- collaborating with and/or supporting other programs at the institution; and
- increasing the number of graduates in a high demand or emerging field of study.

Introduction

The College of Science proposes a progressive, interdisciplinary doctoral program in the physical and biological sciences with a focus on Earth research. The doctoral program in Geosciences would be housed within the Department of Geology. The program would bring many benefits to the University by:

- 1) attracting promising students to a high demand field, increasing the number and quality of graduate students on campus;
- 2) enhancing the economy of Illinois, specifically in workforce training and the development of energy resources;
- 3) increasing the research output of the faculty of the College of Science, including external research funding and publications in national and international journals and symposia; and
- 4) attracting and retaining talented faculty, those that would not consider the University without a doctoral program in Geosciences.

Students completing the program of study would hold a Doctor of Philosophy in Geosciences, with concentrations in one of the following tracks:

Biogeochemistry
Earth Surface Processes
Energy and Mineral Resources
Geophysics and Tectonics
Paleobiology

These concentrations encourage collaboration of faculty from across campus and the proposed program would involve faculty from the Colleges of Science, Engineering, Agriculture, and Liberal Arts and the Departments of Geology, Geography and Environmental Resources, Microbiology, Zoology, Plant Biology, Chemistry and Biochemistry, Physics, Civil and Environmental Engineering, and Mining and Mineral Resources Engineering as mentors and co-advisors.

Background

In the 19th and 20th centuries, science evolved from an initial emphasis on description and categorization of the natural world to theoretical and applied research within narrowly defined sub-disciplines that rarely overlapped. As we enter the 21st century, the trend is reversing, with the scientific enterprise becoming increasingly interdisciplinary, seeking a more holistic understanding of the natural world. "Many new scholarly frontiers are not within a specific

discipline, but occupy intellectual space where numerous disciplines can interact" (Wilson, 1998). The National Academy of Sciences (1995) noted this trend and recommended multidisciplinary education in place of the traditional narrow emphasis in a specialized field. Environmental sciences, which are becoming increasingly important to society, do not fit easily into any one traditional mode of inquiry, but rather demand such an interdisciplinary approach. Schaefer and others (2008) recognized this shift in emphasis and its impact on problems that the United States will face in the future. They believed that current US science agencies are poorly equipped to respond to these challenges and proposed merging the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) into an Earth Systems Science Agency to better facilitate interdisciplinary research. The proposed doctoral program in Geosciences fits well with their vision.

A new program in Geosciences focusing on the study of physical and biological Earth systems will take advantage of existing faculty strengths at SIUC and feed strong demand for training and research in multidisciplinary geoscience applications. Geoscience encompasses a broad range of fields, including the study of the Earth's history, composition, physical and chemical processes, resources, and natural hazards. Geosciences have a unique perspective of time and scale, extending billions of years in the past and to global-scale events. Because of the interaction of humans with earth systems, geosciences are vital to the resolution of such problems as climate change; groundwater supply and pollution; the prediction and mitigation of earthquakes, flooding, and volcanic hazards; and the discovery of natural resources and their utilization. By its very nature, geoscience is interdisciplinary, involving what may at first seem to be disparate fields such as physics, chemistry, microbiology, zoology, ecology, plant biology, even mining engineering, civil engineering, material sciences, geography, and agricultural sciences.

Occupational demand for students completing degrees in geosciences is extremely strong at the present time, with significant promise for further growth to meet the needs of society for energy and natural resources and to solve environmental problems. In fact, at the National meeting of the Geological Society of America this year, the Pardee Keynote Symposium focused on the emerging workforce crisis in the geosciences. The symposium organizers noted that higher education is yet to address the increased demand for geoscientists.

The proposed program would not only train scientists who choose to work in industry, solving environmental problems or seeking and developing energy and natural resources, but also new academics who will teach and conduct research at institutions of higher learning. The proposed program would also strengthen the research mission of the College of Science, allowing faculty to work with promising, but experienced graduate students in sophisticated academic and applied research; research that cannot be completed within existing Masters degree programs. Students working on a Masters degree typically lack some of the basic skills and experience needed for doctoral-level research. Masters students also spend much less time working toward their degrees, which limits the sophistication of their research. External funding would increase, as would the output of scientific papers from the University.

At present, the Department of Geology has eleven faculty. All of the continuing faculty members are active researchers, together publishing over 107 referred publications, including journal articles and book chapters within the last five years (2003 through 2008). External research funding over that same period which involved faculty from the Department of Geology exceeded \$2,775,000. Recent faculty hires, within the last ten years, have been exceptionally productive, elevating the research enterprise in the Department and providing a firm basis for proposing a new doctoral program in Geosciences. The proposed program would also include four faculty from outside the Department of Geology.

At present, the Department of Geology offers Baccalaureate and Masters degrees. Some faculty also participate in the Environmental Resources and Policy doctoral program which focuses on interdisciplinary research between the social and physical sciences. Several of the faculty in the Department of Geology have singled out the lack of a doctoral program in geology or geoscience as a limitation to their productivity and growth at SIUC. Several areas of geology do not fit well under the Environmental Resources and Policy umbrella, and there is significant concern that the University is losing potential students, research opportunities, and perhaps faculty due to the absence of a geoscience doctoral program.

Southern at 150

The proposed doctoral program in Geosciences fits well within the vision set for the University over the next decade or so, as stated in *Southern at 150: Building Excellence through Commitment*. One objective is for Southern Illinois University Carbondale to improve its overall standing with respect to federal research expenditures. A doctoral program in Geosciences would move the University closer to this goal. *Southern at 150* speaks to graduate education and research, noting that “current trends suggest that the 21st century will be one of graduate and professional education...” The document also calls for the University to “... advance its commitment to graduate and professional education to make this university distinctive.” Further noting that “Interdisciplinary research is also believed to be of greater value in developing a variety of skills that will add value to graduate and professional training.”

Southern at 150 is a comprehensive document organized in a hierarchical fashion, with sections listing different commitments for the future. Each commitment has a series of aspirations, which in turn have specific targets. The proposed doctoral program in Geosciences would advance many of the commitments, aspirations, and targets articulated in *Southern at 150*.

Commitment: Seek and Celebrate Faculty Excellence.

Aspiration: Recruit and Retain High-Quality Faculty

Adding a doctoral program in Geosciences would help the University recruit and retain outstanding faculty. *Southern at 150* states “Faculty will be nationally and internationally recognized, and productive as scholars participating in the full range of research and creative activity associated with their unique disciplines.” To attract the very best faculty, however, requires access to the best students, at every level of study. Many talented faculty will not come to a university that does not offer a doctoral program in their field. Geology recently conducted a search to fill a position in geophysics. The applicant pool was excellent, and we interviewed four outstanding scientists. Those that were interviewed indicated real concern about the absence of a doctoral program within the Department. This example provides only anecdotal evidence, but it does indicate at least a reluctance of some promising faculty to join programs which do not have access to doctoral students.

Aspiration: Support and Foster Faculty Excellence

This aspiration has a target for the faculty to “...increase and enhance collaborative and cooperative initiatives across disciplines.” The proposed program would lead to new collaborative, interdisciplinary research with colleagues in the Department, in other Southern Illinois University Carbondale departments, and outside the University.

Commitment: Lead in Research, Scholarly, and Creative Activities

Aspiration: Increase research standing of the University

The addition of a new doctoral program in the Geosciences would enhance the research mission of the University, attracting promising advanced students to collaborate with established scientists, improving the overall research enterprise of the University. A doctoral program in the Geosciences would increase research and development funding to the University at the federal level, one of the goals of this aspiration. The United States Geological Survey, NSF, NASA, Department of Energy and the Department of Defense offer significant funding opportunities in the earth sciences. In 2001, collective federal funding in environmental sciences exceeded \$1.8B, with over \$500M going to the earth sciences. Another goal of this aspiration is to promote the university as a research institution of high quality to granting organizations, private industry, and foundations. Increased quality is associated with programs offering doctoral degrees. In fact, the National Academy of Sciences only ranks disciplinary programs if they have a doctoral degree, making it difficult to determine the standing of a program without a Ph.D. degree relative to its peers or aspirational peers. Therefore, the absence of a doctoral program can then call into question the overall quality of a department, even if it has outstanding faculty. A factor considered by reviewers of grant proposals is the nature and extent graduate students participate in the research. A short time in a program and the lack of prior experience limits Masters degree students ability to contribute to the research mission relative to that of doctoral students. Certain types of research require time and some basic experience that Masters degree students cannot provide. In short, the presence of doctoral students on a proposal can enhance the standing of the proposal in the eyes of the reviewer and funding agency. Involving doctoral students in a program will thus increase grants to the University.

Aspiration: Enhance the Culture of Research and Scholarship.

The proposed program would foster two specific targets within this aspiration; 1) "...to enhance and develop existing and new centers of research, scholarship, and creative activity excellence..., and 2) develop interdisciplinary, interuniversity, and University-industry partnerships designed to foster research, scholarship, and creative activities." Not only does the proposed doctoral program in Geosciences develop a new interdisciplinary academic program, but faculty and students participating in this program would also enhance existing centers of excellence on campus, including the Coal Research Center, the Center for Advanced Friction Studies, the Center for Ecology, and the Materials Technology Center.

At the present time, the Coal Research Center has several initiatives underway, including I-Lab, the Coal Fuels Alliance, and the Center for Advanced Energy Research. I-Lab, or Innovation Lab, focuses on advanced coal utilization technology including coal gasification projects that seek to minimize environmental impacts associated with coal energy, including the release of carbon dioxide into the atmosphere. The Coal Fuels Alliance, supported by the Department of Energy, brings Southern Illinois University Carbondale, the Center for Advanced Energy Research at the University of Kentucky, and Purdue University together in coal energy research. Research in this collaborative program focuses on the development of liquid fuels from coal that would burn more cleanly. A new doctoral program in Geosciences would enhance these initiatives.

Current faculty in the Department have collaborated with scientists in the Center for Advanced Friction Studies. For example, Drs. Crelling and Anderson have applied optical techniques traditionally used to characterize natural carbonaceous materials such as coal and petroleum to synthetic materials widely used in friction applications such as brake materials. Dr. Ishman is active in the Center for Ecology.

The University also has a new academic initiative; the Professional Science Masters Degree in Advanced Energy Management. This program involves faculty from the Department of Geology, and the Colleges of Science, Engineering, Agriculture, and Business and Administration. Some courses offered for the doctoral program in Geosciences would undoubtedly be relevant for the Professional Science Masters program.

Commitment: Offer Progressive Graduate Education

Aspiration: Achieve Excellence in Graduate and Professional Programs

The proposed program is innovative, drawing on the strengths of departments throughout the College of Science and the University. One target calls for an "...appropriate balance of Ph.D. programs". By fitting so many of the other commitments, aspirations, and targets, the proposed program improves the balance of doctoral programs on campus as well as strengthening a program in high demand. A target of this aspiration is to double the number of high quality applicants for graduate study. The discipline of geosciences is exploding as a field of study, with dramatic increases in the need for individuals with significant post baccalaureate and significant interdisciplinary training. Clearly, a new doctoral program in Geosciences would increase graduate applications and enrollment.

Commitment: Promote Excellence in Undergraduate Academics

Aspiration: Shape High-Quality Undergraduate Programs

Undergraduate students benefit from an environment that includes doctoral students engaged in research on topics at the leading edge of the discipline. Research programs often involve undergraduate students as part of a team composed of masters students, doctoral students, and faculty. The interaction between these different members of the team enhances undergraduate education at the University. The greater experience of a doctoral student also would improve classroom instruction because most of the doctoral students involved with the program would also act, at least for some of their time at the University, as teaching assistants. Doctoral students bring greater knowledge and teaching experience into the classrooms over that of masters students holding teaching assistantships.

Commitment: Serve Others

Aspiration: Economic Development in the Region Driven by Our Research and Scholarship

This aspiration has a target to "develop and market cultural, scholarly, and research activities in a way that attracts industry." The doctoral program in Geosciences would enhance the University's ability to develop opportunities in the area of natural resources, especially the coal, oil, gas, and other energy sectors of the region that are so vital to the economic health of the state. This program would also help the University attain state funding because of the interest that Springfield has in coal, oil, and natural gas. The Coal Geology program at Southern Illinois University Carbondale rivals that of any other University in the Nation. In the past 40 years, faculty working in the area of coal geology have received numerous awards from National and International organizations. In fact, four past members of the faculty have each earned the Gilbert H. Cady award for the Geological Society of America for outstanding contributions in coal geology. No other program in the Country can make that claim. In addition to the Cady Award, Dr. John Crelling received the Joseph Becker Award from the Ironmaking Division of the Iron and Steel Society for his work on coal carbonization and technology. He also earned the Reinhardt Thiessen Medal from the International Committee for Coal and Organic Petrology. Only two other people have won all three of these awards. Finally, Dr. Crelling co-edited the textbook in coal petrology used around the world. Clearly, the strength of this program alone warrants a doctoral degree.

Aspiration: Leadership in Regional Development

A specific target of this aspiration is to “utilize key university programs and resources to assist in the development of the coal, energy, and manufacturing sectors in the region.” The proposed program meets this target.

Report of the Washington Advisory Group

In 2003, the University contracted with the Washington Advisory Group (WAG), a prestigious consulting firm, to assess the current state of research at SIUC. A comprehensive report was prepared that included specific recommendations for improving the research standing of the University. The WAG Report recommended that the University focus on particular areas, ones in which it is already strong, such as coal and environmental research. The proposed doctoral program in Geosciences would enhance both these areas at the University. Carefully planned growth, including the addition of a doctoral program in Geosciences would go a long way in making the University a leading institution for energy and environmental studies.

The authors’ of the WAG Report noted the importance of coal to the Illinois economy. They also mentioned the importance of cooperative programs between the federal government (DOE) and the coal industry, that would lead to an integrated sequestration and hydrogen production research power plant. The hope is to produce a coal-fired power plant with zero emissions, including zero emissions of carbon dioxide, a gas that has been linked to global warming. Efficient utilization of coal resources and carbon dioxide sequestration would be research areas attractive to faculty and students working within a doctoral program in Geosciences. Coal will remain an important source of energy in the United States for the foreseeable future, and successful research reducing the release of carbon dioxide into the atmosphere would have a global impact.

2. Need

Explain how the program will meet regional and state needs and priorities.
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The Illinois Board of Higher Education recently developed a new strategic plan; *The Illinois Public Agenda for College and Career Success* which established four goals; Increase Educational Attainment, Increase College Affordability, Address Workforce Needs, and Enhance Economic Growth. The proposed doctoral program in Geosciences addresses two of the Board’s goals; Address Workforce Needs and Enhance Economic Growth.

Address Workforce Needs

Specifically, the *Public Agenda* calls for an increase in “...the number of high-quality post-secondary credentials to meet the demands of the economy and an increasingly global society.” In establishing this goal, the Board recognized that the needs of the workforce are intertwined with economic growth. The proposed doctoral program in Geosciences meets two of the recommendations the Board made to achieve this goal.

Recommendation 1: Increase the number of people with high-quality postsecondary credentials to ensure the state has an educated workforce and an engaged citizenry.

One of the strategies developed to achieve this recommendation is to strengthen “... accountability to demonstrate quality through national assessments with publicly reported results.” The proposed doctoral program in Geosciences has a comprehensive assessment plan, described in another section of this proposal.

Recommendation 3: Increase the number of postsecondary degrees in fields of critical skills shortages.

Another section of this proposal documents the exceptional opportunities that will soon develop in the geosciences as a result of increased demand on energy and natural resources as well as the environmental impacts associated with the development of these resources. The nearly 25% growth in employment opportunities projected by the U.S. Bureau of Labor indicates that geosciences belongs with other fields that have a critical skills shortage. The Public Agenda also specifically notes that the State's "... efforts to capitalize on emerging areas of the economy, such as biofuels, biopharmaceuticals, clean coal technology, and wind energy production, will require new and often multidisciplinary certificate and degree programs at levels ranging from technicians to research scientists." The proposed program in Geosciences is multidisciplinary and it would have a significant focus on the environmentally sound development of the State's extensive coal resources.

Enhance Economic Growth

According to the *Public Agenda*, the state of Illinois "... will use its vast research, education and training, and innovation assets as the sparkplug to ignite entrepreneurial activity and economic expansion to compete with the leading New Economy States." Furthermore, the Board recognized that Illinois' "... colleges and universities are central to the development of state and regional economies, but the roles they play must expand and the connections between higher education and the economy must become stronger."

A doctoral program in Geosciences would promote research and development, create new knowledge, and enhance the economic circumstance of the state, particularly in the areas of energy and other natural resources. The proposed program has a focus on the safe development of coal, an important economic resource for the state, and would strengthen research on carbon dioxide sequestration, the extraction of natural gas from coal seams, and new methods to utilize coal so that it can be burned more cleanly and efficiently. Faculty and graduate students in Geosciences would work closely with industry to develop all of the state's natural resources in a safe, environmentally sound manner. A doctoral program in Geosciences would also foster new research to better develop and protect the state's water resources, prepare for natural hazards such as earthquakes and floods, and find and develop non-energy natural resources. The economic well being of the state is dependent on utilization of these resources and hence requires a steady stream of highly qualified and trained individuals to meet the needs of industry for high level personnel.

One strategy of the *Public Agenda* to enhance the State's economy is to develop "resource pools and incentives that capitalize on state and regional strengths and address state and regional weaknesses." This is exactly the model behind FutureGen and other advanced energy programs under development by the U.S. Department of Energy. Southern Illinois University Carbondale is already actively involved with these initiatives, and a doctoral program in Geosciences would enhance these efforts.

3. Illinois 2011

Demonstrate how the proposed program will support one or more goals of <i>Illinois 2011</i> , the Illinois Board of Higher Education's Strategic Initiative. Programs do not have to contribute to every goal, but must contribute to at least one.

Goal	How met
<p>1. <i>Increase Educational Attainment</i> – 1) Increase success of students at each stage of the P-20 educational pipeline to eliminate achievement gaps by race, ethnicity, socioeconomic status, gender, and disability. 2) Increase the number of adults, including GED recipients, reentering education and completing a postsecondary credential. 3) Reduce geographic disparities in educational attainment.</p>	<p>The proposed program only addresses attainment peripherally. Southern Illinois University Carbondale is in an area of the state with a low level of educational attainment. In the sciences, women choose geosciences in numbers very near that of men, with trends suggesting equal enrollment of men and women in the near future. This should improve overall gender balance in the graduate programs in the University and the State.</p>
<p>2. <i>Increase College Affordability</i> – 1) Make Illinois one of the five most affordable states in the country to get a college education.</p>	<p>The proposed program does not specifically address college costs.</p>
<p>3. <i>Address Workforce Needs</i> – 1) Increase the number of people with high-quality postsecondary credentials to ensure the state has an educated workforce and an engaged citizenry. 2) Improve transitions all along the educational pipeline. 3) Increase the number of postsecondary degrees in fields of critical needs shortages.</p>	<p>Employment predictions summarized in this document indicate that geosciences is a high-demand field, with much higher than average growth over the next decade.</p>
<p>4. <i>Enhance Economic Growth</i> – 1) Boost Illinois into the ranks of the five states with the fastest growing economies.</p>	<p>Doctoral students working with faculty in a doctoral program in Geosciences would improve basic knowledge and enhance the economic circumstance of the State, particularly in the areas of environmental and energy resources. Specifically, the new program would promote cutting edge research in energy resources, an important component of the economy of the State.</p>

4. Similar Programs

Identify similar programs and sponsoring institutions in the state. Compare these programs with the proposed program. Discuss the possible impact of the proposed program on the existing similar programs.

The universities that have doctoral programs in geology, geophysics, or geosciences within the State of Illinois are:

- Northern Illinois University
- Northwestern University
- University of Chicago
- University of Illinois, Chicago
- University of Illinois, Urbana-Champaign

Northwestern University and the University of Chicago are private institutions. All of the existing doctoral programs are located in the northern portion of the state. A doctoral program at

Southern Illinois University Carbondale would provide geographical balance and the University is particularly well positioned for an advanced geoscience degree program with its location at the southern edge of the Illinois coal and oil fields, near the New Madrid seismic zone, and the confluence of the Tennessee, Wabash, Ohio, and Mississippi Rivers.

The main feature that makes this program different from other Ph.D. programs offered in Illinois is the focus on cross department collaboration and interdisciplinary research. In addition, the University's strength in coal and energy research and the hydrology of major river systems is unique, not only in the State, but in the Nation as well. The anticipated demand for geoscience graduates at every degree level indicates that the proposed program should not have any impact on the already established programs. The other State supported programs at the University of Illinois Champaign Urbana, the University of Illinois Chicago, and Northern Illinois University have distinctly different missions. None of the other doctoral programs in the State have as broad an interdisciplinary scope as the proposed program in Geosciences, which would strive to link all the physical sciences with the full spectrum of biological sciences.

University of Illinois Champaign Urbana

The University of Illinois Champaign Urbana offers a Doctorate in Geology. The degree encourages the student to take most courses within the department, requiring up to four hours of coursework in other disciplines. This program has strength in the fields of fluid dynamics and mineralogy, areas distinctly different than those for the proposed doctorate in Geosciences at Southern Illinois University Carbondale.

University of Illinois Chicago

The University of Illinois Chicago offers a Doctorate in Earth and Environmental Sciences. This program is interdisciplinary and shares some features with the proposed doctoral program in Geosciences. However, the UIC program has a greater emphasis on mineralogy, petrology, planetary geology, and lacks an emphasis on energy resources.

Northern Illinois University

Northern Illinois University offers a Doctorate in Geology. Like UIUC, this is a more traditional program. The curriculum encourages students to take courses mainly within the department, and does not specifically promote interdisciplinary study.

5. Future Employment Opportunities

Discuss estimated future employment opportunities for graduates of this program. Compare the estimated need for graduates with the estimated number of graduates from this program and existing programs identified above. Where appropriate, provide documentation by citing data from such sources as employer surveys, current labor market analyses, and future workforce projections (whenever possible, use state labor projections).

Future employment opportunities for geoscience graduates with degrees at every level are exceptional in both the near and long term. The explosive growth in geoscience careers is fueled by declining energy and mineral resources and rapid growth in Asian, South American, and African economies. In addition, economic growth creates pressure on the environment, generating career opportunities for environmental geoscientists. These trends are long term.

The U.S. Department of Labor forecasts a 22 percent growth for geoscientists between 2006 and 2016, a rate about double that of all other occupations. (Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2008-09 Edition, Geoscientists, on the Internet at <http://www.bls.gov/oco/ocos288.htm>; visited February 14, 2008). The following is an excerpt from the Bureau of Labor Web page (note that this excerpt also describes growth in management and policy positions in addition to those in the physical and biological sciences):

The need for energy, environmental protection, and responsible land and water management will spur employment demand. Employment in management, scientific, and technical consulting services should continue to grow as more geoscientists work as consultants. These services have increased their hiring of geoscientists in recent years because of increased government contracting, and private corporations' need for technical assistance and environmental management plans. Moreover, many geoscientists monitor the quality of the environment, including aquatic ecosystems, deteriorating coastal environments, and rising sea levels—all of which will create employment growth for them. An expected increase in highway building and other infrastructure projects will also be a source of jobs for engineering geologists.

Employment is also expected to increase in the oil and gas extraction industry. Many geoscientists work in the exploration and production of oil and gas. Historically, employment of petroleum geologists, geophysicists, and some other geoscientists has been cyclical and affected considerably by the price of oil and gas. When prices are low, oil and gas producers curtail exploration activities and lay off geologists. When prices were higher, companies had the funds and incentive to renew exploration efforts and to hire geoscientists in larger numbers. In recent years, however, a growing worldwide demand for oil and gas and for new exploration and recovery techniques—particularly in deep water and previously inaccessible sites in Alaska and the Gulf of Mexico—has created some stability to the petroleum industry. Geoscientists who speak a foreign

language and who are willing to work abroad should enjoy the best opportunities, as the need for energy, construction materials, and a broad range of geoscience expertise grows in developing nations. (<http://www.bls.gov/oco/ocos288.htm>)

The U.S. Department of Labor forecasts even faster growth for environmental scientists and hydrologists, projecting a 25 and 24 percent growth, respectively in these fields between 2006 and 2016. (Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2008-09 Edition, Environmental Scientists and Hydrologists, on the Internet at <http://www.bls.gov/oco/ocos050.htm>; visited February 14, 2008). The following excerpt details the opportunities for these fields (note that this excerpt also describes growth in management and policy positions in addition to those in the physical and biological sciences):

Job growth for environmental scientists and hydrologists should be strongest in private-sector consulting firms. Growth in employment of environmental scientists and hydrologists will be spurred largely by the increasing demands placed on the environment and water resources by population growth. Further demand should result from the need to comply with complex environmental laws and regulations, particularly those regarding ground-water decontamination, clean air, and flood control.

Much job growth will result from a continued need to monitor the quality of the environment, to interpret the impact of human actions on terrestrial and aquatic ecosystems, and to develop strategies for restoring ecosystems. In addition, environmental scientists will be needed to help planners develop and construct buildings, transportation corridors, and utilities that protect water resources and reflect efficient and beneficial land use.

Demand for hydrologists should also be strong as the population increases and moves to more environmentally sensitive locations. As people increasingly migrate toward coastal regions, for example, hydrologists will be needed to assess building sites for potential geologic hazards and to mitigate the effects of natural hazards such as floods, landslides, and hurricanes. Hydrologists also will be needed to study hazardous-waste sites and determine the effect of pollutants on soil and ground water so that engineers can design remediation systems. Increased government regulations, such as those regarding the management of storm water, and issues related to water conservation, deteriorating coastal environments, and rising sea levels also will stimulate employment growth for these workers.

Many environmental scientists and hydrologists work in consulting. Consulting firms have hired these scientists to help businesses and government address issues related to underground tanks, land disposal areas, and other hazardous-waste-management facilities. Currently, environmental consulting is evolving from investigations to creating remediation and engineering solutions. At the same time, the regulatory climate is moving from a rigid structure to a more flexible risk-based approach. These factors, coupled with new Federal and State initiatives that integrate environmental activities into the business process itself, will result in a greater focus on waste minimization, resource recovery, pollution prevention, and the consideration of environmental effects during product development. This shift in focus to preventive management will provide many

new opportunities for environmental scientists and hydrologists in consulting roles.

Much of the above data regarding opportunities for geoscientists, environmental scientists, and hydrologists applies mainly to graduates holding a Masters degree. More specific information provided by The Bureau of Labor, however, indicates promising trends for those possessing a doctoral degree as well. The Bureau predicts an 11.8 percent increase in academic positions, at both universities and community colleges between 2006-2016 and a 6.6 percent increase over the same period in research and development in physical, engineering, and life sciences. The increased opportunities for students possessing a doctorate in geosciences should exceed these numbers because of the expected increase in the number of students pursuing study in the geosciences. In short, more academic positions will be necessary to train more students pursuing Masters and Bachelors degrees.

Other agencies also report promising career opportunities for geoscientists. The American Geological Institute tracks employment trends in geoscience fields. Their data indicate extremely strong growth in the near future (Keelor, Martinez, and Kaleuati, 2005). The petroleum industry alone will need to replace 50% of its workforce in the next ten years (figure 1). Unlike many of the sciences, the geosciences have long attracted women, and in the very near future the number of women seeking geoscience degrees will draw roughly equal to that of men (figure 2), a remarkable statistic for any science discipline. While the numbers at the doctoral level are a bit lower, only life sciences had a higher proportion of female doctorates than that of geosciences. In 2003, geosciences surpassed chemistry in the proportion of female doctorates, a number well ahead of computer science (20%), physics (19%), and engineering (17%). Not all students possessing the Ph.D. degree choose academics, and figure 3 shows that graduates find opportunities in the oil and gas industry, government, and K-12 education (Keelor, Martinez, Kaleuati, 2005).

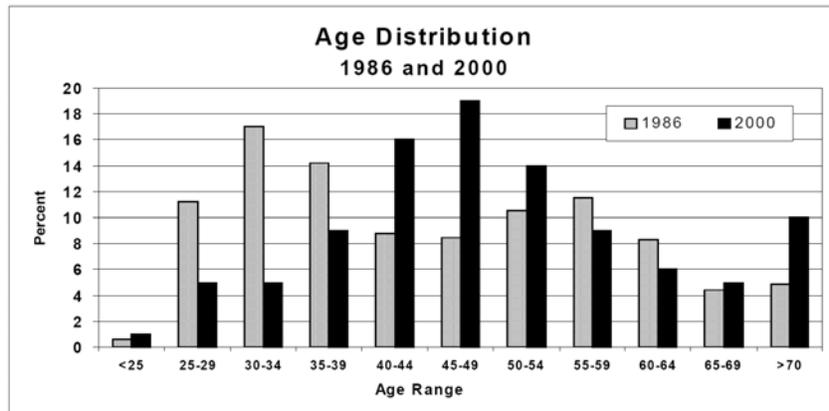


Figure 1. Graph showing the aging workforce in petroleum geology (data from the AGI, 2001)

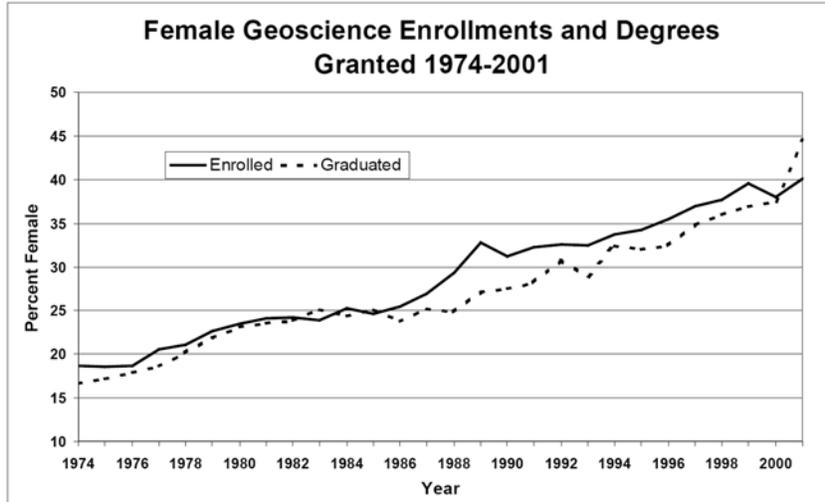


Figure 2. Proportion of women geoscience enrollments and degrees, 1974 to 2001 (AGI, 2001).

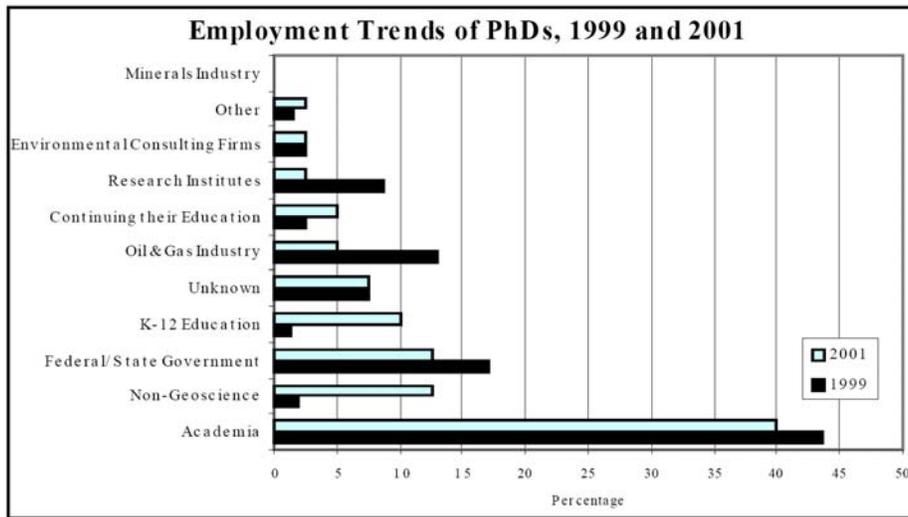


Figure 3. Employment trends for those possessing doctoral degrees in geosciences, 1974 to 2001 (AGI, 2001).

In October, 2007, the Interstate Oil and Gas Compact Commission, which includes governors from 30 states, including Illinois, passed a resolution encouraging an increase in the number of students in petroleum-specific degree programs and research projects. The Commission was responding to a severe shortage in graduates with training in energy resources, particularly petroleum resources. Their resolution called for Congress to “take action that will encourage institutions of higher learning to increase both the number of programs for students and of scholarships available for petroleum-specific degrees.” More recently, the National Science Foundation predicted that the current number of graduates would fail to meet the need for geoscientists to address problems such as climate change, resource depletion, energy sustainability and environmental degradation (GEO Vision: Unraveling Earth’s Complexities

through the Geosciences, October, 2009;
http://www.nsf.gov/news/news_summ.jsp?cntn_id=115717)

The popular press has recognized the increased demand for geoscientists. In an October, 2005 article for Time Magazine, Sean Gregory reported petroleum geology as a career with a low risk of outsourcing. He noted the dramatic increase in salaries, exceeding \$75,000 per year for geoscientists with at least three years experience. Salaries have continued to increase since the publication of this article, with starting salaries in petroleum geology for those with a Masters degree now exceeding \$80,000 per year. Demographics helps to drive this demand; new geoscientists are needed in large numbers with the average age of a petroleum geologist at 49. The mining industry has also scrambled to hire more geologists, driving salaries up dramatically for those with training in natural resource development. In a March, 2008 article posted on Bloomberg.com, Rob Delaney and Stewart Bailey reported that large mining companies are paying geoscience graduates 44% more than three years ago, with salaries sometimes exceeding \$100,000 at the time of hiring and now exceeding that of the average Masters of business administration in the United States. The rising economies of Asian, African, and South American countries not only increase demand for energy resources, but also gold, copper, silver, and other precious metals. The mining industry also suffers from an aging workforce, with as many as half of its workers retiring in the next five years. Delaney and Bailey reported that although the number of graduates will increase in the geosciences over the next three years, the total will still fall about 80% short of the demand. A growing need for geoscientists in energy and natural resources will also increase demand in the environmental geoscience sector, as more and more graduates choose careers in energy and natural resources.

6. Background

Describe the development of the program, including historical and institutional context of the program's development. Also discuss any special needs for this program as expressed by state agencies, industry, research centers, or other educational institutions.

The Department of Geology, Southern Illinois University Carbondale had a more traditional doctoral program in geology from the mid 1980s to the late 1990s. This program had a reputation for high quality, but never achieved high enrollment. The long-term upswing in the demand for geoscientists changes the demographics for a doctoral program in Geosciences, and the interdisciplinary emphasis of the proposed program addresses the changing needs in the field, which should substantially increase overall enrollment. Some faculty in the Department of Geology now participate in the Environmental Resources and Policy doctoral program. This degree program promotes interdisciplinary research in the physical and social sciences. However, an emphasis linking social sciences with the physical sciences does not meet the research objectives of most faculty in the Department of Geology, and other faculty in the College of Science interested in participating in the proposed doctoral program in Geosciences. In the past, a significant number of faculty have felt disenfranchised because they have not been able to attract students into the ER&P program.

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