**GEOLOGICAL SCIENCES**

With one of the most successful graduate programs in the nation, the Department of Geological Sciences has enjoyed a reputation of excellence for more than 100 years. Our doctoral program is ranked among the top 10 percent of U.S. geology programs by the National Research Council and is ranked 1st by *U.S. News and World Report*.

Graduate students have an opportunity to work with approximately 30 tenure and tenure-track faculty who support a wide range of interdisciplinary research programs in biochemistry, economic resources, geodynamics, geophysics, glaciology, global climate change, hydrogeology, paleontology and surficial processes.

The graduate degrees offered include Master of Science (MS) and Doctor of Philosophy (PhD).

Students interested in graduate work in the geological sciences should carefully read the detailed information regarding admission, registration and degree requirements on the Geological Sciences website.

Course code for this program is GEOL.

**Master's Degree**

- Geology - Master of Science (MS) ([catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geology-master-science-ms](http://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geology-master-science-ms))

**Doctoral Degrees**

- Geology - Doctor of Philosophy (PhD) ([catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geology-doctor-philosophy-phd](http://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geology-doctor-philosophy-phd))
- Geophysics - Doctor of Philosophy (PhD) ([catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geophysics-doctor-philosophy-phd](http://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geophysics-doctor-philosophy-phd))

**Certificates**

- Geophysics - Graduate Certificate ([catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geophysics-graduate-certificate](http://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/geophysics-graduate-certificate))
- Hydrologic Sciences - Graduate Certificate ([catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/hydrologic-sciences-graduate-certificate](http://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/geological-sciences/hydrologic-sciences-graduate-certificate))

**Faculty**

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

- Abbott, Lon D. ([https://experts.colorado.edu/display/fisid_145044](https://experts.colorado.edu/display/fisid_145044))
  Senior Instructor; PhD, University of California, Santa Cruz

- Anderson, Robert S. ([https://experts.colorado.edu/display/fisid_130117](https://experts.colorado.edu/display/fisid_130117))
  Distinguished Professor; PhD, University of Washington

- Arthurs, Leilani A. ([https://experts.colorado.edu/display/fisid_145087](https://experts.colorado.edu/display/fisid_145087))
  Assistant Professor; PhD, University of Notre Dame

- Budd, David A. ([https://experts.colorado.edu/display/fisid_101963](https://experts.colorado.edu/display/fisid_101963))
  Professor; PhD, University of Texas at Austin

- Chin, Karen ([https://experts.colorado.edu/display/fisid_122666](https://experts.colorado.edu/display/fisid_122666))
  Associate Professor; PhD, University of California, Santa Barbara

- Clark, Alisha
  Assistant Professor

- Eberle, Jaelyn J. ([https://experts.colorado.edu/display/fisid_126544](https://experts.colorado.edu/display/fisid_126544))
  Professor; PhD, University of Wyoming

- Farmer, G. Lang ([https://experts.colorado.edu/display/fisid_100498](https://experts.colorado.edu/display/fisid_100498))
  Professor; PhD, University of California, Los Angeles

- Flowers, Rebecca M. ([https://experts.colorado.edu/display/fisid_144054](https://experts.colorado.edu/display/fisid_144054))
  Associate Professor; PhD, Massachusetts Institute of Technology

- Ge, Shemin ([https://experts.colorado.edu/display/fisid_101387](https://experts.colorado.edu/display/fisid_101387))
  Professor; Chair; PhD, Johns Hopkins University

- Hynek, Brian Michael ([https://experts.colorado.edu/display/fisid_130622](https://experts.colorado.edu/display/fisid_130622))
  Associate Professor; PhD, Washington University

- Jakosky, Bruce M. ([https://experts.colorado.edu/display/fisid_105845](https://experts.colorado.edu/display/fisid_105845))
  Professor; PhD, California Institute of Technology

- Jones, Craig H. ([https://experts.colorado.edu/display/fisid_105590](https://experts.colorado.edu/display/fisid_105590))
  Professor; PhD, Massachusetts Institute of Technology

- Kopf, Sebastian H. ([https://experts.colorado.edu/display/fisid_155295](https://experts.colorado.edu/display/fisid_155295))
  Assistant Professor; PhD, California Institute of Technology

- Mahan, Kevin H. ([https://experts.colorado.edu/display/fisid_143975](https://experts.colorado.edu/display/fisid_143975))
  Associate Professor; PhD, University of Massachusetts at Amherst

- Marchitto, Thomas ([https://experts.colorado.edu/display/fisid_128241](https://experts.colorado.edu/display/fisid_128241))
  Associate Professor; PhD, Massachusetts Institute of Technology

- Miller, Gifford Hubbs ([https://experts.colorado.edu/display/fisid_102374](https://experts.colorado.edu/display/fisid_102374))
  Professor; PhD, University of Colorado Boulder

- Mojzsis, Stephen J. ([https://experts.colorado.edu/display/fisid_118484](https://experts.colorado.edu/display/fisid_118484))
  Professor; PhD, University of California, San Diego

- Molnar, Peter Hale ([https://experts.colorado.edu/display/fisid_114528](https://experts.colorado.edu/display/fisid_114528))
  Professor; PhD, Columbia University

- Mueller, Karl Jules ([https://experts.colorado.edu/display/fisid_107629](https://experts.colorado.edu/display/fisid_107629))
  Professor; PhD, University of Wyoming

- Overeem, Irina ([https://experts.colorado.edu/display/fisid_125258](https://experts.colorado.edu/display/fisid_125258))
  Associate Professor; PhD, Delft University of Technology (Netherlands)

- Sepulveda Arellano, Julio Cesar ([https://experts.colorado.edu/display/fisid_154923](https://experts.colorado.edu/display/fisid_154923))
  Assistant Professor; PhD, University of Bremen (Germany)

- Sheehan, Anne ([https://experts.colorado.edu/display/fisid_103645](https://experts.colorado.edu/display/fisid_103645))
  Professor; PhD, Massachusetts Institute of Technology

- Simpson, Carl ([https://experts.colorado.edu/display/fisid_159652](https://experts.colorado.edu/display/fisid_159652))
  Assistant Professor; PhD, University of Chicago

- Smyth, Joseph R. ([https://experts.colorado.edu/display/fisid_101056](https://experts.colorado.edu/display/fisid_101056))
  Professor; PhD, University of Chicago
Courses

GEOL 5001 (3) Physics and Chemistry of the Solid Earth
Reviews the physical and chemical characteristics of the solid earth, from the core to the crust, and the processes that govern behavior through the earth. Lectures are supplemented with readings from the recent literature. Topics include convection, phase transitions, melt generation, forces of plate tectonics, origin of continents and lithosphere, continental tectonics, and earthquakes.

Requisites: Restricted to graduate students only.
Recommended: Requisite a course in basic chemistry and a course in physics.
Additional Information: Departmental Category: Graduate Course

GEOL 5002 (3) Physics, Chemistry, and Biology of Sedimentary Systems
Reading and discussion of current issues and themes in the stratigraphic sciences, including stratigraphic and facies analysis, spatial heterogeneity and self-organization, numerical modeling; origin, evolution, mass extinctions, and megatrajectories of life; and paleoceanographic and paleoclimatic signals in sedimentary rocks. Goal is to diversify students’ understanding of the role of physics, chemistry, and biology in attacking research problems in sedimentary systems.

Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5003 (2) Graduate Writing Seminar
Aims at improving graduate student writing, editing, and reviewing skills, while meeting student writing goals. Includes discussion of materials about effective writing, and peer-editing of text that students are producing for their graduate research endeavors.

GEOL 5060 (4) Oceanography
Examines the ocean as a system influencing the Earth's surficial processes and climate. Composition and properties of seawater, ocean circulation, waves, tides, coastal, shallow-, and deep-water processes, biogeochemical cycles, deep sea sediments. Laboratory emphasizes the use of oceanographic data.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 4060
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5080 (3) Advanced Hydrogeology and Modeling Concepts
Introduces advanced groundwater flow and modeling concepts, equations for steady state and transient flow, saturated and unsaturated flow, finite difference method, application of modeling in geologic processes, radial flow and aquifer parameters, infiltration and groundwater recharge, model calibration, verification and prediction. Department enforced prerequisite: MATH 2300 or Fortran.

Additional Information: Departmental Category: Graduate Course

GEOL 5093 (4) Remote Sensing of the Environment
Covers acquisition and interpretation of environmental data by remote sensing. Discusses theory and sensors as well as manual and computerized interpretation methods. Stresses infrared and microwave portions of the spectrum.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 4093 and GEOG 4093 and GEOG 5093
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5110 (3) Geomechanics
Introduces fundamental physical processes important to the transport of heat and mass in the Earth and on Earth's surface. Provides practice with quantitative treatment of geological problems. Solutions for each problem are derived from first principles, including conservation and flux laws. Emphasizes heat conduction and viscous fluid flow. Department enforced prerequisite: restricted to graduate students only and a course in calculus.

Additional Information: Departmental Category: Graduate Course

GEOL 5123 (3) Teaching and Learning in Post-Secondary Science Education
Introduces the science of learning and research-based instructional strategies. Open to students in any STEM discipline considering a career that involves college-level teaching. Students apply research on learning and teaching to the development of instructional materials for a target course they envision teaching at the college level in the future.

Recommended: Prerequisite at least one semester teaching/TAing undergraduate courses (waived with instructor approval).

GEOL 5150 (2) Planetary Field Geology
Provides an overview of the geography, age and origins of the solid (rocky) planets, dwarf planets and moons of our solar system and the processes that form them from comparative studies from comparative geology. Includes modules on volcanism, rifting, aeolian processes, fluvial erosion, impacts, climate change and paleontology.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 4150
Additional Information: Departmental Category: Graduate Course
GEOL 5185 (3) Geomicrobiology
Examines how microbial and chemical processes interact on the Earth’s surface today and have shaped the planet throughout its history. Emphasis will be placed on how the life styles and chemical ingenuity of microorganisms drive key biogeochemical processes including weathering and transformations of carbon, oxygen, sulfur, iron and nitrogen. Towards this goal, major geologic and evolutionary events will be examined through the lens of microbial diversity, metabolic energetics, microbe-mineral interactions, and molecular biomarkers.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4185, ENVS 4185, and MCDB 4185
Grading Basis: Letter Grade

GEOL 5215 (3) Geochronology and Thermochronology
Constraining the timing of events and rates of processes is fundamental to earth science research. The field of geochronology and thermochronology is rapidly evolving. Cutting-edge aspects of geochronologic methods and emerging techniques will be especially emphasized. Lectures will emphasize the principles and assumptions of each technique. Seminar discussions will focus on recent papers that demonstrate state-of-the-art applications to diverse problems.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4215
Additional Information: Departmental Category: Graduate Course

GEOL 5270 (3) Marine Chemistry and Geochemistry
Examines the chemical, biological, geological and physical processes affecting (and affected by) the chemistry of the oceans. Topics include: chemical separation in seawater; the marine carbon cycle and its long-term control on atmospheric CO2; the large-scale interdependence of nutrient distributions and biological productivity, chemical tracers of ocean circulation; the chemistry of marine sediments, including early diagenesis.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4270
Recommended: Prerequisites introductory chemistry, introductory geology, introductory oceanography.
Additional Information: Departmental Category: Graduate Course

GEOL 5280 (3) Aqueous and Environmental Geochemistry
Explores the fundamentals of low-temperature geochemistry to investigate element speciation and chemical behavior in waters, soils and sediments. Topics include water-rock interaction and weathering, mineral dissolution and precipitation reactions, aqueous complexation, mineral surface chemistry, kinetics, element cycles, and redox biogeochemistry. Includes exposure to spectroscopic tools, computer simulations and microbial geochemistry. Department enforced prerequisite: GEOL 3320 or 2 year of college chemistry.
Additional Information: Departmental Category: Graduate Course

GEOL 5305 (3) Global Biogeochemical Cycles
Focuses on the cycling of elements at the global scale with a particular emphasis on human modification of biogeochemical cycles. Major biogeochemical cycles, their past dynamics, present changes and potential future scenarios will be addressed. Ecosystem to global-scale model of the earth system will be discussed along with global scale measurements of element fluxes from satellites, aircraft and measurement networks. Department enforced prerequisite: restricted to graduate students only, general chemistry and some organic chemistry.
Equivalent - Duplicate Degree Credit Not Granted: ENVS 5840
Additional Information: Departmental Category: Graduate Course

GEOL 5330 (3) Cosmochemistry
Investigates chemical and isotopic data to understand the composition of the solar system: emphasis on the physical conditions in various objects, time scales for change, chemical and nuclear processes leading to change, observational constraints, and various models that attempt to describe the chemical state and history of cosmological objects in general and the early solar system in particular. Department enforced prerequisite: graduate standing in physical science and graduate chemistry or physics or math courses.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4330 and ASTR 4330 and ASTR 5330
Additional Information: Departmental Category: Graduate Course

GEOL 5380 (3) Fundamentals of Stable Isotope Geochemistry
This course teaches students the fundamental principles of stable isotope fractionation during physical and biological processes, and the application of these behaviors to a wide range of important geologic questions. The course will use classic case studies from the geologic record to illustrate these principles.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4380
Requisites: Requires prerequisite course of MATH 1300 or APPM 1350 (minimum grade D-).

GEOL 5420 (3) Quaternary Dating Methods
Features in-depth survey of standard and experimental dating methods that provide absolute ages for events of the last two million years of Earth history. Includes theory and application of radiocarbon, uranium series, amino acid, thermo-luminescence, fission track, potassium/argon, hydration, light stable isotopes, and other radioactive techniques.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5430 (3) Paleoenvironment and Climate Geochemistry
Examines scientific tools, data, and theories related to the dramatically varied past climate of the Earth. Focus will be on marine records of climate change and ocean circulation, but ice cores and other continental archives will also be discussed. Course covers the Cenozoic Era (66 Ma to present), but with particular emphasis on the Quaternary ice age cycles.
Recommended: Prerequisites Introductory geology and introductory oceanography or atmospheric science.
Additional Information: Departmental Category: Graduate Course

GEOL 5474 (4) Vertebrate Paleontology
Discusses the history and evolution of the vertebrates, including the phylogenetic relationships and evolutionary patterns of the major groups. Lab focuses on comparative vertebrate osteology and fossil representation of major groups.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4474 and MUSM 5474
Additional Information: Departmental Category: Graduate Course

GEOL 5611 (3) Organic Geochemistry
Explores the "biomarker concept" as a tool to elucidate microbial, biogeochemical, and climatic processes in natural systems through three fundamental goals: a) characterization and classification of organic molecules in complex, natural mixtures; b)
Grading Basis: Letter Grade
GEOL 5612 (3) Techniques in Organic Geochemistry
Explores the techniques in analytical chemistry and organic geochemistry for the study of lipid biomarkers in the environment, which include the following topics: a) Extraction of environmental samples and separation of lipid classes; b) Analysis of apolar lipids using gas chromatography-mass spectrometry (GC-MS); (c) Determine the stable isotope composition of lipids using GC-isotope ratio-MS (GC-IR-MS); (d) Analysis of polar lipids using high performance liquid chromatography-MS (HPLC-MS). Requires previous coursework in general chemistry and Organic Geochemistry. Recommended: Prerequisites Introductory or advanced courses in organic chemistry, biochemistry, biogeochemistry, geochemistry, geomicrobiology, paleoclimate, or geology.

GEOL 5660 (3) Sedimentology & Geobiology of Carbonates
Carbonate sedimentary rocks are a significant component of the geobiological rock record, capturing a history of organisms and the environments they inhabit. This course will focus on how carbonate sediments are formed, deposited, and lithified and what influences the preservation and alteration of textural and geochemical signals. We will cover facies identification, interpreting depositional environment, and carbonate geochemistry, with a particular emphasis on recent advances and unanswered questions at the intersection of carbonates and geobiology, including the role of microbial carbonate precipitation and/or dissolution in the formation and degradation of stromatolites, carbonate mud, ooids, etc.
Recommended: Prerequisite prior coursework in Sedimentology.

GEOL 5670 (3) Isotope Geology
Introduces principles of stable and radiogenic isotope systematics in inorganic and organic geochemistry. Emphasizes application of isotope data to problems in igneous, metamorphic and sedimentary petrology, geochemistry, and petroleum genesis. Equivalent - Duplicate Degree Credit Not Granted: GEOL 4670 Additional Information: Departmental Category: Graduate Course

GEOL 5675 (3) Stable Isotopes in Paleoclimate and Paleocoeology
Explores the use of stable isotope geochemistry for research questions in paleoclimatology and paleoecology. Covers physical and biological drivers of isotopic fractionation, systematics and applications of light elements such as carbon, nitrogen, oxygen, hydrogen, sulfur and boron and some less traditional isotopic systems. Applications include marine and terrestrial paleoclimatic proxies and some uses for ecology and paleoecology.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4675 Grading Basis: Letter Grade Additional Information: Departmental Category: Graduate Course

GEOL 5690 (3) Tectonic History of the Western United States
Provides students with the practical tools needed to make tectonic interpretations through study of the geologic history of the western United States and the geodynamic models used in interpreting that history. Paleomagnetism, geobarometry, geothermometry, geodynamic modeling, and elements of structural geology and stratigraphy are topics considered in this class.
Requisites: Requires prerequisite courses of GEOL 3120 and PHYS 1110 (all minimum grade D-).
Additional Information: Departmental Category: Graduate Course

GEOL 5700 (1-4) Geological Topics Seminar
Offers seminar studies in geological subjects of special current interest. Primarily for graduate students, as departmental staff and facilities permit. Repeatable: Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term. Requisites: Restricted to graduate students only. Additional Information: Departmental Category: Graduate Course

GEOL 5701 (2) Super-Problems in Quaternary Climate
Investigates major problems in the study and understanding of Quaternary climate variation, in seminar format. Each year one major topic will be addressed, such as: the physics and chemistry of the Ice Age ocean circulation; the theory and mechanics of glacial/interglacial atmospheric CO2 change; the origins of the 20, 40, and 100 kyr orbital (Milankovitch) climate cycles.
Recommended: Prerequisites Introductory geology and climatology, oceanography, paleoclimatology, or paleoceanography.
Additional Information: Departmental Category: Graduate Course

GEOL 5702 (1) Geomorphology Seminar
Explores the dynamics and forms of the earth's surface through critical reading and discussion of both classical and modern literature.
Repeatable: Repeatable for up to 10.00 total credit hours.
Additional Information: Departmental Category: Graduate Course

GEOL 5703 (1) Seminar in Tectonics
Focuses on a wide variety of topics related to crust, mantle and whole earth tectonics. Published papers from recent peer-reviewed literature are read and discussed. The format and specific topics will vary each semester (e.g., a relatively focused theme or open format) and will in part be determined by the makeup of enrolled students. Department enforced prerequisite: restricted to graduate students only.
Repeatable: Repeatable for up to 6.00 total credit hours.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Graduate Course

GEOL 5704 (1) Carbonates Seminar
Focuses broadly on the topic of carbonates, including sedimentology, geochemistry, and geobiology of carbonates. Each semester will have a distinct theme under these sub-topics. Students will be responsible for leading discussion on individual readings and will be able to provide input on both the theme and the individual reading selections. Upper-level GEOL majors can register with instructor approval.
Repeatable: Repeatable for up to 10.00 total credit hours.

GEOL 5711 (1-3) Igneous and Metamorphic Field Geology
Applies field techniques to interpretation of igneous and metamorphic rocks. Field exercises and lectures focus on collecting data required to map igneous and metamorphic rock units. Department enforced prerequisites: restricted to graduate students only and GEOL 2001 or GEOL 2700 and GEOL 3020.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Additional Information: Departmental Category: Graduate Course
GEOL 5712 (1-3) Structural Field Geology
Methods of field study of structure of rocks, including observations, data collection and interpretation to understand geometry of deformation and causative processes and kinematics. Field projects are mapped using different scales, air photos, topographic maps and compass and tape. Department enforced prerequisites: GEOL 2001 or GEOL 2700 and GEOL 3020.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: Graduate Course

GEOL 5714 (2) Field Geophysics
Applies geophysical field techniques and data interpretation to studying geological and engineering problems. Fieldwork includes seismic, gravity, magnetic and electrical measurements. Department enforced prerequisite: restricted to graduate students only and GEOL 2001 or GEOL 2700 and MATH 1300 and PHYS 1110.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: Graduate Course

GEOL 5715 (1-3) Field Techniques in Surficial Geology and Geohydrology
Introduces various field techniques and data analysis methods in hydrogeologic studies for students in geology, environmental studies, geography and civil engineering. Exercises include mapping ground water levels, conducting slug and pumping tests, measuring steam flows, interpreting aquifer parameters from geophysical measurements and using field data for water budget analysis. Department prerequisite: GEOL 2001 or GEOL 2700.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: Graduate Course

GEOL 5716 (1-3) Environmental Field Geochemistry
Develops basic field skills in the most commonly performed tasks required for the environmental characterization of solid and aqueous wastes. Media of study include soils, stream sediments, surface waters, ground waters and atmospheric particulates. Department enforced prerequisites: GEOL 2001 or GEOL 2700 and CHEM 1011 and CHEM 1031 or CHEM 1113 or CHEM 1133 and GEOL 3320.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: Graduate Course

GEOL 5717 (2) Field Seminar in Geology and Tectonics
Studies geologic features in and around Colorado to gain an overview of the geologic and tectonic evolution of the western U.S. Department enforced prerequisites: restricted to graduate students only and GEOL 2001 or GEOL 2700 and at least one of the following: GEOL 3120 or GEOL 3320 or GEOL 3430.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: Graduate Course

GEOL 5719 (2) Field Analysis and Tectonics of Crystalline Rocks
Introduces basic and advanced mapping tools and concepts for structural and tectonic analysis of solid-state and magmatic deformation, metamorphism, and fluid flow in igneous and metamorphic rocks. Includes some digital mapping concepts using smartpad and smartphone applications, and computer-based analysis of structure data. Includes multi-day mapping projects in the Front Range, and in western Colorado, southern Wyoming, or northern New Mexico. Also includes introductions to Precambrian tectonic history of western North America and mineral resources of Colorado.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 4719

Requisites: Restricted to graduate students only.

Grading Basis: Letter Grade

GEOL 5725 (1-4) Field Based Special Topics in Geoscience
Explores selected geological subjects of special interest in a field setting.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 4725

Repeatable: Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Graduate Course

GEOL 5775 (3) Introduction to Numerical Modeling in Geoscience
Numerical models play an essential role across the geosciences, with applications that include hypothesis exploration, data interpretation, and prediction. This course provides a hands-on introduction to numerical modeling. Students learn scientific programming and modeling concepts by iterating through a series of model-development assignments in Python and Matlab. Applications span a range of topics in the geosciences, with emphasis on physical processes that involve mass, energy, and/or momentum transport.

GEOL 5800 (3) Planetary Surfaces and Interiors
Examines processes operating on the surfaces of solid planets and in their interiors. Emphasizes spacecraft observations, their interpretation, the relationship to similar processes on Earth, the relationship between planetary surfaces and interiors and the integrated geologic histories of the terrestrial planets and satellites.

Equivalent - Duplicate Degree Credit Not Granted: ASTR 5800

Requisites: Restricted to graduate students only.

Additional Information: Departmental Category: Graduate Course

GEOL 5810 (3) Planetary Atmospheres
Covers the structure, composition, and dynamics of planetary atmospheres. Includes the origin of planetary atmospheres, chemistry and cloud physics, greenhouse effects, climate, and the evolution of planetary atmospheres - past and future.

Equivalent - Duplicate Degree Credit Not Granted: ATOC 5810 and ASTR 5810

Additional Information: Departmental Category: Graduate Course

GEOL 5820 (3) Origin and Evolution of Planetary Systems
Considers the origin and evolution of planetary systems, including protoplanetary disks, condensation in the solar nebula, composition of meteorites, planetary accretion, comets, asteroids, planetary rings and extrasolar planets. Applies celestial mechanics to the dynamical evolution of solar system bodies.

Equivalent - Duplicate Degree Credit Not Granted: ASTR 5820 and ATOC 5820

Requisites: Restricted to graduate students only.

Additional Information: Departmental Category: Graduate Course
GEOL 5830 (3) Topics in Planetary Science
Examines current topics in planetary science, based on recent discoveries, spacecraft observations and other developments. Focuses on a specific topic each time the course is offered, such as Mars, Venus, Galilean satellites, exobiology, comets or extrasolar planets. Department enforced prerequisite: restricted to graduate students in the physical sciences.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5830 and ASTR 5830
Repeatable: Repeatable for up to 6.00 total credit hours.
Additional Information: Departmental Category: Graduate Course

GEOL 5835 (1) Seminar in Planetary Science
Studies current research on a topic in planetary science. Students and faculty give presentations. Subjects may vary each semester. Department enforced prerequisite: senior level undergraduate physics.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5835 and ASTR 5835
Repeatable: Repeatable for up to 4.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5840 (1-3) Independent Study-Quaternary Geology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5841 (1-3) Independent Study-Economic Geology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5842 (1-3) Independent Study-Petrology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5843 (1-3) Independent Study-Sedimentology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5844 (1-3) Independent Study-Structure/Tectonics
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5845 (1-3) Independent Study-Geochemistry
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5846 (1-3) Independent Study-Geophysics
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5847 (1-3) Independent Study-Hydrology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5848 (1-3) Independent Study-Paleontology
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 5849 (1-3) Independent Study-Sediment Petrology
Repeatable: Repeatable for up to 7.00 total credit hours.
Additional Information: Departmental Category: Graduate Course

GEOL 5851 (1-3) Independent Study-Sediment Petrology
Repeatable: Repeatable for up to 7.00 total credit hours.
Additional Information: Departmental Category: Graduate Course

GEOL 5852 (1-3) Independent Study--GIS Applications in Quaternary Geosciences
Leads students through quantitative spatial analysis of environmental and paleoclimatic problems. Each student will develop a project from start to finish, with emphasis on raster GIS for building large empirical databases that bear on process and variability.
Additional Information: Departmental Category: Graduate Course

GEOL 5862 (1-4) Geology Independent Study
Equivalent - Duplicate Degree Credit Not Granted: GEOL 4862
Repeatable: Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

GEOL 5910 (3) Geothermodynamics
Provides a solid foundation in chemical thermodynamic concepts and calculations as applied to geochemistry and geobiology.

GEOL 6050 (3) Space Instrumentation
Provides an overview of the relevant space environment and process, the types of instruments flown on recent mission and the science background of the measurement principles.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6050 and ASEN 6050
Grading Basis: Letter Grade
Additional Information: Departmental Category: Graduate Course

GEOL 6060 (4) Petroleum Geology of Turbidite Systems
Covers the exploration and production aspects of petroleum submarine fans and turbidite systems.
Requisites: Requires prerequisite course of GEOL 6330 (minimum grade B).
Additional Information: Departmental Category: Graduate Course

GEOL 6310 (3) Sedimentary Petrology
Covers interpretation of depositional and diagenetic history of sedimentary rocks as determined from thin-section studies. Department enforced prerequisites: GEOL 3010 and GEOL 3020 and GEOL 3430 or equivalents.
Additional Information: Departmental Category: Graduate Course

GEOL 6330 (4) Applied Sequence Stratigraphy and Basin Analysis
Develops skills in the stratigraphic interpretation of seismic reflection data, recognition of sequence stratigraphy in well logs and outcrop and their applications to basin analysis in petroleum exploration. Department enforced prerequisite: restricted to graduate students only and introductory undergraduate physics and sedimentology/stratigraphy.
Additional Information: Departmental Category: Graduate Course

GEOL 6610 (3) Earth and Planetary Physics 1
Offered alternate years. Examines mechanics of deformable materials, with applications to earthquake processes. Introduces seismic wave theory. Other topics include inversion of seismic data for the structure, composition and state of the interior of the Earth.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6610 and PHYS 6610
Additional Information: Departmental Category: Graduate Course
GEOL 6620 (3) Earth and Planetary Physics 2
Offered alternate years. Covers space and surface geodetic techniques as well as potential theory. Other topics are the definition and geophysical interpretation of the geoid and of surface gravity anomalies; isostasy; post-glacial rebound; and tides and the rotation of the Earth.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6620 and PHYS 6620
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Graduate Course

GEOL 6630 (3) Earth and Planetary Physics 3
Offered alternate years. Examines the solar system, emphasizing theories of its origin and meteorites. Highlights distribution of radioactive materials, age dating, heat flow through continents and the ocean floor, internal temperature distribution in the Earth, and mantle convection. Also covers the origin of the oceans and atmosphere.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6630 and PHYS 6630
Additional Information: Departmental Category: Graduate Course

GEOL 6650 (1-3) Seminar in Geophysics
Advanced seminar studies in geophysical subjects for graduate students.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6650 and PHYS 6650
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Additional Information: Departmental Category: Graduate Course

GEOL 6655 (3) InSAR Processing and Interpretation
Understand the concepts and applications of interferometric synthetic aperture radar (InSAR) and differential InSAR, to include an introduction to physical geodesy and satellite techniques.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 6655
Grading Basis: Letter Grade

GEOL 6670 (2) Geophysical Inverse Theory
Principles of geophysical inverse theory as applied to problems in the Earth sciences, including topography, Earth structure and earthquake locations. Department enforced prerequisites: a course in calculus and a course in computer programming (any language).
Equivalent - Duplicate Degree Credit Not Granted: PHYS 6670
Additional Information: Departmental Category: Graduate Course

GEOL 6940 (1) Master's Candidate for Degree
Requisites: Restricted to graduate students only.
Grading Basis: Pass/Fail
Additional Information: Departmental Category: Graduate Course

GEOL 6950 (1-6) Master's Thesis
Repeatable: Repeatable for up to 6.00 total credit hours.
Additional Information: Departmental Category: Graduate Course

GEOL 6960 (3) Plan II Master's Research
Additional Information: Departmental Category: Graduate Course

GEOL 8990 (1-10) Doctoral Dissertation
All doctoral students must register for not fewer than 30 hours of dissertation credit as part of the requirements for the degree. For a detailed discussion of doctoral dissertation credit, refer to the Graduate School section.
Repeatable: Repeatable for up to 30.00 total credit hours.
Additional Information: Departmental Category: Graduate Course