Graduate work in geology and geophysics is offered at both the master of science (thesis and non-thesis) and doctoral levels. Programs are designed to provide you with an understanding of the fundamentals and principles of geology, geochemistry, and geophysics. Research investigations comprise a significant part of each program, and at the doctoral level an original contribution to the science is required.

Research emphasis of the program is in:
- Low Temperature and Environmental Geochemistry
- Mineralogy/Petrology/Economic Geology
- Geophysics/Tectonics/Remote Sensing
- Sedimentology/Paleontology/Stratigraphy/Petroleum Exploration

In geology and geochemistry, opportunities for research at both the M.S. and Ph.D. levels are available in mining geology, petroleum geology, stratigraphy and sedimentation, geochemistry, clay mineralogy, remote sensing, GIS, palynology, structural geology, igneous and metamorphic petrology, and volcanology.

In geophysics, opportunities for research at both the M.S. and Ph.D. levels are available in the areas of reflection and refraction seismology, theoretical seismology, geophysical data analysis, gravity, magnetics, seismic hazards, and computational geophysics.

The study of the Earth and other planets includes all areas of scientific inquiry. To work effectively in so broad a discipline requires considerable depth and breadth of understanding of physical principles and advanced proficiency in mathematics, particularly for those students contemplating advanced studies in geophysics. A thorough undergraduate training in an earth or physical science is ordinarily regarded as necessary prerequisite for advanced study in geology or geophysics.

Earth sciences have been an integral part of the university since its founding. The program has a long and proud history of faculty and students who have contributed to the advancement of the science and to mineral and hydrocarbon exploration. The university was formerly the Missouri School of Mines. Because of the school's tradition and location near the Missouri Lead District the emphasis of the program has been in hard rock exploration. The program has now expanded to include geochemistry, geophysics, and soft rock geology. Our graduates find employment in mining, environmental, and petroleum industries. It is our intention to provide the student with a sufficiently diverse and complete education that he or she may seek employment in any area of the earth sciences.

The program has a wide variety of equipment for research and exploration in geology, geochemistry, and geophysics. In addition to its own facilities, the Missouri Department of Natural Resources, and the U.S. Geological Survey’s mid-continent mapping division are also located in Rolla. Cooperative research with other departments within the university or other campuses of the University of Missouri may be undertaken by our faculty and graduate students. Interaction with mining engineering, geological engineering, petroleum engineering, metallurgy, environmental engineering, biological sciences and various other programs/departments is routine. Cooperative programs are also undertaken with local mining companies, petroleum companies, or other industries using the skills and techniques of the earth scientist. Thus, your research interests need not fall entirely within the interests of our faculty or within the bounds of the equipment directly available within the program.

Although an advanced degree level is not a requirement for professional practice in geology or geophysics, the B.S. should usually be considered a preparatory, the M.S. should be considered the professional degree, and the Ph.D. should be sought by candidates interested in a career in teaching or research. The M.S. degree is typically granted with a thesis option, although a non-thesis option is now available. A qualifying examination is required of all Ph.D. students during the third semester of residency. For students whose native language is not English, a minimum score of 550 on the standard Test of English as a Foreign Language is generally required for admission.

Neil L Anderson, Professor
PHD University of Calgary
Acquisition processing.

Ralph E Flori Jr, Associate Professor
PHD University of Missouri-Rolla
Engineering mechanics, mechanical earth modeling, reservoir engineering, reservoir simulation, engineering education.

Stephen Shangxing Gao, Professor
PHD University of California-Los Angeles
Seismology, solid earth geophysics, crustal deformation, computational geophysics, plate tectonics.

John Patrick Hogan, Associate Professor
PHD Virginia Polytechnic Institute
Igneous petrology, structural geology, crust and mantle evolution.

Kelly Hong Liu, Professor
PHD University of California-Los Angeles
Exploration geophysics, digital signal processing, seismic hazard, earth structure and dynamics.

Marek Locmelis, Assistant Professor
PHD Marquarie University, Sydney

Francisca Oboh Ikuenebe, Professor
PHD Cambridge University
Program Head of Geology and Geophysics. Palynology, biostratigraphy, sedimentology, paleoclimatology.

Jonathan Obrist Farner, Assistant Professor
PHD Missouri University of Science and Technology

David J Wronkiewicz, Associate Professor
PHD New Mexico Institute of Mining & Technology

Wan Yang, Associate Professor
PHD University of Texas at Austin
Sedimentology, sequence stratigraphy, petroleum geology, paleoclimatology.

GEOLOGY 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.
**GEOLOGY 5001 Special Topics** (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**GEOLOGY 5010 Seminar** (RSD 0.0-6.0)
Discussion of current topics.

**GEOLOGY 5040 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**GEOLOGY 5085 Internship** (IND 3.0)
Students will select, with their committee's advice, problems for investigation and preparation of a graduate research proposal. Problems must provide higher level experiential learning consistent with a graduate degree in geology. Assessment is based upon the quality of written and oral presentations and supervisor's evaluation. Repeatable for credit. Prerequisite: Graduate Standing.

**GEOLOGY 5099 Research** (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

**GEOLOGY 5111 Advanced Physical Geology** (LEC 3.0)
Examination of topics concerned with the physical properties of earth materials, processes affecting change of the surface and interior of the earth, and the driving forces causing these changes. Weekly critical assessment of literature, and an oral presentation and term paper required. Prerequisite: Consent of instructor.

**GEOLOGY 5121 Advanced Historical Geology** (LEC 2.0 and LAB 1.0)
Study of the physical and biological history of the Earth beginning with the origin of the solar system up to the present. Emphasis will be placed on processes that shaped the Earth and its ecosystems. Prerequisite: Entrance requirements for the MST program in Earth Science.

**GEOLOGY 5311 Depositional Systems** (LEC 3.0)
Development of three dimensional depositional models using Walther's Law, Walther's Warning and seismic stratigraphy. Emphasis on overall geometries and internal porosity and permeability characteristics of aquifers and hydrocarbon reservoirs. Includes 3-D models for clastic, carbonate and evaporate sequences. Prerequisites: Geology 1110 or Geo Eng 1150; accompanied or preceded by both Geology 3310 and Geology 3620.

**GEOLOGY 5411 Advanced Geochemistry** (LEC 3.0)
A study of the absolute and relative abundance of elements and isotopes in the Earth, principles of element transport, formation of the Earth's crust, mineral deposits, and soils. Field trip fee required. Prerequisite: Geology 3410.

**GEOLOGY 5510 Applied Petroleum Geology** (LEC 1.0 and LAB 2.0)
The principles of petroleum geology are applied in solving hydrocarbon exploration and developmental problems. Geological and economical techniques for evaluating hydrocarbonbearing reservoirs are presented, with methods for decisionmaking under conditions of extreme uncertainty. Prerequisite: Geology 5411.

**GEOLOGY 5513 Petroleum Geology** (LEC 2.0 and LAB 1.0)
Principles of origin, migration, and accumulation of oil and gas. The laboratory introduces the procedures used for exploration, and development of hydrocarbon resources. Prerequisites: Geology 1110 or Geo Eng 1150; accompanied or preceded by both Geology 3310 and Geology 3620.

**GEOLOGY 5521 Coal Petrology** (LEC 3.0)
Formation, composition, and properties of coals. Discussion of the geology of selected coal deposits, the analysis of coal, and the optical identification of coal minerals. Prerequisite: Permission of instructor.

**GEOLOGY 5541 Granites And Rhyolites** (LAB 1.0 and LEC 3.0)
Processes governing the generation and crystallization of felsic magma will be covered, with specific reference to: 1) crust vs mantle sources, 2) melt migration and emplacement, 3) magma chamber dynamics, 4) the volcanic-plutonic connection, and 5) the relationship to tectonic setting. A field trip at the student’s expense is required. Prerequisite: Geology 2620.

**GEOLOGY 5611 Advanced Igneous Petrology** (LAB 1.0 and LEC 3.0)
Identification of coal minerals. Prerequisite: Permission of instructor.

**GEOLOGY 5621 Coal Petrology** (LAB 1.0 and LEC 3.0)
Petrology, chemistry and sedimentology of carbonates and other associated chemical sedimentary rocks. Prerequisites: GEOLOGY 2620, 3620 and CHEM 1320 or equivalent; GEOLOGY 3410 recommended.

**GEOLOGY 5641 Advanced Igneous Petrology** (LEC 2.0 and LAB 1.0)
The genesis of eruptive rocks as evidenced by the physico-chemical conditions of formation of their constituent minerals. A critical examination of various magmatic processes. Use of advanced petrographic techniques. Prerequisites: GEOLOGY 4631.

**GEOLOGY 5661 Advanced Stratigraphy and Basin Evolution** (LEC 3.0)
Advanced topics in sedimentary geology including: tectonic controls on sedimentary basin development, global sequence stratigraphy, regional facies and diagenetic patterns, basin hydrogeology, thermal evolution of basins and distribution of economic resources. This course should be preceded or accompanied by Geology 3410. Prerequisites: Geology 2620 and Geology 3310.

**GEOLOGY 5671 Clay Mineralogy** (LEC 2.0 and LAB 1.0)
Mineral structure, geochemical properties, occurrence, environment, and uses of clays. Determination of physical properties, optics, x-ray diffraction, and thermal features of clays. Field trip fee required. Prerequisites: Geology 2610 and 3410, or Chem 2310, or Civ Eng 5715, or Geo Eng 5172.

**GEOLOGY 5679 Field and Laboratory Studies in Earth Science** (LAB 3.0)
Hands-on laboratory and field experiences in the Earth Sciences. This course is designed to be taught in an intensive three week session during the summer on the S&T campus. Prerequisites: GEOLOGY 2096 or 5121 or equivalents.

**GEOLOGY 5681 Lidar Principles and Application** (LEC 3.0)
Provides a comprehensive understanding of light detection and ranging (lidar) technology as it has been developed for commercial use; various methods of deploying technology for collection of data for mapping, engineering and science, and application of the data using specialized software for editing and processing point cloud data. Assumes GIS experience. Prerequisite: Senior or graduate standing.

**GEOLOGY 5741 Micropaleontology** (LEC 2.0 and LAB 1.0)
This course studies the fossil and soft-body characteristics of bacteria, protists, microinvertebrates and organic-walled microfossils (palynomorphs). Focused discussions on systematics, evolutionary histories, paleoecology, and geologic applications of the microfossil groups. Extraction of foraminifera and palynomorphs from rocks in lab. Prerequisite: Geology 3631.
GEOL 6000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department.
Consent of instructor required.

GEOL 6001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEOL 6010 Seminar (IND 0.0-6.0)
Discussion of current topics.

GEOL 6040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOL 6050 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

GEOL 6085 Internship (IND 3.0)
Students will select, with their committee’s advice, problems for investigation and preparation of a graduate research proposal. Problems must provide higher level experiential learning consistent with a graduate degree in geology. Assessment is based upon the quality of written and oral presentations and supervisor’s evaluation. Repeatable for credit. Prerequisite: Graduate standing.

GEOL 6099 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

GEOL 6211 Geodynamics (LEC 3.0)
The applications of continuum physics to geological and petroleum engineering problems. Topics include plate tectonics, stress and strain in solids, elasticity and flexure, heat transfer, gravity, fluid mechanics, rock rheology, faulting, and flow in porous media. Prerequisites: Math 2222 and Geology 3310. (Co-listed with Pet Eng 6711).

GEOL 6311 Advanced Structural Geology (LAB 1.0 and LEC 2.0)
The course provides theoretical background, analytical techniques, and hands-on experience for analyzing geologic structures at a variety of scales hand sample to global. Prerequisites: Geology 3310, Geophys 4096.

GEOL 6321 Analytical Structural Geology (LAB 1.0 and LEC 2.0)
The course provides theoretical background, analytical techniques, and hands-on experience, for quantifying processes that lead to the formation and evolution of rocks and structures produced as a result of deformation at a variety of scales - hand sample to global. Poster and oral presentations, and a research paper required. Prerequisites: Geology 3310, Geophys 4096.

GEOL 6331 Geotectonics (LEC 3.0)
A critical study of the origin, and differentiation of the earth, evolution of the crust, and plate tectonics. Geology of the continents and ocean basins. Regional tectonic analysis of pre cambrian shields, platforms, orogenic belts, and a review of internal energy sources. Emphasis is on North America. Prerequisite: Geology 3310.

GEOL 6341 Advanced Remote Sensing And Image Processing (LEC 2.0 and LAB 1.0)
Quantitative methods of utilizing remote sensing technology for terrain analysis. Digital image processing of landsat and/or aircraft scanner data for mineral resource studies and geological engineering applications. Prerequisite: Geo Eng 5146. (Co-listed with Geo Eng 6146).

GEOL 6411 Advanced Isotope Geochemistry (LEC 2.0 and LAB 1.0)
The use of radiogenic and stable isotopes in geology in the study of the evolution of Earth, crust, mantle, and the Solar System as well as applications to geothermometry, ore petrogenesis, paleontology, and the global climate system. Prerequisites: Geology 2620, 3620, 3410.

GEOL 6421 Environmental Geology (LEC 3.0)
Overview of environmental problems facing humans. Emphasis will be placed on surface and groundwater pollution, geological hazards, and pressures on Earth’s ecosystems and natural resources by urbanization and population growth. Prerequisites: GEOL 1110 or 1120 or equivalents.

GEOL 6511 Advanced Petroleum Geology (LAB 2.0 and LEC 1.0)
Examples of various types of oil and gas accumulation are reviewed in detail. Study of criteria useful in evaluating the petroleum potential of undrilled areas. Special investigation assignment is required. Prerequisite: Geology 4511.

GEOL 6521 Advanced Ore Microscopy (LEC 1.0 and LAB 2.0)
A study of ore suites utilizing various advanced, quantitative ore microscopy techniques including hardness, spectral reflectance, indentation, color, rotation property measurements, fluid inclusion geothermometry, and salinity measurements. Laboratory study includes demonstration and operation of the luminoscope and other microbeam techniques. Prerequisite: Geology 4521.

GEOL 6531 Applied Ore Microscopy (LEC 1.0 and LAB 2.0)
Application of ore microscopic and petrographic techniques to problems in ore beneficiation, pelleting, sintering, smelting, refining, refractories, cement, mining, and exploration. Discussions and laboratories are based upon industrial case histories. Prerequisite: Geology 4521.

GEOL 6541 Geology of Natural Resources (LEC 3.0)
The origin and distribution of economically important natural resources including soils, water resources, metals, non-metals, building materials, petroleum, and other energy resources. Prerequisites: GEOL 1110 or 1120 or equivalents.

GEOL 6551 Ore Deposition (LAB 1.0 and LEC 2.0)
An advanced study of mineral deposits, time and space in deposition, theories of deposition and their effect on exploration. Discussions based on maps, logs, and samples from the world’s typical mineral deposits. Two all day field trips at student expense required. Prerequisite: Geology 3511.

GEOL 6611 Advanced Palynology (LEC 1.0 and LAB 2.0)
Study of the processes of sporopollenin preservation, sedimentation and palynofacies. Major emphasis on independent palynostratigraphic research. Chronicle of Phanerozoic palynology in lectures. Prerequisite: Geology 3631 or 4641.

GEOL 6621 Clastic Sedimentary Petrology (LAB 1.0 and LEC 2.0)
Petrology and petrography of clastic sedimentary rocks. Emphasis on origins, diagenesis and description of clastic, sedimentary rocks. Prerequisite: Geology 3620.
GEOPHYS 5221 Wave Propagation (LEC 3.0)
A study of Hamilton's principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydrodynamic radiation, and Allen's functions and point sources. Prerequisites: Geophys 281, 3221.

GEOPHYS 5231 Seismic Data Processing (LAB 1.0 and LEC 2.0)
Introduction to seismic data processing. Topics to be covered include statics corrections, filtering, velocity analysis, deconvolution, stacking and migration. The course has a field component to record seismic data. If this is offered in the summer, an off-campus trip may be needed. Extra fee may be charged to cover the field expenses. Prerequisites: Geophys 3210 or Geophys 5202.

GEOPHYS 5241 Advanced Electrical And Electromagnetic Methods In Geophysical Exp (LAB 1.0 and LEC 2.0)
Theory of the electrical geophysical methods as applied to subsurface investigations addressing geologic, engineering, groundwater and contaminant transport problems. Course content includes both passive and active methods and recent advances in the application of these methods. Course will include a field component illustrating application of techniques to local problems. Prerequisites: Geophys 3251, Math 2222.

GEOPHYS 5261 Computational Geophysics (LEC 3.0 and LAB 2.0) and (LAB 1.0 and LEC 2.0)
Introduction to computational geophysics. Course will include a field component illustrating application of techniques to local problems. Prerequisites: Geophys 3251, Math 2222.

GEOPHYS 5736 Geophysical Field Methods (LAB 1.0 and LEC 2.0)
Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 5736).

GEOPHYS 5761 Transportation Applications of Geophysics (LAB 1.0 and LEC 2.0)
Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 5761 and Civ Eng 5750).

GEOPHYS 5782 Environmental and Engineering Geophysics (LEC 2.0 and LAB 1.0)
An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 2222. (Co-listed with Geo Eng 5782).

GEOPHYS 6000 Special Problems (IND 0.0-6.0) and (LAB 1.0 and LEC 2.0) and (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOPHYS 6001 Special Topics (IND 0.0-6.0) and (LAB 1.0 and LEC 2.0) and (IND 0.0-6.0)
Discussion of current topics.
**GEOPHYS 6040 Oral Examination (IND 0.0)**
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**GEOPHYS 6050 Continuous Registration (IND 1.0)**
Doctoral candidates who have completed all requirements for the degree except the dissertation and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**GEOPHYS 6099 Research (IND 0.0-15)**
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**GEOPHYS 6211 Advanced Seismic Interpretation (LAB 1.0 and LEC 2.0)**
The integration of geologic information, well log data and seismic information for interpreting the earth’s subsurface using advanced 3-D seismic interpretation software packages. Reservoir identification and evaluation as well as horizon and formation attributes are included. Prerequisites: Geophys 3210 or Geophys 5202.

**GEOPHYS 6231 Advanced Seismic Data Processing (LAB 1.0 and LEC 2.0)**
Theory and application of seismic data processing. Topics to be covered include convolution, correlation, deconvolution, 2-D filtering, migration and inversion. Prerequisites: Geophys 4251, 5231, Stat 3115.

**GEOPHYS 6241 The Theory of Elastic Waves (LEC 2.0 and LAB 1.0)**
A mathematical study of elastic waves in the layered earth. Prerequisites: Geophys 3210.

**GEOPHYS 6251 Geophysical Inverse Theory (LEC 3.0)**
A study of inverse theory applied to geophysical data, focusing on the relationship between data and model spaces and ways to estimate model parameters via global and local optimization techniques. Prerequisites: Geophys 286 or 384, Math 325, Stat 215.