Department of Geology

Why study geology?
In Geology you get to apply techniques and knowledge from chemistry, physics, biology and math to answer important questions about Earth processes, history and future. Geologists are in demand to evaluate geologic hazards, evaluate natural resources, and understand the environment.

Financial Aid
Undergraduate Scholarships
The department awards scholarships from its endowment to meritorious incoming or continuing students in geology. Scholarships also are awarded to students enrolled in Field Camp (http://geo.ku.edu/field-camp-geol-560561) or Field Investigation (http://geo.ku.edu/field-activities). For information, contact the chair.

KU Financial Aid
All undergraduates who wish to be considered for KU financial aid must complete applications with Financial Aid and Scholarships (http://affordability.ku.edu/steps/index.shtml).

Graduate Assistantships and Scholarships
All prospective graduate students are considered for employment and financial aid. Employment may be in the form of teaching assistantships or research assistantships. Research assistantships may be supported with funds from external grants, Geology Associates endowments, the Biodiversity Institute, or the Kansas Geological Survey, which is on campus. Duties, compensation, and conditions of awards are prescribed as much as possible before enrollment. The department also receives funds from corporations and endowments to support fellowships, which permit students to enroll full time without specific research or teaching duties.

Graduate students are eligible for scholarships from the Geology Associates Program. Endowed scholarships include the Angino, Hall, Henbest, Holden, Ireland, McGee, Moore, Patterson, Peoples, and Walters scholarship funds. Other scholarships are awarded from donations from individuals and corporations. Scholarships are awarded on the basis of academic excellence; some funds are designated for protected minorities or women.

Through the Selig Fund and other donations, the department supports graduate student field work. Through the McCallum Fund and other donations, the department underwrites partially some other research expenses, such as purchase of time on analytical equipment. Funding requires an acceptable thesis or dissertation proposal. Students who have no other sources of research support are given preference. Degree-seeking students may apply for loans from the Fritz, Horner, and Johns loan funds.

Visit the Graduate Studies website for information about funding opportunities (http://graduate.ku.edu/ku-funding) for graduate students at KU.

Financial Aid and Scholarships (http://affordability.ku.edu/steps/index.shtml) administers grants, loans, and need-based financial aid.

Careers
Career Opportunities
Opportunities (http://geo.ku.edu/jobinternship-postings) include environmental geology, engineering geology, and hydrogeology, as well as the oil and minerals industries, research, and teaching.

Practice as a professional geologist often requires course work and training beyond the baccalaureate level.

Licensure
Formal study of geology at an accredited college or university is a principal requirement for becoming licensed to practice geology. During the senior year, students who plan to become licensed geologists should take the Fundamentals of Geology examination, offered twice a year. Information on registration is available from the department office or from the Kansas Board of Technical Professions. After passing the examination and after further practice, candidates can sit for the Practice of Geology examination to become licensed. Regulations for licensure may vary from state to state.

Undergraduate Programs
Geology is an interdisciplinary science that applies the principles of chemistry, physics, biology, and other fields to the study of the earth, its resources, and its natural processes. The field has many subdisciplines and specialties that offer stimulating challenges and careers. KU offers broad undergraduate programs in geology and geophysics but emphasizes research in paleontology, sedimentology, crustal evolution, hydrogeology, geobiology, seismology, applied geophysics, glaciology, and geomorphology.

Courses for Nonmajors
The department offers several courses of interest to nonmajors who wish to learn more about geology and related areas such as environmental science, oceanography, and economic resources. Principal courses include GEOL 101, GEOL 105, GEOL 121, GEOL 171, GEOL 302, and GEOL 351. GEOL 103 may be taken in conjunction with either GEOL 101 or GEOL 105 to fulfill the CLAS laboratory science requirement. GEOL 304, GEOL 360, and GEOL 552 all offer opportunities to study more specialized aspects of the earth and do not require advanced prerequisites.

Summer Field Courses
All undergraduate degree programs require field courses during 2 summers. Students should plan to take GEOL 360 in the summer after completing the introductory course. GEOL 560 and GEOL 561 (if required by the program) ideally are taken in the summer between the junior and senior years. Substantial scholarship support is available for geology majors who enroll in those courses.

Combined Degree Programs
A student may combine an interest in geology with a degree in business, education, or journalism.

Graduate Programs
The department offers the M.S. and Ph.D. in geology but permits specialization in a number of areas of geology and in geophysics and hydrogeology. Active areas of instruction and research include geophysics, geomorphology, geochemistry, microbial biogeochemistry,
paleontology, sedimentology, tectonics, and petroleum geology. Students also may work with faculty supervisors at the Kansas Geological Survey and at Kansas State University.

Courses

GEOL 101. The Way The Earth Works. 3 Hours GE3N / N. 
Introduction to the principles of earth science. Study of the formation, occurrence, and structure of minerals and rocks; action of streams, oceans, glaciers, and other agents in the formation and modification of the landscape; mountain building, volcanism, earthquakes, and plate tectonics. Discussion of earth processes in the context of sustainable energy, environmental concerns, climate and other topical issues. This course with GEOL 103 satisfies the College laboratory science requirement. Concurrent enrollment in GEOL 103 is recommended for students taking both. Course may be offered in lecture or online format. LEC.

GEOL 103. Geology Fundamentals Laboratory. 2 Hours U / LFE. 
A course in geologic laboratory studies. This course plus GEOL 101, GEOL 102, GEOL 105, GEOL 106, or GEOL 121 satisfies the College laboratory science requirement. Gives students practical, hands-on experience with identifying earth materials (rocks, minerals, fossils), understanding their relationships to earth processes, understanding topographic and geologic maps, interpreting results of surficial processes, and learning about deep-earth processes such as earthquakes. Includes short field trips to see geologic structures and results of local geologic processes. This lab course may be offered in on-campus lab or online format. Prerequisite: Previous or concurrent enrollment in GEOL 101, GEOL 102, GEOL 105, GEOL 106 or GEOL 121. LAB.

GEOL 105. History of the Earth. 3 Hours GE3N / N. 
An introduction to the physical and biological history of the earth, the methods used to decipher earth history, and the development of the geological sciences. This course with GEOL 103 satisfies the College laboratory science requirement. Concurrent enrollment in GEOL 103 is recommended for students taking both. Not open to students who have taken GEOL 106 or GEOL 304. LEC.

GEOL 108. Troubled Waters: Water Resource Issues and Principles. 3 Hours GE11/GE3N / N. 
Worldwide, water security is necessary for life, and food, industry, and energy production, and is increasingly the source of conflict. This course explores water in the environment and the fundamental interactions between humans and water. Key topics and issues addressed include fundamentals of water and the water cycle; water in geologic processes; water availability, development and sustainability; climate effects including flooding and drought; economics; pollution, disease, sanitation, and health; culture, policy and law, and other challenging issues. Case studies explore examples from Kansas and around the world. LEC.

GEOL 121. Life Through Time: DNA to Dinosaurs. 3 Hours NB GE11/GE3N / N. 
This course leads students on a journey through time to explore the interconnection between life and the geology of Earth, including our own complex relationship with the world around us. If taken with GEOL 122, this course satisfies the College laboratory science requirement. Concurrent enrollment in GEOL 122 is required for students taking both. LEC.

GEOL 122. Life Through Time: DNA to Dinosaurs Laboratory. 1 Hour N. 
This online companion to GEOL 121 allows students a hands-on exploration of the principles and practices of paleontology research. Students will be guided through an individual term-length research project—from shaping a research question to collecting and analyzing data to drawing conclusions to presenting in front of an audience. This lab will not only allow students to explore the fossil record but it will bring them into the scientific conversation. Prerequisite: Corequisite: Students must be concurrently enrolled in GEOL 121. LAB.

GEOL 171. Earthquakes and Natural Disasters. 3 Hours GE3N / N. 
Addresses the subject of natural disasters with concentration on earthquake effects and their mitigation. Briefly treats volcanic eruptions, tidal waves, floods, global warming, severe weather, and catastrophic meteorite impacts from the perspective of geological and human significance. Provides a basic background into earth-science processes. LEC.

GEOL 177. First Year Seminar: _____ 3 Hours GE11. 
A limited-enrollment, seminar course for first-time freshmen, organized around current issues in geology. May not contribute to major requirements in geology. First year seminar topics are coordinated and approved through the Office of First Year Experiences. Prerequisite: First-time freshman status. LEC.

GEOL 301. Introduction to Oceanography. 3 Hours GE3N / N. 
The online course is an introduction to the earth and its oceans, including a discussion of the history of ocean exploration using the approach of the scientific method. The course will explore theories that describe the origin of the solar system, the earth, the atmosphere, and the oceans, in addition to a discussion of the origin of life on the earth. The course will cover the essential physics, chemistry, geology, biology, and the concepts of plate tectonics, as applied to understanding the oceans and seas. This course cannot be taken if a student has completed GEOL 302. LEC.

GEOL 302. Oceanography. 4 Hours GE3N / N. 
An introduction to the origin, nature, and dynamics of the world's oceans, including aspects of geology, chemistry, biology, physics, and meteorology that are involved in ocean processes. The relations between the oceans and humans in the past, present, and future, and instruction in scientific reasoning as it applies to oceanography. Laboratory exercises in critical thinking about oceanography. This course cannot be taken if a student has completed GEOL 301. Prerequisite: An introductory science course. LEC.

GEOL 304. Historical Geology. 3 Hours N. 
An introduction to the physical and biological history of the Earth, the methods used to decipher earth history, and the development of the geological sciences. Concepts of lithostratigraphy, chemostratigraphy and biostratigraphy, and methods of analysis of stratigraphic data focus on the interpretation of Earth history. Prerequisite: GEOL 101 and GEOL 103. LEC.
GEOL 311. Mineralogy and Structure of the Earth. 3 Hours GE3N / N / LFE.
Basic identification and properties of rocks and minerals in the context of whole-earth structure and evolution. Includes basic chemical equilibria for rock and mineral systems and their bearing on processes involved with formation and evolution of Earth's crust, mantle, and core. Two lectures and one lab per week. Prerequisite: GEOL 101, CHEM 130, and eligibility for MATH 125 or MATH 115. LEC.

GEOL 312. Mineral Structures and Equilibria Laboratory. 1 Hour U / LFE.
A laboratory to accompany GEOL 311. Presents more rigorous analysis of the structures, compositions, and chemical equilibria governing the formation and stability of common rock-forming mineral systems. Prerequisite: GEOL 311 (may be taken concurrently), CHEM 130, and eligibility for MATH 125 or MATH 115. LAB.

GEOL 315. Gemstones. 3 Hours NE GE3N / N.
The properties, occurrence, description, determination, mineral affinities, and legend and lore of gems, ornamental stones, and gem materials. LEC.

GEOL 316. Geochemistry. 3 Hours N.
The course is intended to be an introduction to all types of geochemistry. It focuses on the chemistry of the natural world and the chemical evolution of the Earth over geological time. The course is composed of three modules: (a) geochemical fundamentals; (b) natural and anthropogenically perturbed aspects of the Earth's hydrosphere and its interaction with surficial rocks, sediments, soils, the biosphere and the atmosphere; (c) the origin and evolution of Earth's crust-mantle-core) and the solar system through nuclear and high temperature chemical processes. Prerequisite: GEOL 101, CHEM 130 or 190; and eligibility for MATH 115. LEC.

GEOL 319. Special Studies in Geology. 1-6 Hours N.
Special reports upon subjects in which students have a particular interest. Prerequisite: Fifteen hours of geology. IND.

GEOL 399. Senior Honors Research. 2-5 Hours AE61 / N.
Normally two to five hours in any one semester with a maximum of eight hours. An undergraduate research course, in any of the fields of geology, open by permission of the department to seniors in the College who have an average grade of B or higher in geology courses. Prerequisite: Thirty hours of geology, five of which may be taken concurrently with this course. IND.

GEOL 501. Error Analysis. 1 Hour N.
This course covers basic error analysis as it applies to geology. The course will emphasize the description and propagation of errors in data collection and reduction. Subjects include: how to report data and associated errors, error propagation in simple and complex equations, the Normal, Gaussian, and Poisson distributions, linear and higher order regression, and X-squared test. Prerequisite: MATH 125. LEC.

GEOL 512. Igneous and Metamorphic Petrology. 3 Hours N.
The study of minerals, rocks and fluids within the earth's crust and mantle to elucidate their mechanisms of formation and the pressure-temperature-composition conditions within the Earth. The course emphasizes equilibrium thermodynamics, phase equilibria, fractionation mechanisms, tectonic control of petrogenesis, and quantitative analysis of mineral parageneses. Prerequisite: GEOL 311 and first semester calculus, or permission of instructor. LEC.

GEOL 513. Petrology Laboratory. 1 Hour U / LFE.
A laboratory course to accompany GEOL 512. Material covered will include the use of the polarizing microscope in study of rocks in thin sections; identification of rock-forming minerals in thin section; study of textures as guides to the crystallization process; calculations of chemical changes during fractional crystallization and partial melting. Students will also make extensive study of igneous and metamorphic rocks in hand specimens, accompanied by thin section study, with emphasis on composition, texture, and structure. Students must co-enroll in GEOL 512. Prerequisite: GEOL 312. Concurrent enrollment in GEOL 512 required. LAB.

GEOL 521. Paleontology. 3 Hours N.
A study of the structure and evolution of ancient life; the nature and diversity of life through time; the interactions of ancient organisms with their environments and the information that the study of fossils provides about ancient environments; the use of fossils to determine the ages of rocks and the timing of past events in earth history; and the patterns of extinction through time. (Same as BIOL 622.) Prerequisite: BIOL 100 or BIOL 152 or GEOL 105 or GEOL 304. LEC.

GEOL 523. Paleontology Laboratory. 1 Hour U.
Laboratory course in the study of fossils with emphasis on the practice of paleontology and the morphology of ancient organisms. (Same as BIOL 623.) LEC.

GEOL 524. Mammalian Paleontology. 3 Hours.
Evolution of mammals, and anatomical modifications involved in the process as ascertained from the fossil record. Lectures and laboratory. (Same as BIOL 524.) Prerequisite: One of the following: BIOL 225, BIOL 412, BIOL 413, GEOL 304, GEOL 521, or consent of the instructor. LEC.
GEOL 525. Geobiology: The Coevolution of Life and Rocks. 3 Hours N.
This course is an exploration of the parallel evolution of life and the Earth. In the almost 4 billion years since life first appeared, biological processes have been influencing and been influenced by physical and chemical processes in the atmosphere, cryosphere, hydrosphere, and inside the Earth. Microbial processes helped form fossils, reefs, and the oxygen we all breathe; the traces microbes leave behind in the rock record inform our understanding of how life originated and evolved on Earth, what environmental changes triggered the Big Five mass extinctions, and guide NASA's exploration of the solar system. Prerequisite: BIOL 152 and GEOL 101. LEC.

GEOL 528. The Biology and Evolution of Fossil Plants. 3 Hours N.
A lecture course in which fossil plants, protists and fungi are examined throughout geologic time. Emphasis will be directed at palaeoecology, biogeography and the stratigraphic distribution and composition of ancient floras. (Same as BIOL 640.) Prerequisite: BIOL 413, or permission of instructor. LEC.

GEOL 529. Laboratory in Paleobotany. 1 Hour U / LFE.
An examination of selected fossil plants throughout geological time and the techniques used to study them; laboratory will include identification and the use of plant fossils in biostratigraphy. (Same as BIOL 641.) Prerequisite: BIOL 413 or permission of instructor. Must be taken concurrently with GEOL 528. LAB.

GEOL 532. Stratigraphy. 4 Hours AE61 / N / LFE.
A study of the principles of lithostratigraphy, biostratigraphy, and sequence stratigraphy. Methods of analysis of stratigraphic data focus on the interpretation of earth history. The stratigraphic record of North America is presented for evaluation of its geologic history. Three lectures and one laboratory per week. Required field trip. Prerequisite: GEOL 101, GEOL 521, and GEOL 331. LEC.

GEOL 533. Shales and Other Mudstones. 3 Hours N.
This course defines mudstones and shales. Deposition and constituents of fine-grained sediment; geochemistry, diagenesis and lithification of such deposits. Organic constituents of mudstone and their function as sources of crude oil and natural gas. Petrophysics and mechanical properties of mudstones and their potential as reservoirs of hydrocarbons. Not open to students with credit in GEOL 733. Prerequisite: GEOL 331. LEC.

GEOL 534. Volcanology. 3 Hours N.
Physical and geochemical volcanology. Considers relationship of tectonics and volcanism; types of magmas; rheology of lavas, pyroclastic density currents, and mass movements in volcanic environments; and interpretation of processes and conditions of formation of volcanic rocks from their field character. Field trips to ancient volcanic complexes. Prerequisite: GEOL 331 and GEOL 512, or permission of instructor. LEC.

GEOL 535. Petroleum and Subsurface Geology. 4 Hours N / LFE.
A general study of the occurrence, properties, origin, and migration of petroleum. Studies of various oil fields and oil-bearing basins. Laboratory studies include well logs, subsurface mapping, and cross-sections. Prerequisite: GEOL 331 and either GEOL 562 or CPE 327, or permission of instructor. LEC.

GEOL 536. Geological Log Analysis. 1 Hour U.
Application of well logging measurements to interpretation subsurface. LEC.

GEOL 537. Petroleum Reservoir Characterization. 3 Hours N.
Geological, geophysical, and engineering characterization of a petroleum reservoir. Includes mapping; petrophysical, production, and pressure analysis; and numerical modeling. Considers economic analysis of steps to improve oil recovery. Students who have completed GEOL 837 may not take GEOL 537 for credit. Prerequisite: GEOL 535 and permission of instructor. LEC.

GEOL 541. Geomorphology. 4 Hours N / LFE.
A critical study of landforms in relation to tectonics, climatic environment, and geologic processes. The use of geomorphic methods in the interpretation of Cenozoic history is emphasized. Laboratory exercises in analysis of field observations, maps, and photographs. Required field trip and fee. (Same as GEOG 541.) Prerequisite: GEOL 101 and GEOL 103, GEOG 104 and GEOG 105, or GEOL 304 and GEOL 103. LEC.

GEOL 542. Energy and Society. 3 Hours AE51 / N.
In this course, you will gain the necessary understanding of energy technologies and policies to evaluate options for energy usage and its socioeconomic and environmental impacts. You will analyze different opportunities and impacts of energy systems that exist within and between groups defined by national, regional, household, ethnic, and gender distinctions. Analysis of the range of current and future energy choices will be stressed, as well as the role of energy in determining local environmental conditions and global climate. Prerequisite: A course in Biology, Chemistry, Physics, or Geology. LEC.

GEOL 543. Environmental Ethics: A View from the National Parks. 3 Hours AE51.
To what extent are our National Parks protected from pollution, invasive species, mining, climate change and tourism? In this course you will learn about the geologic processes that form our National Parks as well as the competing interests that stakeholders have on the land. Prerequisite: A course in Biology, Chemistry, Physics, or Geology. LEC.

GEOL 548. Geology and Culture of Polynesia. 3 Hours AE42 / N.
Polynesia, encompassing over 1,000 islands in the southern and central Pacific Ocean, was the last region of the Earth to be settled by humans. Around 3000-1000 BCE, people from northwest Melanesia first reached one of these islands, and over the next few centuries spread to colonize all of the islands. However, despite the fact that all of the Polynesian islands were settled by colonists who stemmed from a single population with a shared culture, language, technology, and agriculture, the cultures of these islands are incredibly rich and varied. In this course we will examine some of the cultural mores and practices of the Polynesian islands, including how these were shaped by the climate, geology, soil, hydrology, and marine resources of each individual island. In this course we will examine these factors and assess their potential impact on the cultures present in the region. Prerequisite: A course in Biology, Chemistry, Physics, or Geology. LEC.

GEOL 551. Engineering Geology. 3 Hours N.
Consideration of geologic factors affecting engineering projects. Topics include: techniques of site exploration, engineering properties of soil and rock, geologic conditions important in the design of major structures, and geologic information useful in land-use planning. Prerequisite: An introductory course in geology or consent of instructor. LEC.

GEOL 552. Introduction to Hydrogeology. 3 Hours N.
Physical description of hydrogeologic media. Elementary groundwater hydraulics: analytical and graphical solutions for steady-state application. Well hydraulics and pumping tests. Basic groundwater geology. Effects of topography and geology on regional flow systems. Field and numerical delineation and analysis of groundwater flow systems and applications. Chemical characteristics of groundwaters and their relationship to aquifer geology and hydrology. Investigations of groundwater quality and contamination. Prerequisite: Two semesters each of calculus, physics, and chemistry. LEC.
GEOL 555. Climate Science. 3 Hours N.
This course explores the science of climate change. Students will learn how the climate system works; what factors cause climate to change across different time scales and how those factors interact; how scientists use models, observations and theory to make predictions about future climate; and the possible consequences of climate change for our planet. Students will learn how climate change today is different from past climate cycles and how satellites and other technologies are revealing the global signals of a changing climate. Finally, the course looks at the connection between human activity and the current warming trend and considers some of the potential social, economic and environmental consequences of climate change. Prerequisite: GEOL 101 or GEOL 121. LEC.

GEOL 560. Introductory Field Geology. 3 Hours AE61 / N.
Summer session. The study of the principles of field geology and the application of field methods to solve geological problems. Includes use of topographic maps and aerial photographs for geological mapping, the study of stratigraphic methods by measuring sections, and working field trips to areas of regional geological interest. Given at the University of Kansas Geology Field Camp near Canon City, Colorado. Fee. Prerequisite: GEOL 331, GEOL 360, and GEOL 562, or consent of instructor. FLD.

GEOL 561. Field Geology. 3 Hours N.
Summer session. The application of the principles of field geology to solve complex geological problems in the field. Given at the University of Kansas Geology Field Camp near Canon City, Colorado, or at other sites as appropriate. Fee. Prerequisite: GEOL 560. FLD.

GEOL 562. Structural Geology. 4 Hours N / LFE.
A study of primary and secondary rock-structures and their genesis. Includes techniques of structural analysis and introduces mechanics of rock deformations. Lectures, laboratory, and required field trip. Prerequisite: GEOL 311; PHSX 111, PHSX 114, or PHSX 211 and PHSX 216; and MATH 115 or MATH 126. LEC.

GEOL 572. Geophysics. 3 Hours N.
Introductory study of gravitational, magnetic, seismic, electrical, and thermal properties of the earth. Measurements, interpretation, and applications to exploration, earth structure, and global tectonics. Prerequisite: An introductory course in geology; MATH 116 or MATH 127; and PHSX 115 or PHSX 212 and PHSX 236. PHSX 115 or PHSX 212 may be taken concurrently. LEC.

GEOL 573. Geodynamics and Plate Tectonics. 3 Hours N.
Study of physical processes in the solid Earth and of geophysical approaches to studying Earth systems at regional and global scales. Topics include global potential fields, thermal regime, rheology and Earth deformation, earthquakes and seismic structure, plate motions and global tectonics. Prerequisite: An introductory course in geology; MATH 116 or MATH 126; and PHSX 115, PHSX 214, or PHSX 212 and PHSX 236. LEC.

GEOL 575. Seismic Exploration. 3 Hours N.
Application of seismic reflection and refraction techniques to the description of near-surface geology and the exploration for energy and mineral resources. Theory of seismic information, data collection, data processing using computers, and geologic interpretation. Prerequisite: A course in computer programming, either FORTRAN or C, which may be taken concurrently. An introductory geophysics course, such as GEOL 572. LEC.

GEOL 576. Potential Fields Exploration. 3 Hours N.
Use of gravity, magnetic, and electrical signals in the exploration for energy and mineral resources. Elementary potential field theory, data collection methods, data analysis, and interpretation using computers. Prerequisite: A course in computer programming, either FORTRAN or C, which may be taken concurrently. An introductory geophysics course, such as GEOL 572. LEC.

GEOL 577. Environmental Geophysics. 3 Hours N.
Application of the methods of geophysical exploration to evaluate, mitigate, and prevent environmental problems below the surface of the earth. Development of fundamental principles and discussion of environmental case histories using seismic, gravity, magnetic, electromagnetic, electrical, and radar methods. Prerequisite: An introductory course in geology; MATH 116 or MATH 126; and PHSX 115, PHSX 214, or PHSX 212 and PHSX 236. LEC.

GEOL 578. Seismic Data Analysis and Interpretation. 3 Hours N.
Interpretation methods applied to seismic exploration and reservoir characterization. Topics include: rock physics, the convolutional model, synthetic seismograms, seismic response of hydrocarbon reservoirs, resolution, seismic velocity, depth conversion, seismic attributes, AVO, inversion, seismic anisotropy, 3-D 4-D interpretation, S-wave and converted wave interpretation, laboratory use of commercial seismic interpretation software. Prerequisite: GEOL 575 or consent of the instructor. LEC.

GEOL 579. Hydrogeophysics. 3 Hours N.
This course is designed to introduce students to current hydrogeophysics research. Students will learn about determining, predicting, and studying the physical properties and hydrologic processes associated with groundwater flow, contaminant transport, and microbeminal interactions using geophysical measurements at different scales. This course combines lectures, literature review and discussion, and student presentations. Not open to students with credit in GEOL 779. Prerequisite: GEOL 101 or GEOL 121. LEC.

GEOL 591. Topics in Geology: 1-5 Hours N.
May include lectures, discussions, readings, laboratory, and field work in geology. Will be given as needed. May be taken more than once. LEC.

GEOL 711. X-Ray Analysis. 1-2 Hours.
Introduction to the theory and practice of X-ray diffraction and X-ray fluorescence analysis as applied to geological materials. Includes safety training necessary for the operation of X-ray analytical equipment in the department. Prerequisite: GEOL 311 and PHSX 115 or PHSX 212. LEC.

GEOL 712. Microstructures and Petrofabrics. 3 Hours.
This course is geared towards developing a qualitative and quantitative understanding of the fundamentals of rock and mineral deformation necessary to interpret comprehensively microstructural data. Microstructures and petrofabrics contain a wealth of information on kinematics, rheology, and boundary conditions of deforming rocks, important information that often goes unnoticed and unused. This course builds on knowledge acquired in undergraduate structural geology and petrology courses and will give students the tools for a more rigorous and sophisticated evaluation of thin sections and quantitative microstructural and textural data. Required field trip. Prerequisite: GEOL 512 and GEOL 562; or consent of the instructor. LEC.

GEOL 713. Advanced Petrology. 1 Hour.
Advanced topics in igneous and metamorphic petrology with emphasis on chemical and isotopic modeling. Course may be repeated, as topics covered vary. LEC.

GEOL 714. Thermochronology. 3 Hours.
This advanced course is intended to provide students with an in-depth understanding of the fundamentals and an appreciation of the complexities of thermochronology. The primary focus of this course is on modern thermochronological dating methods, a quantitative understanding of noble gas diffusion, data acquisition and interpretation,
numeral modeling of complex thermochronological data, and hands-on
laboratory experience in the KU thermochronology facilities. Prerequisite:
MATH 122 and GEOL 717; or consent of the instructor. LEC.

GEOL 715. Geochemistry. 3 Hours.
Application of chemical equilibria and kinetics to geological environments
and processes, with emphasis on processes involving solution equilibria.
Includes introduction to thermodynamic aspects of equilibria. Prerequisite:
CHEM 188 and MATH 122. LEC.

GEOL 716. Geologic Thermodynamics. 2 Hours.
Classical thermodynamics with an emphasis on phase equilibria, solid-
solution chemistry, and modeling of natural systems. Prerequisite: Second
semester calculus, or permission of instructor. LEC.

GEOL 717. Geochronology. 2-4 Hours.
Principles and applications of natural radioactive systems for
geochronology and cosmochemistry, including use of radiogenic
isotopes as geochemical tracers. Prerequisite: GEOL 512 or consent of
instructor. LEC.

GEOL 718. Stable Isotope Geochemistry. 1-3 Hours.
Principles and applications of equilibria among stable isotopes in the
geological environment, with emphasis on the isotopic systems of
hydrogen, carbon, and oxygen. Prerequisite: GEOL 715 or consent of
instructor. LEC.

GEOL 721. Micropaleontology. 3 Hours.
Systematics, paleontology, evolution, and biostratigraphy of microfossils,
particularly foraminifera, ostracods, and conodonts. Preparation
of material for study. Applications of micropaleontology to geologic
problems. Prerequisite: GEOL 521 or BIOL 100 or 152. LEC.

GEOL 722. Paleocology. 3 Hours.
Principles of ecology as applied to the interpretation of past environments.
Prerequisite: GEOL 521. LEC.

GEOL 723. Museum Internship. 1-6 Hours.
Provides directed, practical experience in research, collection, care,
and management, public education, and exhibits with emphasis to suit
the particular requirements of each student. Graded on a satisfactory/
unsatisfactory basis. (Same as AMS 799, ANTH 799, and MUSE 799.) INT.

GEOL 724. Paleobiogeography. 3 Hours.
The study of the coevolution of the Earth and its biota. The class will
focus on using phylogenetic approaches with fossil taxa to study how
tectonic change has influenced the evolution of life and also to determine
what evolutionary patterns can tell us about the nature and sequence of
geological events. Prerequisite: GEOL 521, or consent of the instructor.
LEC.

GEOL 725. Paleontology of Lower Vertebrates. 3 Hours.
General account of the osteology, geologic distribution, and evolution of
the principal groups of fishes, amphibians, reptiles, and birds. Lectures
and laboratory. (Same as BIOL 790.) Prerequisite: GEOL 105 or GEOL
304, or GEOL 521. LEC.

GEOL 727. Macroevo1ution. 3 Hours.
This course will present a broad survey of topics in macroevolution
including the differences between micro- and macroevolutionary
patterns and processes and the manners of formulating and analyzing
macroevolutionary questions. Discussions will focus on the relevance
of hierarchy theory and levels of selection; an overview of species
concepts, both ontological and epistemological; and an analysis of the
neo-Darwinian synthesis as related to innovations in evolutionary theory.
In addition, the relevance of contingency and extinction to evolutionary
theory will be emphasized. LEC.

GEOL 728. Paleopedology. 3 Hours.
Paleopedology is the study of ancient soils preserved in the geologic
record. The course covers concepts of paleopedology and its applications
to the interpretation of paleoenvironmental, paleoecologic, and
paleohydrogeo1ogy settings and its use in sequence stratigraphy and
paleoclimatology. Prerequisite: GEOG 535, GEOL 331, or GEOL 532; or
consent of the instructor. LEC.

GEOL 729. Ichnology. 3 Hours.
Ichnology is the study of organ-organism-substrate interactions. The class
will cover concepts and applications of ichnology in the marine and
continental realms, including the behavior of such organisms as microbes,
plants, invertebrates, and vertebrates preserved in the geologic record as
trace fossils. Ichnology is applied in geology and in the petroleum industry
to interpret ancient environments, hydrogeology, ecology, and climate.
Prerequisite: GEOL 331, GEOL 521, or GEOL 532; or consent of the
instructor. LEC.

GEOL 731. Terrigenous Depositional Systems. 4 Hours.
Processes that operate in recent sedimentary environments, responses
toj those processes, and criteria for determining depositional
environments of ancient sedimentary rocks. Lectures, practical exercises,
and field trips. Prerequisite: GEOL 331 or GEOL 532. LEC.

GEOL 732. Carbonate Depositional Systems. 3 Hours.
Patterns and processes of contemporaneous carbonate deposition
and diagenesis, depositional models; applications to interpretation of
carbonate rocks. Lecture, discussion, laboratory and field trips.
Prerequisite: GEOL 532 (may be taken concurrently). LEC.

GEOL 733. Shales and Other Mudstones. 3 Hours.
This course defines mudstones and shales. Deposition and constituents
of fine-grained sediment; geochemistry, diagenesis and lithification
of such deposits. Organic constituents of mudstone and their function
as sources of crude oil and natural gas. Petrophysics and mechanical
properties of mudstones and their potential as reservoirs of hydrocarbons.
Not open to students with credit in GEOL 533. Prerequisite: GEOL 331.
LEC.

GEOL 741. Advanced Geomorphology. 1-3 Hours.
Detailed discussions of processes and landforms characteristic of
specific environments. Considered during separate semesters will be
general methodology, and fluvial, arid regions, glacial, and shoreline
geomorphology. Course may be taken more than once. (Same as GEOG
741.) Prerequisite: GEOL 541. LEC.

GEOL 751. Physical Hydrogeology. 3 Hours.
Study of fluid flow in subsurface hydrologic systems. Investigation of the
ground water environment including porosity, and hydraulic conductivity
and their relationship to typical geologic materials. Examination of Darcy's
law and the continuity equation leading to the general flow equations.
Discussion of typical hydraulic testing methods to estimate aquifer
parameters in various situations and apply these to water resource
problems. Study of the basic mechanisms that determine the behavior of
typical regional flow systems. (Same as CE 752.) LEC.

GEOL 753. Chemical and Microbial Hydrogeology. 4 Hours.
Lecture and discussion of chemical and microbiological controls
on groundwater chemistry. Topics include thermodynamic and
microbiological controls on water-rock reactions; kinetics; and
microbiological, chemical and isotopic tools for interpreting water
chemistry with respect to chemical weathering and shallow diagenesis.
Origins of water chemistry, changes along groundwater flow paths,
and an introduction to contaminant biogeochemistry will be discussed
through the processes of speciation, solubility, sorption, ion exchange,
oxidation-reduction, elemental and isotopic partitioning, microbial
metabolic processes and microbial ecology. An overview of the basics of environmental microbiology, including cell structure and function, microbial metabolism and respiration, microbial genetics and kinetics of microbial growth will be covered. (Same as CE 753.) Prerequisite: One year of chemistry, one year of calculus, one year of biology, an introductory course in hydrogeology, or consent of the instructors. LEC.

**GEOL 754. Contaminant Transport. 3 Hours.**
A study of the transport of conservative and non-conservative pollutants in subsurface waters. Case studies are used to illustrate and develop a conceptual understanding of such processes as advection, dispersion, retardation, chemical reactions, and biodegradation. Computer models are developed and used to quantify these processes. (Same as CE 754.) Prerequisite: Introductory Hydrogeology or consent of instructor. LEC.

**GEOL 755. Site Assessment and Remediation. 3 Hours.**
Site Assessment and Remediation encompasses both the academic and applied aspects of environmental geology. The student is presented with the historical, regulatory and risk characteristics of environmental issues as well as specific geologic principles such as GIS and remote sensing, geophysics, geomorphology and surface and groundwater practices. Site assessment concepts include surface and subsurface sampling, analyses and interpretations, conceptual site models, environmental geologic forensics, and environmental Phase I site assessments (USEPA and ASTM). Environmental geology project management principles and practices are examined in detail. These cores aspects of the course form the basic structure in understanding and applying environmental remediation and state-of-the-art/state-of-the-practice processes. Case studies are researched and analyzed for both the assessment and remediation phases of the program. Prerequisite: GEOL 751. LEC.

**GEOL 761. Topics in Regional Field Geology: _____ 1-5 Hours.**
A detailed field study of a carefully selected area that includes features of several phases of geology. Field trip fee. Prerequisite: GEOL 561 or equivalent and departmental approval. FLD.

**GEOL 763. Tectonics and Regional Geology. 3 Hours.**
Topics vary with demand and include fundamental features of plate tectonics, interpretation and distribution of regional geology of mountain belts with emphasis on tectonic setting and processes, regional geology, and tectonics of selected mountain belts. Prerequisite: GEOL 562, GEOL 512, or GEOL 331, and GEOL 572. LEC.

**GEOL 771. Advanced Geophysics: _____. 1-3 Hours.**
Topics to vary with demand and include heat flow, wave propagation, synthetic seismograms, groundwater exploration, geothermal exploration, electrical methods in exploration, rock mechanics-tectonophysics, rock magnetism, geomagnetism, paleomagnetism, geophysical inverse theory, and others upon sufficient demand. May be repeated for different topics. (Same as PHSX 727.) Prerequisite: GEOL 572 or GEOL 573/PHSX 528 or consent of instructor. LEC.

**GEOL 773. Seismology. 3 Hours.**
General theory of seismic waves, wave field extrapolation (migration) by finite difference methods, construction of travel-time curves, reflection and attenuation of coefficients, earthquake source mechanism, distribution and forecasting of earthquakes. Prerequisite: MATH 250/AE 250/ARCE 250/CE 250/CPE 250/EECS 250/EPHX 250/ME 250 and either GEOL 572 or GEOL 573 or PHSX 528. LEC.

**GEOL 775. Near-Surface Seismology. 3 Hours.**
Theoretical and applied study of all aspects of near-surface reflection, refraction, and surface-wave seismology from design and acquisition to interpretation. Prerequisite: MATH 250, GEOL 572, or consent of the instructor. LEC.

**GEOL 776. Ground Penetrating Radar. 3 Hours.**
Theoretical and applied study of radar methods used for imaging the subsurface. Topics include EM theory relating to wave propagation through earth environments, GPR data acquisition, processing and interpretation. Prerequisite: Consent of the instructor. LAB.

**GEOL 779. Hydrogeophysics. 3 Hours.**
This course is designed to introduce students to current hydrogeophysics research. Students will learn about determining, predicting, and studying the physical properties and hydrologic processes associated with groundwater flow, contaminant transport, and microbemineral interactions using geophysical measurements at different scales. This course combines lectures, literature review and discussion, and student presentations. Not open to students with credit in GEOL 579. LEC.

**GEOL 780. Conservation Principles and Practices. 3 Hours.**
This course will acquaint the future museum professional with problems in conserving all types of collections. Philosophical and ethical approaches will be discussed, as well as the changing practices regarding conservation techniques. Emphasis will be placed on detection and identification of causes of deterioration in objects made of organic and inorganic materials, and how these problems can be remedied. Storage and care of objects will also be considered. (Same as AMS 714, BIOL 700, HIST 722 and MUSE 706.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

**GEOL 781. Introduction to Museum Exhibits. 3 Hours.**
This course will consider the role of exhibits as an integrated part of museum collection management, research, and public service. Lecture and discussion will focus on issues involved in planning and producing museum exhibits. Laboratory exercises will provide first hand experience with basic preparation techniques. Emphasis will be placed on the management of an exhibit program in both large and small museums in the major disciplines. (Same as AMS 710, BIOL 787, HIST 723, and MUSE 703.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

**GEOL 782. The Nature of Museums. 3 Hours.**
The purpose of this course is to provide an overview of the kinds of museums, their various missions, and their characteristics and potentials as research, education, and public service institutions responsible for collections of natural and cultural objects. (Same as AMS 721, BIOL 700, HIST 722, MUSE 701.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

**GEOL 783. Museum Management. 3 Hours.**
Lecture, discussion, and laboratory exercises on the nature of museums as organizations; accounting, budget cycles, personnel management, and related topics will be presented using, as appropriate, case studies and a simulated museum organization model. (Same as AMS 731, BIOL 785, HIST 728, and MUSE 701.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

**GEOL 784. Introduction to Museum Public Education. 3 Hours.**
Consideration of the goals of an institution's public education services, developing programs, identifying potential audiences, developing audiences, and funding. Workshops and demonstrations are designed for students to gain practical experience working with various programs and developing model programs. (Same as AMS 797, BIOL 784, HIST 721, and MUSE 705.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

**GEOL 785. Principles and Practices of Museum Collection Management. 3 Hours.**
Lecture, discussion, and laboratory exercises on the nature of museum collections, their associated data, and their use in scholarly research;
cataloging, storage, fumigation, automated information management and related topics will be presented for museums of art, history, natural history and anthropology. (Same as AMS 730, BIOL 798, HIST 725, and MUSE 704.) Prerequisite: Museum Studies student, Indigenous Nations Studies student, or consent of instructor. LEC.

GEOL 791. Advanced Topics in Geology: ______. 1-5 Hours. Selected offerings in geology. Intended primarily for graduate students and qualified seniors. May include lectures, discussions, reading, laboratory and field work. May be taken more than once. LEC.

GEOL 837. Geoscience and Petroleum Engineering. 3 Hours. Advanced geological, geophysical, and engineering characterization of a petroleum reservoir. Includes mapping; petrophysical, production, and pressure analysis; and numerical modeling. Considers economic analysis of steps to improve recovery. Students who have completed GEOL 537 may not take GEOL 837 for credit. LEC.

GEOL 851. Field and Laboratory Methods: Physical Hydrogeology. 1 Hour. Introduction to field and laboratory methods commonly used in physical hydrogeology. Practical experience with common water level measurement techniques, various well pumping techniques, well installation and geologic core sampling, and hydraulic testing. Prerequisite: Introductory course in hydrogeology and familiarity with computer use for data processing, or consent of instructor. FLD.

GEOL 852. Field and Laboratory Methods: Contaminant Transport. 1 Hour. Introduction to laboratory methods for evaluating reactive transport parameters, followed by development and implementation of computer models. Students will gain experience building models starting from basic transport equations using a spreadsheet platform and, where appropriate, commercial software packages. Prerequisite: GEOL 751 (may be taken concurrently) or equivalent, or consent of the instructor. LAB.

GEOL 853. Field and Laboratory Methods: Chemical Hydrogeology. 1 Hour. Practical experience in measuring unstable chemical parameters in groundwater, including pH, Eh, dissolved oxygen, temperature, alkalinity, specific conductance, and turbidity. Practical experience in collecting water samples for chemical analysis, choosing appropriate sample containers and preservation methods, and special techniques for collecting samples for determination of parameters sensitive to environmental changes such as oxygen level or temperature. Prerequisite: GEOL 753 (may be taken concurrently) or equivalent, or consent of the instructor. FLD.

GEOL 854. Field and Laboratory Methods: Geobiology. 1 Hour. Practical experience in cultivating, enumerating and visualizing groundwater microorganisms. Geochemical and molecular techniques for studying microbial community diversity, biomineralization and mineral dissolution, and biodegradation of organic contaminants will be covered. Practical experience in collecting water samples for preservation of microorganisms sensitive to environmental changes such as oxygen level or temperature. Prerequisite: GEOL 753 (may be taken concurrently) or equivalent, or consent of the instructor. FLD.

GEOL 891. Special Studies in Geology. 1-5 Hours. May be repeated. RSH.

GEOL 899. Master's Thesis. 1-12 Hours. Thesis Hours. Graded on a satisfactory progress/limited progress/no progress basis. Prerequisite: Graduate standing. THE.