

Geology

COLLEGE OF SCIENCE

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Graduate Faculty:

Anderson, Ken B., Professor, Ph.D., University of Melbourne, Australia, 1989; 2004. Organic geochemistry.

Conder, James, Associate Professor, Ph.D., Brown University, 2001; 2008. Geodynamics, seismology.

Crelling, John C., Professor, *Emeritus*, Ph.D., Pennsylvania State University, 1973; 1977.

Esling, Steven P., Associate Professor and *Chair*, Ph.D., University of Iowa, 1984; 1982. Hydrogeology, quaternary stratigraphy, geomathematics.

Ferre, Eric C., Professor, Ph.D., University of Toulouse, France, 1989; 2003. Structural geology, rock magnetism, tectonics.

Fifarek, Richard H., Associate Professor, *Emeritus*, Ph.D., Oregon State University, 1985; 1985.

Filiberto, Justin, Associate Professor, Ph.D., Stony Brook University, 2006; 2011. Igneous petrology, planetary, petrology, geochemistry.

Hummer, Daniel R., Assistant Professor, Ph.D., The Pennsylvania State University, 2010, 2016. Mineralogy, petrology, high temperature geochemistry.

Ishman, Scott E., Professor, Ph.D., The Ohio State University, 1990; 1999. Paleocology, Cenozoic paleobiology, foraminifera.

Lefticariu, Liliana, Associate Professor, Ph.D., Northern Illinois University, 2004, 2007. Isotope geochemistry, environmental geochemistry.

Marzolf, John E., Associate Professor, *Emeritus*, Ph.D., The University of California, Los Angeles, 1970; 1982.

Potter-McIntyre, Sally, Assistant Professor, Ph.D., University of Utah, 2013; 2013. Sedimentology and stratigraphy.

Rimmer, Sue, Professor, Ph.D., Pennsylvania State University, 1985; 2009. Coal geology and petrology, source-rock geochemistry.

Sexton, John L., Professor, Ph.D., Indiana University, 1974; 1985. Geophysics, seismic reflection and refraction.

The Department of Geology offers programs leading to the Master of Science degree (thesis required), a Master of Arts degree in Earth Sciences (thesis not required), a Graduate Certificate in Earth Sciences, and a Doctor of Philosophy degree in Geosciences. Students may also pursue a Doctor of Philosophy degree in the geological sciences under the auspices of the interdisciplinary doctoral program in *Environmental Resources and Policy* (ER&P). For details, refer to the Environmental Resources and Policy entry in this catalog.

All graduate programs require a nonrefundable \$65 application fee that must be submitted with the application for Admissions to Graduate Study in Geology. Applicants must pay this fee online by credit card.

Graduate Programs

The objectives of the graduate degree programs are to develop the student's competence in the basic fields of earth science and to provide for specialization dependent on student and faculty

interest. Facilities and staff are available for studies involving environmental geology, geomorphology, hydrogeology, paleontology, micropaleontology, paleoecology, coal petrology, coal geology, Pleistocene geology, environmental geochemistry, molecular organic geochemistry, solid earth geophysics, environmental geophysics, applied geophysics, geographic information systems, remote sensing, surface and subsurface mapping, structural geology, stratigraphy, sedimentation, sedimentary petrology, sedimentary environments, ore deposits, petrology, mineralogy, crystallography, energy resources, and petroleum geology. Many of the faculty are actively conducting research in which statistical and computer techniques are applied to problem solving in the earth sciences. Interdisciplinary research with other departments is encouraged.

SIU Geology faculty and graduate students conduct internationally-recognized research all over the globe. In North America, there are current and recent research efforts in locations ranging from Alaska to Florida, from Nova Scotia to the Sonoran Desert. Farther afield, SIU Geology researchers are active in Antarctica, Asia, South America, South Africa, and Europe. The Southern Illinois region itself offers a wide variety of geological conditions ideal for individual study and research.

Students must be admitted unconditionally to the Graduate School before they can be officially admitted to the graduate program in geology. Admission to the graduate program in geology is based on an evaluation of the preparation, ability, and promise of the applicant. Prerequisites for admission include: 1) receipt of GRE test scores sent directly to the Department of Geology; 2) completion of the online application; and 3) receipt of at least three letters of recommendation from professors, academic advisers, former employers, or others familiar with the applicant's academic performance, research, or other relevant work. The Department of Geology normally admits graduate students for entrance in the fall semester; however, applicants will be considered for spring admission.

A student admitted with course deficiencies may be required to complete or audit some undergraduate courses. First year teaching assistants are required to enroll in and complete GEOL 500. Other specific requirements will be determined by the student's advisory committee. Students are evaluated on an individual basis. Their programs are determined by their career goals and the results of informal interviews with individual faculty members.

Requirements for the Master of Science Degree (Thesis Option)

- A total of 30 hours of graduate work completed with a grade point average of 3.0 or better constitutes the minimum credit requirement for the master's degree.
- Courses taken are determined by the student and an advisory committee. The student will not be allowed to apply more than eight hours of independent study or research courses toward the master's degree (exclusive of thesis credits).
- A student majoring in geology may select a minor field. The minimum course work should then include 20 hours of geology and 10 hours in the minor field.

- A thesis subject must be approved by the chair of the advisory committee at least 20 weeks before the date of graduation.
- A final oral examination, primarily concerned with defense of the thesis is administered as the last step before graduation. The student may be asked any questions the committee feels are relevant.
- In order to pass the final oral examination, students must receive a favorable majority vote from their thesis committee meeting in formal session. Should the student fail the final oral examination, the student, upon concurrence of a majority of the committee, may arrange a time for a re-examination not less than 30 nor more than 120 days after the first examination. Students who fail the final orals on their second attempt will be ineligible for the master's degree from the Department of Geology.
- Two copies of the approved thesis must be presented to the Graduate School at least three weeks prior to graduation, and a third copy must be presented to the Department of Geology.

Requirements for the Master of Arts Degree in Earth Sciences

The Master of Arts Degree in Earth Sciences is open to post baccalaureate students with degrees in earth science, geology, or related fields. Two fields of concentration are available: *Geospatial Analysis* and *Environmental Geology*. It is intended to expand the knowledge, skills, and specialized training in geological topics. The courses taken will be determined by interests of the individual student, but must be approved by the student's three-person departmental advisory committee. At least three (3) credits of GEOL 591, Individual Research in Geology must be taken.

Recommended Courses for the Geospatial Analysis

Concentration:

- GEOL 420 (3) Petroleum Geology
- GEOL 428 (3) Paleocology and Environments of Deposition
- GEOL 435 (3) Solid-Earth Geophysics
- GEOL 466 (3) Tectonics
- GEOL 474 (3) Geomorphology
- GEOL 476 (3) Quaternary Geology
- GEOL 478 (3) Advanced Environmental Geology
- GEOL 481 (3) Sedimentary Basin Analysis
- GEOL 484 (3) Geologic Remote Sensing
- GEOL 526 (3) Advanced Topics in Applied Paleocology
- GEOL 535 (3) Advanced Topics in Geophysics
- GEOL 536 (3) Earthquake Seismology
- GEOL 538A,B (3) Gravity and Magnetism
- GEOL 576 (3) Coastal Geomorphology and Sedimentology
- GEOL 577 (3) Advanced Topics in Surficial Geology
- GEOL 578 (3) Fluvial Geomorphology
- GEOL 579 (3) Soil Geomorphology
- GEOL 591 (3) Individual Research in Geology
- GEOG 420 (3) Advanced Geographic Information Systems Studies

Recommended Courses for the Environmental Geology

Concentration:

- GEOL 417 (3) Isotope Geochemistry
- GEOL 420 (3) Petroleum Geology
- GEOL 421 (3) Organic Geochemistry
- GEOL 428 (3) Paleocology & Environments of Deposition
- GEOL 470 (3) Hydrogeology
- GEOL 471 (1) Hydrogeology Laboratory
- GEOL 474 (3) Geomorphology
- GEOL 476 (3) Quaternary Geology
- GEOL 478 (3) Advanced Environmental Geology
- GEOL 481 (3) Sedimentary Basin Analysis
- GEOL 484 (3) Geologic Remote Sensing
- GEOL 517 (3) Advanced Topics in Geochemistry
- GEOL 526 (3) Advanced Topics in Applied Paleocology
- GEOL 527 (3) Micropaleontology
- GEOL 576 (3) Coastal Geomorphology and Sedimentology
- GEOL 577 (3) Advanced Topics in Surficial Geology
- GEOL 578 (3) Fluvial Geomorphology
- GEOL 579 (3) Soil Geomorphology
- GEOL 591 (3) Individual Research in Geology
- GEOG 420 (3) Advanced Geographic Information Systems Studies

Graduate Certificate

The Certificate in Earth Science with an optional concentration in Geospatial Analysis or Environmental Geology is open to post baccalaureate students with degrees in earth science, geology, or related fields. It is intended to expand the knowledge, skills, and specialized training in geological topics. The course work will include eighteen (18) graduate credit hours in Geology. While there are no specific courses required, the courses taken will be determined by the student and the departmental Coordinating Committee. For the concentrations in Geospatial Analysis and Environmental Geology, please refer to the recommended course lists above for the Non-Thesis Master's program.

Students must maintain a *B* average in graduate courses and must follow the rules of the Certificate Policy established by the Graduate School. Maximum time allowed to complete the requirements for the certificate is five years.

Requirements for the Doctor of Philosophy Degree in Geosciences

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 SIU. 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 Master's 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.

Environmental Resources and Policy Doctoral Program

The central focus of the Environmental Resources and Policy Ph.D. is advanced interdisciplinary training and research on geological, physical, biological, and social processes responsible for natural resource and environmental problems facing contemporary society. Additionally, the ER&P Ph.D. focuses on assessing public policy alternatives to address those problems and create new opportunities.

Within the broad and flexible ER&P framework, a customized program is developed for each student, permitting him/her to conduct research in traditional and non-traditional earth science sub disciplines, under the direction of one or more Geology faculty members. The program is jointly guided by the Department of Geology, the Department of Geography and Environmental Resources, and the College of Agricultural Sciences (Departments of Agribusiness Economics; Forestry; and Plant, Soil, and Agricultural Systems), with support from the School of Law, the College of Engineering, other key faculty at SIU, and State of Illinois environmental agencies. Please see the Environmental Resources and Policy section of this catalog for detailed information and admission procedures.

Assistantships

Teaching assistantships are awarded and supervised by the Department of Geology. Research assistantships are usually available only from research grants of individual faculty members and are supervised by the faculty member in receipt of the sponsoring grant. Research assistantship awards require prior approval of the assistantship committees of the department. Students in the Geology Master of Science program, the Geosciences Ph.D. Program, and the Environmental Resources and Policy Ph.D. program are eligible to apply for teaching and research assistantships from the Department of Geology.

As a matter of policy, the Department of Geology does not ordinarily provide any student working on a master's degree financial support for more than two years, or four years for doctoral students. Requests for relaxation of this policy must be made in writing to the department chair.

Courses (GEOL)

Courses with a laboratory may require purchase of a laboratory manual and a supply fee. All courses requiring field trips may have a field trip fee.

GEOL 401-3 Physical Nature of the Earth for Teachers. This is an on-line course that offers an overview of the materials that form the Earth and the dynamic processes that shape the Earth, including both surficial processes and plate tectonics. This course will cover content appropriate for science teachers preparing to teach Physical Geology as a Dual-Credit course in high schools. Topics include: components and processes that create rocks and the cycles that change one rock into another; how plate tectonics has shaped the Earth; surficial processes (weathering, landslides, movement of ice, water, and wind); hazardous processes (earthquakes, volcanoes, flooding); and resources such as water, soil, and mineral and energy sources. This course is designed to be taken in conjunction with GEOL 402, a 1-hr laboratory course. Only open to students in the Dual Credit Certificate for Teachers program.

GEOL 402-1 Physical Nature of the Earth Laboratory for Teachers. Through active learning activities, this course offers examination of the materials that form the Earth and the dynamic processes that shape the earth, including surficial processes and plate tectonics. This course will cover content appropriate for science teachers preparing to teach labs associated with Physical Geology as a Dual-Credit course in high schools. This is offered as a hybrid distance education (on-line) class and includes both at-home and in-class laboratory assignments. For the in-class components, students will come

to SIUC's campus for 2 half days (Saturdays) as indicated in the schedule. This course is designed to be taken in conjunction with GEOL 401, a 3-hr online course in which the students learn about earth materials and earth processes in greater depths. Only open to students in the Dual Credit Certificate for Teachers program.

GEOL 403-3 Historical Geology Teacher Enhancement. GEOL 403 is an online course designed to train science teachers to teach Historical Geology as a Dual Credit course in high schools. This course covers the basic principles involved in the study of geology and the history of the Earth preserved in the rock record. We begin with the large-scale components of Earth systems and geologic time, and then learn about the evolution of life recorded in the fossil record from the earliest life through the present. This course covers not just WHAT we know, but how we know it. This course is designed to be taken in conjunction with GEOL 404, a 1-hr laboratory course. Only open to students in the Dual Credit Certificate for Teachers program.

GEOL 404-1 Historical Geology Teacher Enhancement Lab. GEOL 404 is the laboratory section that accompanies the online Historical Geology Teacher Enhancement. This laboratory course offers hands-on activities to complement the online lectures and will provide teachers with a structure to teach labs in their own Dual Credit high school courses. This course covers the basic principles involved in the study of geology and the history of the Earth preserved in the rock record. We study sedimentary rocks, and learn how to read the clues to past environments and life preserved within samples. This course is done partially at home, but requires a six hour in house lab session. Only open to students in the Dual Credit Certificate for Teachers program.

GEOL 405-2 Science Writing and Scientific Communication. Course will teach "survival skills" in scientific reading, writing, communicating, and publishing for new graduate students. Topics will include database search, analysis of journal articles, abstracts, figures, and tables, Powerpoint presentations, proposals, posters, thesis writing, and preparation of journal submissions. Enrollment is open to graduate students in the sciences and is by permission of the instructor.

GEOL 411-3 Volcanology. Study of volcanoes, their distribution, forms, composition, eruptive products and styles of potential hazards. Relationship of magmatic characteristic, eruptive style, and depositional products to the geologic framework is examined. Prerequisite: GEOL 315.

GEOL 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: GEOL 310, 315.

GEOL 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. Restricted to advanced standing. Special approval needed from the instructor.

GEOL 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: GEOL 310, PHYS 203B or 205B.

GEOL 416-3 The Geochemistry of Natural Waters. The purpose of this class is to provide students with a strong theoretical background in aqueous geochemistry, environmental geochemistry, and groundwater geochemistry for application in a wide range of research topics. The approach combines conceptual knowledge with quantitative skills in a cyclic fashion to build independent understanding and chemical intuition. Prerequisites: GEOL 310, CHEM 200, 201, 210, 211 or consent of instructor. Lab fee: \$15.

GEOL 417-3 Isotope Geochemistry. Isotope fractionation in natural systems containing D/H, carbon, oxygen, nitrogen, and sulfur. Application of stable isotope studies to environmental processes, paleoclimatology, and geothermometry. Stable and radioactive isotopes as tracers in hydrologic processes, ore deposits, sedimentology, and in crust-mantle differentiation processes. Prerequisite: GEOL 310, CHEM 200, 201, 210, 211, or equivalent.

GEOL 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: GEOL 310, CHEM 200, 201, 210, 211 or equivalent.

GEOL 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 required. Prerequisite: GEOL 302, 315 or consent of instructor. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$60.

GEOL 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 geological knowledge to the search for and production of petroleum and natural gas. Prerequisite: GEOL 221, 224.

GEOL 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: GEOL 325 or consent of instructor.

GEOL 423-3 Geomicrobiology. (Same as MICR 423 and MBMB 423) The course will focus on the role that microorganisms play in fundamental geological processes. Topics will include an outline of the present understanding of microbial involvement of weathering of rocks, formation and transformation of soils and sediments, and genesis and degradation of minerals. Elemental cycles will also be covered with emphasis on the interrelationships between the various geochemical cycles and the microbial tropic groups involved. Prerequisite: Microbiology 301 and Chemistry 210 and 211. Recommended: GEOL 220, 221 or 222.

GEOL 425-3 Invertebrate Paleontology and Paleoecology. (Same as ZOO 425) 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. Field trips required. Prerequisite: GEOL 325 or a biology course. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$199.

GEOL 428-3 Paleocology 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. Field trips required. Prerequisite: GEOL 425, 325, or concurrent enrollment. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$199.

GEOL 430-3 Planetary Geology. Study of the solar system and planet formation, focusing on formation, differentiation and secondary processes. Geologic histories and geological processes of other planets are examined and compared with our understanding of the Earth. Prerequisite: GEOL 310.

GEOL 435-3 Solid-Earth Geophysics. Earth's size, shape, mass, age, composition, and internal structure are reviewed 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. Prerequisite: GEOL 302, MATH 150, or consent of instructor.

GEOL 436-3 Applied Geophysics. Theory and practice of geophysics applied to exploration for natural resources including oil, minerals, coal, groundwater, and for archaeology, environmental, and meteorite impact sites and earthquake zones. Methods include seismic reflection, refraction, and surface waves also gravity, magnetic, and electrical. Up to 3 one-day field trips may be conducted on weekends. Recommend: GEOL 220 or 222, PHYS 203A/B or PHYS 253A/B. Prerequisite: MATH 150. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$80.

GEOL 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. Field trips required. Prerequisite: GEOL 436 or consent. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$199.

GEOL 440-1 to 8 Advanced Topics in the Geological Sciences.

Individual study or research or advanced studies in various topics. Restricted to advanced standing. Special approval needed from the instructor.

GEOL 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.

GEOL 450-3 Introduction to Field Geology. Introduction to field techniques, principles of geologic mapping and map interpretation. Expense will vary in proportion to distance

traveled and locations visited and will be determined before each semester. Prerequisite: GEOL 310 with a grade of C or better.

GEOL 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. Expense 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. Special approval needed from the instructor.

GEOL 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. One 3-day field trip is required. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$150. Prerequisite: GEOL 302, MATH 150, or consent.

GEOL 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 GEOL 471 concurrently. Prerequisite: GEOL 220 or 222; or consent of instructor.

GEOL 471-1 Hydrogeology Laboratory. Problem sets, laboratory experiments, and field exercises in hydrogeology. Majors must take concurrently with GEOL 470. Field trips required. Prerequisite: GEOL 220 or 222; or consent of instructor. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$150.

GEOL 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. Field trips required. Prerequisite: GEOL 220 or 222; 223. Expense will vary in proportion to distance traveled and locations visited and will be determined before each semester. Field trip fee not to exceed \$60.

GEOL 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 records from ocean sediments and continental ice cores, volcanic activity, and Quaternary climate change. Field trips required. Prerequisite: GEOL 220 or 222; 221, 223, 224; or consent of instructor; GEOL 474 recommended.

GEOL 480-3 Geology of Coal. Stratigraphy, sedimentation and structure of coal deposits; modern analogs; origin of splits and partings in coal seams; coal quality and rank; coal exploration and mining; methods of resource evaluation. Prerequisite: GEOL 220 or 222; 221, 223, and 224; or consent of instructor.

GEOL 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. Special approval needed from the instructor. Lab fee: \$10.

GEOL 482-3 Organic Petrology. Petrology and geochemistry of coals and dispersed organics; emphasis on applications to the coal and oil industries; origin of coal and source rock constituents; geochemical and petrographic changes with increased maturation. Prerequisite: GEOL 220 or 222; 221, 223, and 224; or consent of instructor.

GEOL 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. Lab fee: \$10.

GEOL 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: GEOL 220 or consent of the instructor. Lab fee: \$25.

GEOL 490-1 to 3 Internship. Credit for supervised practical experience with an external geological agency or company; prior approval of the sponsoring agency and the department is required. Restricted to advanced standing.

GEOL 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.

GEOL 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: GEOL 325 or GEOL 474.

GEOL 513-3 Quantitative Methods in the Earth Sciences. An introduction to quantitative methods in an Earth Sciences context. Topics include sampling plans for geologic studies, non-parametric tests of geological data, comparisons of geological samples, analysis of sequential geological data. Course will deal with numerical examples from different areas of geology. Special approval needed from the instructor.

GEOL 515-3 Instrumental Analysis in Geology. An introduction to modern methods of instrumental inorganic geochemical 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: GEOL 310, CHEM 210 or equivalent; GEOL 418 recommended.

GEOL 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: GEOL 418 or consent of instructor.

GEOL 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: GEOL 310 or consent.

GEOL 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. Special approval needed from the instructor.

GEOL 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. Special approval needed from the instructor.

GEOL 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: GEOL 325; GEOL 418 recommended.

GEOL 524-2 to 9 (2 to 6 per semester) 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. Special approval needed from the instructor.

GEOL 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: GEOL 425 or consent of instructor.

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

GEOL 527-3 Micropaleontology. Structure, classification, paleocology, 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. Field trips required. Prerequisite: GEOL 425 or consent of instructor. Field trip fee: \$85.

GEOL 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, isostasy, 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 the weekends. Prerequisite: GEOL 435 or GEOL 436 or consent of instructor.

GEOL 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 the weekends. Prerequisite: GEOL 435 or GEOL 436, MATH 150 or consent of instructor.

GEOL 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: MATH 150 or consent.

GEOL 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 weekends.

GEOL 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 geochemistry, 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: GEOL 550.

GEOL 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. Special approval needed from the instructor.

GEOL 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: GEOL 470.

GEOL 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. Special approval needed from the instructor.

GEOL 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. Prerequisite: GEOL 474. Special approval needed from the instructor. Field trip fee: \$35.

GEOL 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: GEOL 482.

GEOL 584-3 Advanced Geologic Remote Sensing. An advanced course covering the nature of electromagnetic radiation, the electromagnetic spectrum and the interaction between electromagnetic radiation and matter. Remote sensing

systems will be presented and the fundamentals of digital image processing will be introduced from a theoretical and practical viewpoint. A series of case studies with applications ranging from mineral exploration to volcano monitoring will be covered. Field Trip Fee: \$40.

GEOL 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 understanding 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. Special approval needed from the department.

GEOL 588-3 Global Energy Resources. Ready access to energy is essential to sustaining modern societies. This course will discuss the nature of the resources that have been, are, or potentially could be used to provide energy in the US and around the globe, including fossil fuels, nuclear energy resources, bioenergy resources and emerging energy resources such as geothermal, wind, tidal, and solar energy.

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

GEOL 599-1 to 6 Thesis (1 to 8 hours per semester). Research for and writing of the master's thesis. Maximum of six hours to be counted toward a Master's degree.

GEOL 600-1 to 30 (1 to 16 per semester) Dissertation. Research for and writing of the doctoral dissertation. Special approval needed from the instructor.

GEOL 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.

GEOL 699-1 Postdoctoral Research. Must be a Postdoctoral Fellow. Concurrent enrollment in any other course is not permitted.