7. Program Description
Provide a brief narrative description of the program, including a list of its central academic objectives. Explain how the curriculum is structured to meet the program's stated objectives.

The College of Science proposes a progressive, interdisciplinary doctoral program in Geosciences to attract dynamic, talented graduate students to Southern Illinois University Carbondale. Although the program will be housed in the Department of Geology, faculty participating in the program from other departments in the College will have input into admissions, the curriculum, and student research mentoring. We note the strong track record of current Geology faculty in participating in inter-departmental research projects, including an 11-department collaboration on an Interdisciplinary Graduate Education Research and Training (IGERT) proposal led by a member of the geology faculty and now in the final round of competition with NSF. Appendix A lists specific faculty with backgrounds relevant to the Geosciences doctoral program, along with courses offered from across campus appropriate to the program.

8. Admissions Requirements
Provide a brief narrative description of minimum admission requirements.

An admissions committee composed of faculty participating in the doctoral program in Geosciences will make decisions concerning the admission of students to, and retention of students in the doctoral program, subject to the requirements of the Graduate School. At least half of the members of the admissions committee will be from the Department of Geology. Admission is based on an evaluation of the preparation, ability, and promise of the applicant. Admission requirements include GRE test scores; a transcript of all collegiate course work; and three letters of recommendation from professors, academic advisors, or others familiar with the student's academic performance and promise for research. The evaluation of applicants for admission is based primarily on the student's academic record, although additional evidence of scholarly ability or achievement will also be considered in the admission process.

Students entering the doctoral program in Geosciences should meet, as a minimum, the requirements of a Masters degree program in a physical or biological science, mathematics, or engineering. However, exceptional students may be considered for post-baccalaureate accelerated entry into the doctoral program. This requires approval by a majority vote of the faculty participating in the doctoral program in Geosciences.

Upon entering the program, students will have a preliminary counseling conference. The purpose of this conference is to allow the students and their advisors to establish a suitable curriculum and research program commensurate with the students' backgrounds, interests, and career goals.

9. Graduation Requirements
Provide a brief narrative description of all graduation requirements, including, but not limited to, credit hour requirements.

Requirements

The primary objective of the doctoral program in Geosciences is to develop a student capable of successfully conducting original research and the presentation of an acceptable dissertation describing the results, analysis, and implications of that research. To achieve this goal, the

student must meet the criteria established by the University, the Graduate School, and the faculty participating in the doctoral program in Geosciences. The program of study will be flexible, to allow students to take courses offered by departments within the College of Science, and across campus. Each student is expected to take graduate level courses (excluding readings, independent studies, and internship) of at least 3 credits each from at least four different faculty members at SIUC. The program requires a minimum of 48 semester hours, 24 of which may be 600-level dissertation credits.

Before the end of their second year in the program, students shall have (1) established an advisory committee including their dissertation adviser and four additional members (any member of the graduate faculty in the University can serve on the committee, but at least one member must be from a department other than the Department of Geology); (2) demonstrated competence in at least one research tool (the student's advisory committee will determine the requirements and research tool competence); and (3) presented themselves to the advisory committee for a comprehensive written and oral examination. At this time, the student must also select from one of the program concentrations:

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

The format of the comprehensive examinations shall be established by the faculty participating in the doctoral program in Geosciences. Students who fail the comprehensive examinations and wish to remain in the program may, with faculty consent, retake the examinations. Students who fail the second written-oral examination will be dropped from the program. After successful completion of the comprehensive exams, the student must prepare and defend a dissertation proposal. If a student successfully defends the dissertation proposal, he or she is admitted to candidacy for the Ph.D. degree. The comprehensive examinations and dissertation proposal defense are part of the formal assessment process.

As a candidate for the degree of Doctor of Philosophy in Geosciences, the student is expected to make normal progress toward the successful completion and presentation of original research. Ordinarily, the doctoral student should expect to spend a minimum of two years beyond the Masters degree, or its equivalent, in residence. Students will be required to present an acceptable dissertation describing original research performed with minimal supervision and deemed by the advisory committee to be of such quality as to merit publication in appropriate professional journals. A final oral examination will be held after completion of the doctoral dissertation. This examination will concentrate on the defense of the dissertation but is not restricted to the dissertation topic or area. The dissertation will be accepted provided the dissertation advisor and at least three of the other four members of the committee so agree.

Degree requirements, graduation, and time limits are subject to the general guidelines of the Graduate School.

Course Listing

While faculty from different departments in the College of Science are expected to add courses appropriate for the doctoral program in geosciences, the addition of a Ph.D. program will not require specific changes to the course listings. The College, and Department of Geology already

have a wide range of advanced graduate courses listed in the catalog. The addition of a Ph.D. program will make it possible to offer many of these as well as new courses on a more regular basis.

Appendix A lists graduate courses from across campus appropriate for the individual tracks. Appendix B lists the graduate courses within the Department of Geology.

10. Student Outcomes

Explain what students are expected to know and/or be able to do upon completing the program.

The doctoral program in geosciences has three main learning objectives:

1) Students will have further developed their fundamental knowledge of the Geosciences beyond the Masters degree, gaining additional theoretical and practical knowledge of the subject matter in one of the following concentrations:

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

2) Students will be able to conduct independent, original research; creating new knowledge that can pass rigorous peer review. By completion of the degree the students will be expected to have published in, or produced papers for submission to, respected journals appropriate to their research. They will also gain additional competence by presenting the results of their research at seminars and at professional meetings and conferences.

3) Students will obtain an interdisciplinary education, by completing graduate coursework from departments across campus, within the Colleges of Science, Engineering, Agriculture, and Liberal Arts. The proposed program complements existing doctoral programs in engineering, chemistry and biochemistry, plant biology, physics, mathematics, and zoology within the College of Science.

Students completing the program would possess the knowledge and skills to seek academic and industry positions which focus on basic and applied research.

The dissertation advisor and members of the advisory committee will mentor the student by offering continued guidance and support in the selection of courses. Prior to selection of their advisory committee, the Graduate Program Director in the Department of Geology will mentor the student. Student-to-faculty and student-to-student interaction will be promoted by the use of seminars within the College. By its very nature, a doctoral program promotes independent learning; students are required to draft research papers, attend and present papers at seminars and conferences, participate in discussion groups, and assist in teaching and the development of introductory courses.

11. Assessment of Student Learning

Describe how the realization of student outcomes identified above will be measured. Measures may include end- or near-end-of-program assessment of student learning, in addition to course

by-course assessment such as: (1) evaluation of capstone experiences (senior projects, recitals, exhibits, portfolios, etc.); (2) pre- and post-testing (value-added assessment).

Section 14, Program Assessment provides details on assessment measures. Assessment is mainly based on the written and oral comprehensive exams, the dissertation proposal defense, and the dissertation defense. Detailed evaluations associated with these exams will track the student's progress throughout the degree program and allow the faculty to examine each of the student outcomes.

12. Program Accreditation

Describe the institution's plans for seeking programmatic accreditation if applicable.

Geosciences does not have an accreditation body.

13. Graduate Licensure

Indicate if this program prepares graduates for entry into a career or profession that is regulated by the state of Illinois. If so, indicate how the program is aligned with licensure/certification and/or entitlement requirements.

Although the State of Illinois regulates the profession of geology, this mainly impacts graduates with a masters degree, not those holding a doctorate.

Appendix A
Geoscience Doctoral Program Tracks

Biogeochemistry

Description:
The Biogeochemistry track of the proposed doctoral program in geosciences will focus on the interdisciplinary interfaces between traditional geosciences and the chemical, biochemical, chemodynamic, biological, ecological and engineering phenomena which are implicit in both natural and anthropogenic processes occurring in the lithosphere, hydrosphere, atmosphere and biosphere. This track will create a unique option for graduate education and research in advanced geosciences for students with degrees and expertise in the areas of chemistry, atmospheric sciences, terrestrial and aquatic ecology, microbiology, and engineering. The interdisciplinary research conducted by these individuals will prepare them for cross-disciplinary careers in resource utilization and management, environmental impact assessment and remediation, and future energy development. The goal of this track of the Ph.D. program will be to prepare a unique cadre of geoscientists with a broad understanding of biological processes.

Faculty outside of the Department of Geology who could participate in this track:
Jay Means, Chemistry (chemodynamics)/Pharmacology (toxicology) and Dean of COS
Boyd Goodson, Chemistry (protein interactions)
Brian Lee, Chemistry (structural biochemistry)
Matt McCarroll, Chemistry (fluorescence, spectroscopy)
Gabriela Perez-Alvarado, Chemistry (NMR, protein interactions)
Gary Kinsel, Chemistry (MALDI, proteomics)
Luke Tolley, Chemistry (instrumentation development, biological applications)
Qingfeng Ge, Chemistry (materials science and biology, enzyme catalysis)
Lichang Wang, Chemistry (fluorescence sensors)
Dunren Che, Computer Science (bioinformatics)
Michelle Zhu, Computer Science (bioinformatics)
Laurie Achenbach, Microbiology (bioremediation)
Kelly Bender, Microbiology (environmental stress response)
John Haddock, Microbiology (biodegradation)
Sara Baer, Plant Biology (biogeochemistry, restoration)
Loretta Battaglia, Plant Biology (restoration)
Stephen Ebbs, Plant Biology (remediation)
Matt Geisler, Plant Biology (bioinformatics)
David Gibson, Plant Biology (restoration, global environmental change)
Karen Renzaglia, Plant Biology (hornwort biogeography)
Dave Vitt, Plant Biology (biogeochemistry of peatlands)
Richard Halbrook, Zoology (wildlife toxicology)
Mike Lydy, Zoology (aquatic toxicology)
Brian Klubek, Plant Soil Science & Ag Systems, Agriculture (soil microbiology)
Lizette Chevalier, Civil and Environmental Engineering, Engineering (contaminant hydrology)
James Blackburn, Civil and Environmental Engineering, Engineering (environmental processes)
Sanjeev Kumar, Civil and Environmental Engineering, Engineering (soil-structure interactions)
John Nicklow, Civil and Environmental Engineering, Engineering (applied hydrology)
Rolando Bravo, Civil and Environmental Engineering, Engineering (hydrology)
Bruce DeVantier, Civil and Environmental Engineering, Engineering (remediation)
Yanna Liang, Civil and Environmental Engineering, Engineering (bioremediation)
Xingmao (Samuel) Ma, Civil and Environmental Engineering, Engineering (bioremediation)

James Blackburn, Mechanical Engineering Energy Processes, Engineering (bioremediation)
Kanchan Mondal, Mechanical Engineering Energy Processes, Engineering (bioremediation)

Relevant Courses in Geology:

GEOL 413	Quantitative Methods in Geology
GEOL 414	Paleobotany
GEOL 417	Isotope Geochemistry
GEOL 418	Low Temperature Geochemistry
GEOL 419	Ore Deposits
GEOL 420	Petroleum Geology
GEOL 421	Organic Geochemistry
GEOL 425	Invertebrate Paleontology and Paleoecology
GEOL 428	Paleoecology and Environments of Deposition
GEOL 440	Advanced Topics in Geological Sciences
GEOL 454	Field Geology
GEOL 470	Hydrogeology
GEOL 478	Advanced Environmental Geology
GEOL 480	Coal Geology
GEOL 483	Forensic Geology
GEOL 510	Advanced Sedimentology
GEOL 515	Instrumental Analysis in Geology
GEOL 517	Advanced Topics in Geochemistry
GEOL 518	Clay Mineralogy
GEOL 523	Carbonates
GEOL 524	Advanced Topics in Sedimentary Geology
GEOL 525	Advanced Topics in Invertebrate Paleontology
GEOL 526	Advanced Topics in Applied Paleoecology
GEOL 527	Micropaleontology
GEOL 550	Advanced Economic Geology
GEOL 551	Advanced Topics in Economic Geology
GEOL 570	Advanced Hydrogeology
GEOL 576	Coastal Geomorphology and Sedimentology
GEOL 577	Advanced Topics in Surface Geology
GEOL 578	Fluvial Geomorphology
GEOL 579	Soil Geomorphology

Relevant Courses outside of Geology:

CHEM 431	Environmental Chemistry
CHEM 434	Instrumental Analytical Chemistry
CHEM 451	(a and b) Biochemistry
MBMB 456	(CHEM 456, BIOCHEM 456) Biophysical Chemistry
CHEM 462	Classical Physical Chemistry
CHEM 466	Physical Chemistry Laboratory
CHEM 531	Introduction to Analytical Separations
CHEM 532	Analytical Chemistry Instrumentation
CHEM 536	Principles of Mass Spectrometry
CHEM 537	Fluorescence Spectroscopy
CS 438	Bioinformatics Algorithms
MBMB 425	Biochemistry and Physiology of Microorganisms
PLB 426	Plant Genomics and Bioinformatics
PLB 427	Plant Biochemistry

PLB 443	Restoration Ecology
PLB 450	Plant Geography
PLB 471	Bioinformatics
PLB 501	Research Transmission Electron Microscopy
PLB 502	Research Scanning Electron Microscopy
PLB 545	Ecosystem Ecology
PLB 546	Nutrient Cycling Methods
PLB 557	Biostatistics
PLB 558	(ZOOL 558) - Advanced Biostatistics
MBMB 545	Soil Microbiology
ZOOL 411	Environmental Risk Assessment
ZOOL 532	Wildlife Toxicology
ZOOL 534	Wildlife Habitat Analysis
CE 412	Contaminant Flow, Transport and Remediation
CE 418	Water and Wastewater Treatment
CE 471	Groundwater Hydrology
CE 500	Environmental Remediation Technologies
CE 512	Aqueous Systems Analysis

Earth Surface Processes

Description:
The Earth Surface Processes track of the doctoral program in geosciences will focus on geological processes active at, and relevant to the earth-surface system. This system lies at the nexus of several sub-systems, including lithospheric dynamics, the surface and subsurface hydrosphere, the atmosphere, and the biosphere. Geological forms and processes at the Earth's surface reflect the combined and overlapping influences of all these sub-systems. The earth-surface system is also particularly applicable to a broad range of human issues, including natural hazards, natural resources, and pollution and remediation issues. The goal of this track of the PhD program will be to train top-flight geological researchers in the complex and multidisciplinary scientific fields vital to the study of the earth surface.

Faculty outside of the Department of Geology who could participate in this track:
Andrew Balkansky, Anthropology
Prudence Rice, Anthropology
Izumi Shimada, Anthropology
Paul Welch, Anthropology
John Nicklow, Civil and Environmental Engineering
Lizette Chevalier, Civil and Environmental Engineering
Rolando Bravo, Civil and Environmental Engineering, Engineering (hydrology)
Bruce DeVantier, Civil and Environmental Engineering, Engineering (remediation)
Yanna Liang, Civil Environ Eng, Engineering (bioremediation)
Christopher Lant, Geography
Tonny Oyana, Geography
Justin Schoof, Geography
Matthew Therrell, Geography
Guangxing Wang, Geography
Matthew Whiles, Zoology
James Garvey, Zoology
Sara Baer, Plant Biology

Karl Williard, Forestry
Charles Ruffner, Forestry
Jon Schoonover, Forestry

Relevant Courses in Geology:

GEOL 474	Geomorphology
GEOL 478	Advanced Environmental Geology
GEOL 576	Coastal Geomorphology
GEOL 578	Advanced Fluvial Geomorphology
GEOL 421	Organic Geochemistry
GEOL 425	Invertebrate Paleontology
GEOL 428	Paleoecology and Environments of Deposition
GEOL 470	Hydrogeology
GEOL 484	Geologic Remote Sensing
GEOL 510	Advanced Sedimentology
GEOL 517	Advanced Topics in Geochemistry
GEOL 522	Sedimentary Petrology -- Siliciclastics
GEOL 523	Sedimentary Petrology -- Carbonates
GEOL 526	Advanced Topics in Applied Paleoecology
GEOL 570	Advanced Hydrogeology
GEOL 579	Soil Geomorphology

Relevant Courses outside of Geology:

ANTH 410K	Ecological Anthropology
CE 410	Solid Waste Engineering
CE 412	Contaminant Flow, Transport and Remediation in Porous Media
CE 472	Open Channel Hydraulics
CE 473	Hydrologic Analysis and Design
CE 512	Aqueous Systems Analysis
CE 516	Water Quality Modeling
CE 523	Soil Dynamics
CE 572	Advanced Hydraulic Design
CE 573	Modeling of Hydrosystems
FOR 402	Forest Hydrology
FOR 502	Advanced Watershed Hydrology and Management
GEOG 401	Introduction to Geographic Information Systems
GEOG 404	Spatial Analysis
GEOG 406	Introduction to Remote Sensing
GEOG 408	Advanced Remote Sensing
GEOG 425	Integrated Water Management
GEOG 434	Water Resources Hydrology
PLB 440	Grassland Ecology
PLB 443	Restoration Ecology
PLB 444	Quantitative Ecology (Ecology and Analysis of Communities)
PLB 445	Wetland Plant Ecology
PSAS 441	Soil Morphology and Classification
PSAS 442	Soil Physics
PSAS 547	Soils and Environmental Quality
Zool 415	Limnology
Zool 458	Issues in Aquatic Ecology
Zool 521	Stream Ecology

Zool 557	Biostatistics
Zool 558	Advanced Biostatistics

Energy and Mineral Resources

Description:
Exploitable concentrations of energy and mineral resources result from complex interrelated natural processes. Advancing our understanding of energy and mineral resource systems and meeting the unprecedented demands of supplying adequate resources for the global economy will require innovative basic and applied research in the geosciences. The Energy and Mineral Resources track of the proposed doctoral program in geosciences will provide for interdisciplinary studies focusing on the geological, chemical, biological and physical processes relevant to the origin, accumulation, discovery and recovery of energy and mineral resources that are essential for sustaining the world's growing population and rising standards of living. The goal of this track of the proposed PhD program is to provide the cutting-edge, intermultidisciplinary and technology-based training that will prepare and inspire emerging geoscientists to meet future challenges in the study and discovery of mineral and energy resources.

Faculty outside of the Department of Geology who could participate in this track:
Yoginder P. Chugh, Mining and Mineral Resources Engineering
Satya Harpalani, Mining and Mineral Resources Engineering
Manoj Mohanty, Mining and Mineral Resources Engineering
Bradley Paul, Mining and Mineral Resources Engineering
Tomasz Wiltowski, Mechanical Engineering and Energy Processes
Kanchan Mondal, Mechanical Engineering and Energy Processes
Tonny J. Oyana, Geography and Environmental Resources
Guangxing Wang, Geography and Environmental Resources
Gary R. Kinsel, Chemistry
Ling Zang, Chemistry
Luke T. Tolley, Chemistry
Matthew E. McCarroll, Chemistry

Relevant Courses in Geology:

GEOL 414	Paleobotany
GEOL 417	Isotope Geochemistry
GEOL 418	Low Temperature Geochemistry
GEOL 419	Ore Deposits
GEOL 420	Petroleum Geology
GEOL 421	Organic Geochemistry
GEOL 423	Geomicrobiology
GEOL 425	Invertebrate Paleontology and Paleoecology
GEOL 428	Paleoecology and Environments of Deposition
GEOL 435	Solid-Earth Geophysics
GEOL 436	Exploration Geophysics
GEOL 437	Field Geophysics
GEOL 454	Field Geology
GEOL 462	Fundamentals of Structural Geology II
GEOL 466	Tectonics
GEOL 470	Hydrogeology

GEOL 480	Geology of Coal
GEOL 481	Sedimentary Basin Analysis
GEOL 482	Coal Petrology
GEOL 484	Geologic Remote Sensing
GEOL 510	Advanced Sedimentology
GEOL 517	Advanced Topics in Geochemistry
GEOL 522	Sedimentary Petrology – Siliciclastics
GEOL 523	Sedimentary Petrology – Carbonates
GEOL 524	Advanced Topics in Sedimentary Geology
GEOL 525	Advanced Topics in Invertebrate Paleontology
GEOL 526	Advanced Topics in Applied Paleoecology
GEOL 527	Micropaleontology
GEOL 535	Advanced Topics in Geophysics
GEOL 536	Earthquake Seismology
GEOL 537	Applied Seismology
GEOL 538	Gravity and Magnetism.
GEOL 550	Advanced Economic Geology
GEOL 565	Rock Deformation and Structural Systems
GEOL 566	Advanced Topics in Structural Geology
GEOL 551	Advanced Topics in Economic Geology
GEOL 570	Advanced Hydrogeology
GEOL 576	Coastal Geomorphology and Sedimentology
GEOL 578	Fluvial Geomorphology
GEOL 582	Advanced Coal Petrology
GEOL 591	Individual Research in Geology

Relevant Courses outside of Geology:

MNGE 401	Mining Environmental Impacts and Permits.
MNGE 420	Mineral and Coal Processing
MNGE 430	Economics of Mineral Resources
MNGE 431	Rock Mechanics: Principles and Design
MNGE 440	Material Handling Systems
MNGE 455	Mine Environment, Health and Safety Engineering
MNGE 530	Mine Management
MNGE 540	Production Engineering in Coal Mines
MNGE 550	Industrial Minerals
ME 568	Alternative Fuel & Energy
ME 408	Energy Conversion Systems
ME 446	Energy Production & Management
GEOG 401	Introduction to Geographic Information Systems.
GEOG 404	Spatial Analysis.
GEOG 406	Introduction to Remote Sensing
GEOG 408	Advanced Remote Sensing
GEOG 417	GIS Programming and Customization
GEOG 420	Advanced Geographic Information Systems (GIS) Studies
CHEM 411	Intermediate Inorganic Chemistry
CHEM 434	Instrumental Analytical Chemistry
CHEM 444	Intermediate Organic Chemistry
CHEM 451	Biochemistry
CHEM 462	Classical Physical Chemistry
CHEM 511	Advanced Inorganic Chemistry

CHEM 532 Analytical Chemistry Instrumentation
CHEM 533 Analytical Spectroscopy
CHEM 536 Principles of Mass Spectrometry
CHEM 537 Fluorescence Spectroscopy
CHEM 541 Organic Structure and Reactivity
CHEM 549 Advanced Topics in Organic Chemistry
CHEM 552 Biomolecular Structure and Function
CHEM 559 Advanced Topics in Biological Chemistry

Geophysics and Tectonics

Description:
The Geophysics and Tectonics track of the doctoral program in geosciences will offer advanced training in the quantitative physical methods to study the Earth and the forces and movements that cause plate tectonics. The program will provide both a theoretical and applied foundation in exploration and applied geophysics, seismology, geodynamics, gravity and geomagnetism. Applications include fossil fuel and mineral exploration, archaeological geophysics, seismic hazard studies, planetary geology and solid earth deformation studies as well as coupling at multiple time scales between the lithosphere and global climate. The goal of this track of the PhD program is to train the young generation of geoscientists in the geophysical and modeling techniques used today and tomorrow in industrial and academic research.

Faculty outside of the Department of Geology who could participate in this track:
Sanjeev Kumar, Civil and Environmental Engineering
Vijay Puri, Civil and Environmental Engineering
Gary Butson, Civil and Environmental Engineering
Bruce DeVantier, Civil and Environmental Engineering
Kent Hsiao, Civil and Environmental Engineering
Tony Oyana, Geography and Environmental Resources
Justin Schoof, Geography and Environmental Resources
Matthew Therrell, Geography and Environmental Resources
Guangxing Wang, Geography and Environmental Resources
Yoginder Chugh, Mining and Mineral Resources Engineering
Manoj Mohanty, Mining and Mineral Resources Engineering
Bradley Paul, Mining and Mineral Resources Engineering
Naushad Ali, Physics
Andrei Kolmanov, Physics
Aldo Migone, Physics
Leo Silbert, Physics
Mesfin Tsige, Physics

Relevant Courses in Geology:
GEOL 420 Petroleum Geology
GEOL 435 Solid-Earth Geophysics
GEOL 436 Elementary Exploration Geophysics
GEOL 437 Field Course in Geophysics
GEOL 460 Geological Data Processing
GEOL 462 Fundamentals of Structural Geology
GEOL 466 Tectonics
GEOL 470 Hydrogeology

GEOL 474	Geomorphology
GEOL 484	Geologic Remote Sensing
GEOL 535	Advanced Topics in Geophysics
GEOL 536	Earthquake Seismology/Observational seismology
GEOL 537	Applied Seismology
GEOL 538a	Gravity
GEOL 538b	Magnetism
GEOL 565	Rock Deformation and Structural Systems
GEOL 591	Advanced topics in Geophysics

Relevant Courses outside of Geology:

CE 445	Fundamental Theory of Earthquake Engineering
CE 447	Seismic Design of Structures
CE 551	Finite Element Analysis
CE 554	Experimental Mechanics
CS 306	Basic Linux/Unix Programming
CS 406	Basic Linux Systems Administration
CS 471	Optimization Techniques
ECE 355	Systems and signals
ECE 468	Digital Signal Processing
ECE 558	Digital Image Processing
GEOG 404	Spatial Analysis
GEOG 406	Introduction to Remote Sensing
GEOG 408	Advanced Remote Sensing
GEOG 417	GIS Programming & Customization
GEOG 428	GIS and Environmental Modeling
GEOG 431	Climatology
GEOG 436	Natural Hazards
MATH 405	Intermediate Differential Equations
MATH 409	Fourier Analysis
MATH 455	Complex Analysis with Applications
MATH 483	Mathematical Statistics in Engineering and the Sciences
MATH 475	Numerical Analysis
MATH 450	Methods of Advanced Calculus
MATH 406	Linear analysis
MATH 407	Introduction to PDE
MATH 421	Linear algebra
MATH 505	ODE
MATH 507	PDE
MATH 508	Integral Equations
MATH 575	Matrix computations
MATH 566	Continuum mechanics
MNGE 400	Principles of Mining Engineering
MNGE 418	Mining of Ore Deposits
MNGE 430	Economics of Mineral Resources
MNGE 431	Rock Mechanics: Principles and Design
MNGE 535	Rock Fragmentation
PHYS 410	Mechanics II
PHYS 420	Electricity and Magnetism II
PHYS 425	Solid State Physics I
PHYS 500	Mathematical Methods in Physics

PHYS 520	Electromagnetic Theory
PHYS 550	Computational Physics
PHYS 565	Solid State Physics II
PHYS 571	X-Ray Diffraction and Electron Microscopy

Paleobiology

Description:
The Paleobiology track of the proposed doctoral program in geosciences will focus on the study and use of paleontological data in earth systems science. This system represents the dynamic interaction between the geosphere and biosphere. The geosphere plays a significant role in shaping the biosphere. Geologic processes and biotic interactions have been major evolutionary driving forces changing the organic landscape through time. The application of Paleobiological principles is also particularly relevant to a broad range of human issues, including climate change, pollution and our understanding of evolution. The goal of this track of the PhD program will be to train highly talented intellectuals in the field of applied Paleobiology that will be competitive for positions that engage in the complex aspects of paleobiology and the Earth's systems.

Faculty outside of the Department of Geology who could participate in this track:
Robert Corruccini, Anthropology
Susan Ford, Anthropology
Ulrich Reichard, Anthropology
Frank Anderson, Zoology
Roger Thomas, Zoology
Matthew Whiles, Zoology
David King, Zoology
Carey Krajewski, Zoology
Brooks Burr, Zoology
David King, Zoology
Dale Vitt, Plant Biology
Sedonia Sipes, Plant Biology

Relevant Courses in Geology:

GEOL 417	Isotope Geochemistry
GEOL 418	Low Temperature Geochemistry
GEOL 425	Paleontology
GEOL 428	Paleoecology and Depositional Environments
GEOL 476	Quaternary Geology
GEOL 481	Sedimentary Basin Analysis
GEOL 510	Advanced Sedimentology
GEOL 517	Advanced Topics in Geochemistry
GEOL 522	Sedimentary Petrology -- Siliciclastics
GEOL 523	Sedimentary Petrology – Carbonates
GEOL 525	Advanced Topics in Invertebrate Paleontology
GEOL 526	Advanced Topics in Applied Paleoecology

Relevant Courses outside of Geology:

ANTH 410K	Ecological Anthropology
ANTH 440A	Fossil Evidence for Human Evolution
ANTH 440C	Context of Human Evolution

ANTH 500A	Theory and Method in Biological Anthropology
ANTH 530	Seminar in Paleoanthropology
ANTH 534	Seminar in Evolutionary Theory
ANTH 538	Seminar in Primate Evolution
ZOOL 402	Natural History of Invertebrates
ZOOL 404	Evolutionary Biology
ZOOL 405	Systematic Zoology
ZOOL 413	The Invertebrates
ZOOL 415	Limnology
ZOOL 458	Issues in Aquatic Ecology
ZOOL 510	Evolutionary Biology
ZOOL 520	Advanced Invertebrates
ZOOL 521	Stream Ecology
ZOOL 554	Systematic Biology Seminar
ZOOL 557	Biostatistics
ZOOL 558	Advanced Biostatistics
ZOOL 577	Population Ecology
ZOOL 578	Population Genetics
PLB 444	Quantitative Ecology (Ecology and Analysis of Communities)
PLB 445	Wetland Plant Ecology
PLB 450	Plant Geography
PLB 545	Ecosystem Ecology

Appendix B
Catalog Description of Existing Geoscience Courses Included in the Curriculum

412-3 Advanced Petrology. In-depth study of the rock forming processes. The relations of rock forming processes to petrographic analysis will be emphasized. Laboratories will deal with hand-specimen and thin-section analysis from selected rock suites with genetic modeling of the resulting data. Prerequisite: 310, 315.

413-3 Quantitative Methods of Geology. An introduction to quantitative methods in a geological and earth sciences context. Topics introduced include sampling plans for geologic studies, non-parametric test of geological data, comparisons of geological samples, analysis of sequential geological data. Laboratories will deal with numerical examples from all areas of geology. Prerequisite: advanced standing and consent of instructor.

415-3 Optical Mineralogy. The optical properties of minerals and the use of the petrographic microscope for identification of crystals by the immersion method and by thin section. Lecture, laboratory. Prerequisite: 310, Physics 203b or 205b.

417-3 Isotope Geochemistry. Stable and radioactive isotopes and the applications of isotopic studies to igneous and metamorphic petrology, ore deposits, sedimentology, surface processes, geothermometry and geochronology. Introduction to isotopic techniques and mass spectroscopy. Laboratory or research project required. Pre-requisite: 310, 315 and 325 or consent. Recommended: Physics 203, Mathematics 150 and Geology 419.

418-3 Low Temperature Geochemistry. The application of chemical principles to geologic processes that occur on and near the earth's surface. Lecture, laboratory. Prerequisite: 310, Chemistry 200, 201, 210, 211 or equivalent.

419-3 Ore Deposits. Overview of the occurrence, geology and origin of metalliferous mineral deposits. Geologic principles and research techniques important to the understanding of mineral deposits. Introduction to exploration and mining methods. Lectures, laboratories, and field trips. Up to one or two day field trips may be required on weekends. Lab fee: $15. Prerequisite: 302, 315 or consent of instructor.

420-3 Petroleum Geology. The geological occurrences of petroleum including origin, migration and accumulation; a survey of exploration methods, and production problems and techniques. Laboratory study applies geo-logical knowledge to the search for and production of petroleum and natural gas. Prerequisite: 221, 224.

421-3 Organic Geochemistry. The nature, origin and fate of natural and artificial organic materials in rocks and sediments. Topics include characterization of fossil fuels using biological marker compounds, petroleum source rock evaluation, and organic pollutants in the environment. Prerequisite: 325 or consent of instructor.

425-3 Invertebrate Paleontology and Paleoecology. Concepts of paleontology and paleoecology. Emphasis on functional morphology, lifestyles and habitats of fossil invertebrates and algae. The nature and evolution of marine and coastal paleocommunities. The effects of extinction events on paleocommunities and biodiversity. Laboratory. Up to 3 one- or two-day field trips may be required on weekends. Field trips required. Field trip fee = $85. Lab fee: $15. Prerequisite: 325 or a biology course.

428-3 Paleoecology and Environments of Deposition. Characteristics, distribution, and classification of recent and ancient environments. Criteria for recognizing ancient environments. Sedimentological and paleoecological approaches. Recognition of ancient environments and environmental associations. Laboratory. Up to 3 one- or two-day fields trips may be required on weekends. Prerequisite: 425, 325, or concurrent enrollment.

434-3 Engineering and Environmental Geophysics. Geophysical methods used in engineering and environmental site characterization and assessment and the geophysical detection of environmental hazards. Up to 3 one- or two-day field trips may be required on the weekends. Prerequisite: Physics 203a or 205a, 203b or 205b, Mathematics 150.

435-3 Solid-Earth Geophysics. Earth's size, shape, mass, age, composition, and internal structure are re-viewed in detail as understood from its volcanism, gravity and magnetic fields, seismicity and motion of continents and ocean basins; plate tectonics. Up to 3 one- or two-day field trips may be required on weekends. Pre-requisite: 302, Mathematics 150 or consent of instructor.

436-4 Elementary Exploration Geophysics. Theory and practice of geophysics as applied to the exploration and development of natural resources. Laboratory involves use of geophysical instruments and interpretation of data. Up to 3 one- or two-day field trips may be required on the weekends. Prerequisite: 220 or 222; 223, Mathematics 150.

437-3 Field Course in Geophysics. Use of geophysical equipment for collection, analysis and interpretation of seismic, gravity, magnetic, electrical and other types of geophysical data. Up to 10 Saturday field trips may be required. Lab fee: $10 Prerequisite: 436 or consent.

440-1 to 8 Advanced Topics in the Geological Sciences. Individual study or research or advanced studies in various topics. Prerequisite: advanced standing and consent of instructor.

445-3 Museum Studies in Geology. History, nature and purpose of geology in museums, relationships of geology to other museum disciplines, application of geologic methods to museum functions, preparation and preservation of specimens; nature, acquisition and utilization of geologic collections in museums, role of research in museums.

450-2 Introduction to Field Geology. Introduction to field techniques, principles of geologic mapping and map interpretation. Field trip fee $5.00. Prerequisite: 302, 315 or concurrent enrollment.

451-1 to 12 Field Experience in Geology. Preparation for and participation in academically rigorous field trips guided by faculty members. Trips will be to areas of geological interest and will occur during official breaks within or between semesters. Expenses will vary in proportion to the distance traveled and duration of trip and will be determined before each trip. A student may only take a specific trip once for credit. Prerequisite: consent of instructor.

454-6 Field Geology. Advanced field mapping in the Rocky Mountains, including problems in stratigraphy, structure, petrology, paleontology, geomorphology, and economic geology. Lab fee $250. Prerequisite: 302, 315, 325; 450 recommended.

460-3 Geological Data Processing. Computer applications to geological problems including the processing and programming of data and the interpretation and evaluation of results. Lecture, laboratory. Prerequisite: Engineering 222 or Computer Science 202.

462-3 Fundamentals of Structural Geology II. Intermediate topics in structural geology including strain theory, field strain analysis, geometry of complex mesoscopic structures and introduction to dislocations, deformation history and microfabric analysis. Hypotheses and orogenesis are discussed and evaluated. Lecture and assigned problems only. Prerequisite: 302 or equivalent.

466-3 Tectonics. Fundamentals of geodynamics applied to plate tectonics: mantle composition and rheology, deformation of the lithosphere, structural characteristics of plate margins, stability of triple junctions, diachronous tectonics, and orogenesis will be examined in detail. Up to 3 one or two day field trips may be required on weekends. . Prerequisite: 302, Mathematics 150 or consent of instructor.

470-3 Hydrogeology. Study of the distribution, origin and movement of groundwater and the properties of geologic materials that control groundwater flow and contaminant transport. Geology majors must also take 471 concurrently. Prerequisite: 220 or 222; 223; Mathematics 150, or consent of instructor.

471-1 Hydrogeology Laboratory. Problem sets, laboratory experiments, and field exercises in hydrogeology. Geology majors must take this course concurrently with 470. Prerequisite: 220 or 222; 223; Mathematics 150; or consent of instructor.

474-3 Geomorphology. Study of erosional and depositional processes operating at the earth's surface and landforms resulting from these processes. Relationship of processes and landforms to the geologic framework is examined. Laboratory. Up to 3 one- or two-day field trips may be required on weekends..Prerequisite: 220 or 222; 223.

476-3 Quaternary Geology. Methods used to identify, map, date and correlate Quaternary deposits and interpret Quaternary history. Covers glacial, fluvial, coastal, lacustrine and eolian chronologies, oxygen-isotope re-cords from ocean sediments and continental ice cores, volcanic activity and Quaternary climate change. Field trips required. Prerequisite: 220 or 222; 223, 221, 224; or consent of instructor; 474 recommended.

478-3 Advanced Environmental Geology. Application of principles of geomorphology and Quaternary geology to environmental problems and geologic hazards. Lectures and case studies emphasize neotectonics, volcanic hazards, landslides and other mass movements, floods, river channel changes and coastal erosion. Up to 3 one- or two-day field trips may be required on weekends. Prerequisite: 474; 476 recommended.

480-3 Geology of Coal. Geology as related to exploration, development and mining of coal; stratigraphy, sedimentation and structure of coal deposits; type of coal basins and their tectonic setting; concepts of cyclical deposition in coal basins; origin of splits and partings in coal seams; relationship of modern environments and ancient coal-forming environments; structural problems relevant to exploration and mining of coal; methods of resource evaluation. Three 1-hour lectures week; five half-day field trips. Prerequisite: 220 or 222; 223, 221, 224, 302, 325, or consent of instructor.

481-3 Sedimentary Basin Analysis. The use of stratigraphy, structure, sedimentology and geophysics to determine the paleogeographic evolution of sedimentary basins. Topics include the study of the relationships between host strata and both primary and post-depositional non-

renewable resources, plate tectonics and basin evolution and subsurface geologic methods. Prerequisite: consent of instructor.

482-3 Coal Petrology. Structural features and microscopy of coal seams. Origin and alteration of coal constituents. Includes field trips, study of coal specimens and techniques. Prerequisite: 220 or 222; 223, 221, 224; or consent of instructor.

483-3 Forensic Geology. An introduction to the use of geological materials and techniques in criminal investigation. Details from actual criminal cases will be used as examples in all the topics covered which include rock and mineral types, geological and topographic maps, fossils, sand, soils, spores and pollen, geological building materials, art fraud and gemstones. Techniques covered will include optical microscopy, scanning electron microscopy, and x-ray diffraction.

484-3 Geologic Remote Sensing. Applications of remote sensing using aerial photographs, multi-spectral imagery, hyperspectral imagery, thermal infrared imagery, and radar imagery, in structural geology, stratigraphy, geomorphology, oil and mineral exploration, geologic hazard analysis, and planetary exploration. Prerequisite: 220 or consent of the instructor.

500-1 to 2 Teaching for Geology Graduate Students. To help teaching assistants develop skills in conducting laboratory work and leading discussions. One hour required for all teaching assistants in geology. Graded S/U only.

510-2 Advanced Sedimentology. Basic principles of field observation, field and laboratory sampling, and data analysis of clastic sedimentary rocks; introduction to laboratory techniques; introduction to statistical, physical and empirical models in sedimentary geology. Field trips required. Prerequisite: 325 or 474.

515-3 Instrumental Analysis in Geology. An introduction to modern methods of instrumental inorganic geo-chemical analysis that are particularly important in the geology sciences. This includes both operational theory and practical application of methods for the analysis of minerals, rocks and aqueous solutions. Lecture, laboratory. Prerequisite: 310, Chemistry 222 or equivalent, and consent of instructor; 418 recommended.

517-2 to 9 (2 to 6 per semester) Advanced Topics in Geochemistry. Specialized topics in geochemistry. Topics covered might include thermodynamic modeling of mineral-solution equilibria, the role of kinetics in mineral-solution reactions, experimental hydrothermal geochemistry or other topics to be announced by the department. Maximum credit nine semester hours. Prerequisite: 418 or consent of instructor.

518-3 Clay Mineralogy. Study of the structure, chemistry, origin, and geologic importance of clay minerals. Industrial and other applications of clays. Lecture, laboratory. Prerequisite: 310 or consent.

520-2 to 9 (2 to 6 per semester) Advanced Topics in Igneous and Metamorphic Petrology. Petrologic principles and their relationships and other selected topics to be announced by the department. Prerequisite: consent of instructor.

522-3 Sedimentary Petrology—Siliciclastics. The petrography and petrology of siliciclastic rocks, emphasizing sandstone. Microscopic studies of composition and components of detrital clastic rocks, their origin, provenance, characteristics, diagenesis, cementation and lithification. Prerequisite: 325 or 415 or consent; 520 or 521 recommended.

523-3 Sedimentary Petrology—Carbonates. The origin, classification, diagenesis, and geochemistry of carbonate rocks, with emphasis on petrographic analysis. Study of recent carbonate depositional environments. Laboratory required. Prerequisite: 325, 418 recommended.

524-2 to 9 (2 to 6 per semester) Advanced Topics in Sedimentary Geology. Advanced topics in sedimentary geology. Topics may include clastic depositional environments, carbonate depositional environments; diagenesis of sedimentary rocks, and other topics to be announced by the department. Up to 3 one- or two-day field trips may be required on the weekends. Prerequisite: 428 or 522 or 523 or consent of instructor.

525-2 to 6 (2 to 3 per semester) Advanced Topics in Invertebrate Paleontology. Lectures, readings, field and laboratory studies, including techniques and quantitative methods of study. Preparation for research in paleontology. Topics may include corals, bryozoans, brachiopods, mollusks, echinoderms, biostratigraphy, tempo and mode of invertebrate evolution and other topics to be announced by the department. Maximum credit six semester hours. Prerequisite: 425 or consent of instructor.

526-3 Advanced Topics in Applied Paleoecology. Lectures, field, and laboratory studies, including techniques and quantitative methods. Preparation for research in paleoecology. Emphasis on using fossil marine invertebrates and trace fossils to interpret ancient sedimentary environments. Prerequisite: 428 or consent.

527-3 Micropaleontology. Structure, classification, paleoecology, stratigraphic distribution, and evolution of microfossils. Laboratory work in techniques of collection, preparation and study of microfossils. Identification and use of microfossils in solving stratigraphic and paleoenvironmental problems. Preparation for research in micropaleontology. Up to 3 one- or two-day field trips required on weekends. Field trips required. Field trip fee=$85. Prerequisite: 425 or consent of instructor.

535-1 to 9 (1 to 6 per semester) Advanced Topics in Geophysics. Specialized topics in geophysics. Examples include but are not limited to seismic stratigraphy, mid-continent seismicity, isostacy, data processing techniques. The topic to be covered is announced by the department. Maximum credit nine semester hours. Up to 3 one- or two-day field trips may be required on weekends. Prerequisite: 435 or 436 or consent of instructor.

536-3 Earthquake Seismology. Observational seismology. Topics include earthquake source mechanisms; propagation, reflection and refraction of elastic waves; ray theory; dispersion of surface waves; the effect of earth structure on the seismogram; and the seismograph. Research projects will be conducted using data from the SIU Geophysical Observatory. Up to 3 one- or two-day field trips may be required on weekends. Prerequisite: 435 or 436, Mathematics 150 or consent of instructor.

537-3 Applied Seismology. Study of the seismic reflection techniques, including theory and methods of collection and analysis of seismic reflection data, the seismic method, waveform analysis, and digital filtering with computer applications and seismic instrument characteristics. Up to 3 one- or two-day field trips may be required on weekends. Prerequisite: Mathematics 150 or consent.

538-6 (3,3) Gravity and Magnetism. (a) Gravity. Study of gravitational methods used in the solution of geo-logical problems; topics include theory, field operations, data reduction, anomaly

separation, two and three-dimensional analysis, and interpretation. Up to 5 one- or two-day field trips may be required on the weekends. (b) Magnetism. Study of magnetic methods used in the solution of geological problems; topics include theory, origin, time variations and induction, paleomagnetism, magnetic properties of earth materials. Field operations, anomaly separation, and interpretation. Up to 5 one- or two-day field trips may be required on the weekends. Prerequisite: 435 or 436, Mathematics 150 or consent of instructor.

550-4 Advanced Economic Geology. In-depth examination of the geologic characteristics, classification and origin of metallic mineral deposits. Aspects of mineral exploration and mining techniques are also discussed. Laboratory exercises emphasize hand specimen and petrographic study of ore and host rock suites. Up to 3 one- or two-day field trips may be required on the weekends.

555-1 to 6 (1 to 3 per semester) Advanced Topics in Economic Geology. Advanced study in a specific area of economic geology to be determined by course participants. Course content may focus on a specific type of mineral deposit or such topical areas as field characteristics, mineral exploration techniques, stable isotope geo-chemistry, fluid inclusion studies and hydrothermal processes. Maximum six credit hours. Field trips may be required on up to 3 weekends and possibly over Spring vacation. Prerequisite: 550.

565-3 Rock Deformation and Structural Systems. Advanced topics in structural geology with emphasis on theoretical and experimental study of rock deformation and analysis of complex structural systems. Lecture and assigned problems only. Prerequisite: 462.

566-3 Advanced Topics in Structural Geology. Lectures, readings, and discussion of advanced aspects of rock deformation: dislocation theory and its applications to flow processes of rocks; experimental rock deformation; incremental and finite strain theory and analysis; and recent developments in structural geology. Prerequisite: 565.

570-3 Advanced Hydrogeology. A combination of lectures, seminars, and independent studies of advanced topics in hydrogeology, particularly geochemistry and the response of aquifers to stresses such as tides, recharge and saline intrusion. Prerequisite: 470.

576-3 Coastal Geomorphology and Sedimentology. Detailed examination of coastal processes and clastic coastal depositional systems. Coastal storms, wave processes, tidal systems, sea level changes, coastal sediment transport, deltaic, barrier island strandplain, estuarine depositional systems and coastal stratigraphic sequences. Field trip to Louisiana and Texas Gulf Coast required. Field trip fee: $35. Up to 3 one- or two-day field trips may be required on weekends. Prerequisite: 474 or consent of instructor.

577-2 to 9 (2 to 6 per semester) Advanced Topics in Surficial Geology. Studies of processes, landforms, and deposits in the surface or near surface geologic setting. Selected topics to be announced by the department. Maximum credit nine semester hours. Prerequisite: consent of instructor.

578-3 Fluvial Geomorphology. Detailed study of fluvial processes and landforms within the context of major concepts in geology and geomorphology. Topics include drainage basins, hydro-climatology and surface water hydrology, channel processes, fluvial depositional systems, paleohydrology and changes in fluvial systems through time. Field trips required. Field trip fee: $35. Prerequisite: 474 and consent instructor.

579-3 Soil Geomorphology. Study of geomorphologic applications of soils. Covers the effects of time, climate, parent material, topography, eolian additions on soil development, classification and chemistry; soil indices; pedogenic thresholds; paleosols; use of soils to evaluate landform age, landform stability, Quaternary stratigraphy, faulting and climate fluctuations. Field trips required. Prerequisite: 474 or consent of instructor.

582-1 to 6 (1 to 3 per semester) Advanced Coal Petrology. Microscopy, source materials, coalification, constitution, and classification of peats, lignites, bituminous coal, anthracite; applications to industrial problems. Prerequisite: 482.

585-3 Earth and Space Science for Teachers. Class designed to help teachers gain an understanding of some of the earth science concepts they need to teach today's standards-based curricula. Develops an under-standing of earth materials, how the earth works, earth resources, the causes of natural disasters, and the exploration of the bodies of our solar system. Prerequisites: A general physical science course or equivalent and consent of the department.

591-1 to 6 Individual Research in Geology. Investigations in geology other than those for theses or dissertations.

599-1 to 6 Thesis. Minimum of three hours to be counted toward a Master's degree.

600-1 to 30 (1 to 16 per semester) Dissertation. Research for and writing of the doctoral dissertation. Pre-requisite: consent of instructor.

601-1 per semester Continuing Enrollment. For those graduate students who have not finished their degree programs and who are in the process of working on their dissertation, thesis, or research paper. The student must have completed a minimum of 24 hours of dissertation research, or the minimum thesis, or research hours before being eligible to register for this course. Concurrent enrollment in any other course is not permitted. Graded S/U or DEF only.