

# Geological Sciences

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## Faculty

**Professor** M. Appold\*\*, F. G. Gomez\*\*, K. G. MacLeod\*\*, J. Schiffbauer\*\*  
**Associate Professor** J. W. Huntley\*\*  
**Assistant Professor** R. deGraffenreid\*\*, N. Hopkins\*, S. Jacquet\*\*, C. Liu, T. Rivera\*\*, T. Selly\*

- \* Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.
- \*\* Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

## Undergraduate

- BA in Geological Sciences (<https://catalog.missouri.edu/collegeofartsandscience/geologicalsciences/ba-geological-sciences/>)
- BS in Geological Sciences (<https://catalog.missouri.edu/collegeofartsandscience/geologicalsciences/bs-geological-sciences/>)
- Minor in Geological Sciences (<https://catalog.missouri.edu/collegeofartsandscience/geologicalsciences/minor-geological-sciences/>)

The Department of Geological Sciences offers two undergraduate degree programs, a Bachelor of Arts and a Bachelor of Science, both with major in Geological Sciences. The BA is geared to those students interested in using geological knowledge in an allied career such as environmental law or science journalism, while the BS is geared toward students interested in careers as environmental geoscientists and hydrogeologists, the mining and fossil fuel industries, or an advanced degrees geology or geophysics. The BS capstone is a 6 week field camp at our permanent field station, Camp Branson, in Wyoming. This camp is sought after by students from around the country and its graduates are well regarded by employers. In addition, students majoring in other departments can minor in geological sciences.

## Departmental Honors

Departmental Honors can be achieved by students who maintain a cumulative GPA of 3.3 or higher, and who complete a Senior Thesis in Geological Sciences.

## Dual Degrees

The Department of Geological Sciences offers dual degree programs with the Department of Soil, Environmental and Atmospheric Science in their emphasis area of Environmental Soil Science and with the Department of Civil and Environmental Engineering and with the College of Education in the Bachelor of Science in Education, emphasis in Earth Science Education. For more information, contact an advisor in the department.

## Graduate

While a graduate degree in Geological Sciences is not currently offered, the department does offer graduate degrees in Geology (<https://catalog.missouri.edu/collegeofartsandscience/geology/>). The catalog provides a complete list of degree program options (<https://catalog.missouri.edu/degreesanddegreeprograms/>).

### GEOL 1050: Planet Earth

An introduction to Earth Science. Topics include: evidence for continental drift and plate tectonics, causes and prediction of natural hazards, the scale of geological time.

**Credit Hours:** 3

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### GEOL 1100: Introduction to the Earth with Laboratory

Three lectures, 2-hours lab. Earth processes and products and their impact on human needs and the environment. One field trip. For the Mizzou Online sections, there will not be required lectures, lab, and field trip.

**Credit Hours:** 4

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### GEOL 1120: Laboratory Investigations of the Earth

This hybrid-lab course introduces basic methods of earth science investigation and inquiry with an emphasis on earth sciences. Key concepts include basic scientific methodology, earth materials and processes, and the societal relevance of geoscience research and application. Upon completion of the course, the successful student will have learned to apply course material to improve thinking, problem solving and decision-making. Graded on A-F basis only.

**Credit Hours:** 2

**Recommended:** GEOL 1050 as a corequisite (although the course will be a stand-alone introduction to the geosciences)

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### GEOL 1200: Environmental Geology with Laboratory

The interaction between geologic processes and human society. Topics include mineral, water, and energy resources, volcanic hazards, earthquakes, landslides, floods, coastal erosion, pollution problems and environmental management.

**Credit Hours:** 4

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### GEOL 1400: Themes in Geology

5-week course organized around a central theme or topic, up to 3 different sections can be taken for credit.

**Credit Hour:** 1

**GEOL 2100: Independent Study in Geology**

Directed Library research in geological topics, under the supervision of faculty sponsor. May be repeated for a maximum of 3 hours credit.

**Credit Hour:** 1-3

**Prerequisites:** instructor's consent

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**GEOL 2120H: Faults and Earthquakes: Past, Present, and Future - Honors**

Seminar in science and societal ramifications of earthquakes. Geologic background includes causes, behavior, and distribution of faults. Student-led discussions cover historical disasters, economic, political, psychological, and cultural perspectives.

**Credit Hours:** 3

**Prerequisites:** ENGLSH 1000

**Recommended:** Honors eligibility

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**GEOL 2130: Physical Geology for Scientists and Engineers**

Introduction to physical geology and Earth processes with a focus on applications and societal relevance. In addition to basic geologic processes, physical principles will illustrate the interactions between geology and engineering, using a calculus-based approach.

**Credit Hours:** 4

**Prerequisites:** MATH 1500

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**GEOL 2150: The Age of the Dinosaurs**

Study of the evolution of dinosaurs during the Mesozoic Era. New information on dinosaur life habits, food resources, dispersal by plate tectonics, and theories of extinction will be covered.

**Credit Hours:** 3

**Prerequisites:** 1000-level science course

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**GEOL 2160: Volcanoes and the Human Environment**

This course gives students an understanding of how volcanoes work, how they are studied, and how they have impacted human cultures. Students will gain appreciation of volcanology as a broad scientific discipline within geology and the role that science plays in public policy. Graded on A-F basis only.

**Credit Hours:** 3

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**GEOL 2160H: Volcanoes and the Human Environment - Honors**

This course gives students an understanding of how volcanoes work, how they are studied, and how they have impacted human cultures. Students will gain appreciation of volcanology as a broad scientific discipline within geology and the role that science plays in public policy. Graded on A/F basis only.

**Credit Hours:** 3

**Recommended:** Honors eligibility required

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**GEOL 2220: Seminar: Headline Topics in the Geological Sciences**

Seminar organized around a central theme that is the focus of intense ongoing research and public debate.

**Credit Hours:** 3

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**GEOL 2220H: Honors Seminar: Headline Topics in the Geological Science**

Seminar organized around a central theme that is the focus of intense ongoing research and public debate.

**Credit Hours:** 3

**Prerequisites:** ENGLSH 1000

**Recommended:** Honors eligibility

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**GEOL 2300: Earth Systems and Global Change**

Study of the earth as a whole, taking into account the many interwoven components of the geosphere, hydrosphere, atmosphere and biosphere.

**Credit Hours:** 3

**Recommended:** 1000-level Science course

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**GEOL 2350: Earth and Life Through Time**

Summary of principles and techniques used in reconstructing Earth's history. Survey of major events that have affected Earth and its inhabitants. Review of geologic history of North America.

**Credit Hours:** 3

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200

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**GEOL 2360: Earth and Life Through Time Laboratory**

A laboratory course designed to improve understanding of Earth History by examination of maps and mineral, rock, sediment and fossil samples.

**Credit Hour:** 1

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200

**Corequisites:** GEOL 2350

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**GEOL 2400: Surficial Earth Processes and Products with Laboratory**

Semiquantitative analysis of geologic processes that shape the earth's surface. Includes topics in sedimentation and geomorphology.

**Credit Hours:** 4

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200, and MATH 1100

**GEOL 2500: Regional Geology Field Trip**

Field based study of a particular geologic region, including classroom preparation prior to the field trip. The trip will last 7-10 days, either during Spring Break or immediately after finals week. May be repeated for credit.

**Credit Hours:** 3**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200**GEOL 2600: Mineral and Energy Resources of the Earth**

This course examines the geology of Earth's major mineral and energy resources--their origin, distribution, and characteristics--and societal implications of their use and abundance. Major topics: fossil fuels, nuclear energy, base & precious metals, non-metallic minerals, water.

**Credit Hours:** 3**GEOL 3085: Problems in Geological Sciences**

Problems in Geological Sciences.

**Credit Hour:** 1-5**Prerequisites:** instructor's consent**GEOL 3102: Topics in Geological Sciences-Biological/Physical/Mathematics**

Organized study of selected topics. Subject and earnable credit may vary. Departmental consent for repetition.

**Credit Hour:** 1-99**Prerequisites:** junior standing or higher and instructor's consent**GEOL 3110: Geology of Missouri**

Exploration of the landscape and history of Missouri as influenced by and recorded in its geology. In-class field trips in addition to weekend and overnight field trips to areas of unique geologic interest required (virtual options available, as needed). Graded on A-F basis only.

**Credit Hours:** 3**Prerequisites:** GEOL 1100 or GEOL 1200**GEOL 3250: Mineralogy**

Introduction to crystallography, crystal chemistry and crystal structures. Systematic study of mineral groups. Includes identification of minerals by physical, chemical and optical properties.

**Credit Hours:** 5**GEOL 3550: Introduction to Paleontology with Laboratory**

Study of the morphology, paleontology, patterns of evolution, and causes of extinction in geologically important groups of invertebrate and vertebrate fossils. Lab concentrates on identification of biostratigraphically important fossils (mostly invertebrates). Several half-day field trips.

**Credit Hours:** 4**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200**GEOL 3800: Sedimentology and Stratigraphy with Lab**

Mechanics of sediment transport by fluid flow and gravity flow, origins of stratification and sedimentary structures, facies characteristics depositional environments.

**Credit Hours:** 4**Prerequisites:** GEOL 3250**GEOL 4002: Topics in Geological Sciences-Biological Science**

Organized study of selected topics. Subjects and earnable credit may vary. May be repeated with departmental consent.

**Credit Hour:** 1-99**Prerequisites:** instructor's consent**GEOL 4006: Topics in Geological Sciences-Mathematical Science**

Organized study of selected topics. Subjects and earnable credit may vary. May be repeated with departmental consent.

**Credit Hour:** 1-99**Prerequisites:** instructor's consent**GEOL 4007: Topics in Geological Sciences-Physical Science**

Organized study of selected topics. Subjects and earnable credit may vary. May be repeated with departmental consent.

**Credit Hour:** 1-99**Prerequisites:** instructor's consent**GEOL 4100: Groundwater Hydrology**

(cross-leveled with GEOL 7100). Analysis of groundwater occurrence, flow, recovery, and solute transport within shallow levels of the Earth's crust.

**Credit Hours:** 3**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200, and PHYSCS 1210 or PHYSCS 2750, and MATH 1400 or MATH 1500

**GEOL 4120: Engineering Geology**

(cross-leveled with GEOL 7120). Fundamentals of earth materials and geological processes and their applications in engineering works and environmental sciences. Includes properties of minerals and rocks, rock and soil mechanics, surficial geological processes, and practice of engineering.

**Credit Hours:** 3**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200, and MATH 1500, or instructor's consent**GEOL 4130: Groundwater Modeling**

(cross-leveled with GEOL 7130). Use of leading groundwater flow and contamination modeling software. Theory of groundwater flow, solute transport, and selected numerical solution techniques. Applications to water resource, environmental, and geological problems.

**Credit Hours:** 3**Prerequisites:** GEOL 4100 or equivalent**GEOL 4150: Structural Geology**

(cross-leveled with GEOL 7150). The mechanical behavior of earth materials. Analysis of the geometry and mechanics of faults, fractures, and folds. Laboratory includes problems on stresses and strains associated with deformation, geometric analysis of deformation structures, and interpretation of geologic maps.

**Credit Hours:** 4**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200 and MATH 1140 or MATH 1160 or MATH 1500**GEOL 4200: Economic Geology with Laboratory**

Geochemistry of ore deposits. Introduction to types of mineral deposits, genesis of ore, and current areas of research. Laboratory emphasizes hand-specimen and polished-section studies of a wide variety of ore deposit types.

**Credit Hours:** 4**Prerequisites:** GEOL 4900**GEOL 4300: Introduction to Low-Temperature Geochemistry**

Introduction to the chemical alteration of rock-forming minerals in weathering environments and to factors controlling the chemical composition of subsurface water.

**Credit Hours:** 3**Prerequisites:** GEOL 3300 or instructor's consent**GEOL 4318: Environmental Soil Chemistry**

(same as SOIL 4318, ENV\_SC 4318; cross-leveled with GEOL 7318, SOIL 7318, ENV\_SC 7318). Study of chemical constituents and

processes occurring in soils. Topics include soil minerals and weathering processes, organic matter, solution chemistry, oxidation-reduction reactions and adsorption processes.

**Credit Hours:** 3**Prerequisites:** SOIL 2100 or GEOL 2400, CHEM 1320 and CHEM 1330. Junior standing or instructor's consent**GEOL 4350: Taphonomy**

(cross-leveled with GEOL 7350). The purposes of this course are to 1) analyze patterns in the history of life and 2) to recognize the biased processes that led to its preservation. We will accomplish these goals by examining two disparate fossil preservation pathways: 1) Konservat Lagerstätten: fossil deposits that are notorious for the exceptional and rare preservation of soft tissues and 2) Konzentrat Lagerstätten: fossil deposits that are exceptional for the enormous amount of fossilized skeletal material they contain. Through careful examination of both the rare and the hyper-abundant, we can address the fundamental question of paleobiology: how literally can the fossil record be read as the history of life? Graded on A-F basis only.

**Credit Hours:** 3**Prerequisites:** GEOL 2350, GEOL 2360**GEOL 4370: Conservation Paleobiology**

(cross-leveled with GEOL 7370). Humans are having an undeniable influence on Earth systems, including the biosphere. Climate change, habitat destruction, over-hunting/harvesting, pollution, and invasive species are among the primary stressors of modern biodiversity. How have ecosystems responded to such stressors in the past? How do we determine what a "pristine" ecosystem looks like when planning ecosystem restoration? Paleontologists are uniquely equipped to address these questions using the fossil record. In this course we will review the important questions in this emerging discipline, learn about the tools used to address these questions, and learn from case studies involving invertebrate, vertebrate, and plant fossils from a variety of environments.

**Credit Hours:** 3**GEOL 4650: Plate Tectonics**

(cross-leveled with GEOL 7650). Formation, evolution, and structure of the earth. Rules, causes, and implications of plate tectonics with emphasis on present-day features.

**Credit Hours:** 3**Prerequisites:** GEOL 3250 or GEOL 4150 or instructor's consent**GEOL 4650W: Plate Tectonics - Writing Intensive**

Formation, evolution, and structure of the earth. Rules, causes, and implications of plate tectonics with emphasis on present-day features.

**Credit Hours:** 3

**Prerequisites:** GEOL 3250 or GEOL 4150 or instructor's consent

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**GEOL 4680: Neotectonics and Earthquake Geology**

(cross-leveled with GEOL 7680). Introduction to techniques and concepts of active crustal deformation from the geological and geodetic perspectives. Topics include tectonic geomorphology, paleoseismology, Quaternary dating, tectonic geodesy, numerical models of faults, and earthquake hazard assessment.

**Credit Hours:** 3

**Prerequisites:** GEOL 4150 or GEOL 4650

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**GEOL 4750: Microanalysis for Geological Sciences**

(cross-leveled with GEOL 7750). This course is intended to provide a working knowledge of electron and X-ray microbeam analytical instruments - both in principle and in practice. Lectures will focus on the physics of how these instruments collect data, and how these data can be interpreted. In addition, students will gain hands-on experience with operating these instruments, specifically on their own samples, as well as preparing their samples for microanalysis and interpreting/manipulating the resulting data. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** Instructor's Consent (instrument time is limited so enrollment must also be limited)

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**GEOL 4800: Introduction to Geophysics**

(cross-leveled with GEOL 7800). Introduction to the fundamentals of geophysical methods and their applications in geology, environmental studies, and exploration. Topics include seismic, gravity, magnetic, and electric methods.

**Credit Hours:** 3

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200 and MATH 1700 or instructor's consent

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**GEOL 4900: Igneous and Metamorphic Petrology with Laboratory**

Introduction to igneous and metamorphic rock associations and rock-forming processes. Emphasis on understanding the evolution of the Earth in view of igneous and metamorphic rock petrogenesis.

**Credit Hours:** 4

**Prerequisites:** GEOL 3250

**Recommended:** GEOL 3300

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**GEOL 4950: Senior Thesis**

Research conducted in an area of the Geological Sciences under the auspices of a member of the faculty. Under normal circumstances, this research should be completed over two semesters. May be repeated for a maximum of 3 hours credit.

**Credit Hour:** 1-3

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**GEOL 4992: Geology Field Camp**

A capstone field course for students majoring in geology or related fields. Through a thorough investigation of the geology of the Rocky Mountains centered in western Wyoming, students will develop skills in assessing the geologic history, materials, resources, and active processes of a region. Additionally, students will be exposed to and develop proficiency in the essential field methods in traditional and applied geoscience research. Includes an excursion to Yellowstone and Grand Teton National Parks. Graded on A-F basis only.

**Credit Hours:** 6

**Recommended:** Junior or Senior-standing and GEOL 3800 and GEOL 4150

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**GEOL 7002: Topics in Geological Sciences-Biological/Physical/Mathematics**

Organized study of selected topics. Subjects and earnable credit may vary. May be repeated with departmental consent.

**Credit Hour:** 1-99

**Prerequisites:** instructor's consent

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**GEOL 7085: Problems in Geological Sciences**

**Credit Hour:** 1-8

**Prerequisites:** instructor's consent

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**GEOL 7100: Groundwater Hydrology**

(cross-leveled with GEOL 4100). Analysis of groundwater occurrence, flow, recovery, and solute transport within shallow levels of the Earth's crust.

**Credit Hours:** 3

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200, and PHYSCS 1210 or PHYSCS 2750, and MATH 1400 or MATH 1500

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**GEOL 7120: Engineering Geology**

(cross-leveled with GEOL 4120). Fundamentals of earth materials and geological processes and their applications in engineering works and environmental sciences. Includes properties of minerals and rocks, rock and soil mechanics, surficial geological processes, and practice of engineering.

**Credit Hours:** 3

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200 and MATH 1500, or instructor's consent

**GEOL 7130: Groundwater Modeling**

(cross-leveled with GEOL 4130). Use of leading groundwater flow and contamination modeling software. Theory of groundwater flow, solute transport, and selected numerical solution techniques. Applications to water resource, environmental, and geological problems.

**Credit Hours:** 3**Prerequisites:** GEOL 4100 or equivalent**GEOL 7150: Structural Geology**

(cross-leveled with GEOL 4150) The mechanical behavior of earth materials. Analysis of the geometry and mechanics of faults, fractures, and folds. Laboratory includes problems on stresses and strains associated with deformation, geometric analysis of deformation structures, and interpretation of geologic maps.

**Credit Hours:** 4**Prerequisites:** instructor's consent and GEOL 1100 or GEOL 2130 or GEOL 1200 and MATH 1140 or MATH 1160 or MATH 1500**GEOL 7200: Economic Geology with Laboratory**

Geochemistry of ore deposits. Introduction to types of mineral deposits, genesis of ore, and current areas of research. Laboratory emphasizes hand-specimen and polished-section studies of a wide variety of ore deposit types.

**Credit Hours:** 4**Prerequisites:** GEOL 4900**GEOL 7300: Introduction to Low-Temperature Geochemistry**

Introduction to the chemical alteration of rock-forming minerals in weathering environments and to factors controlling the chemical composition of subsurface water.

**Credit Hours:** 3**Prerequisites:** GEOL 3300 or instructor's consent**GEOL 7318: Environmental Soil Chemistry**

(same as SOIL 7318, ENV\_SC 7318; cross-leveled with GEOL 4318, SOIL 4318, ENV\_SC 4318). Study of chemical constituents and processes occurring in soils. Topics include soil minerals, and weathering processes organic matter, solution chemistry, oxidation-reduction reactions and adsorption processes.

**Credit Hours:** 3**Prerequisites:** SOIL 2100 or GEOL 2400, CHEM 1320 and CHEM 1330 or instructor's consent**GEOL 7350: Taphonomy**

(cross-leveled with GEOL 4350). The purposes of this course are to 1) analyze patterns in the history of life and 2) to recognize the biased

processes that led to its preservation. We will accomplish these goals by examining two disparate fossil preservation pathways: 1) Konservat lagerstätten: fossil deposits that are notorious for the exceptional and rare preservation of soft tissues and 2) Konzentrat lagerstätten: fossil deposits that are exceptional for the enormous amount of fossilized skeletal material they contain. Through careful examination of both the rare and hyper-abundant we can address the fundamental question of paleobiology: how literally can the fossil record be read as the history of life? Graded on A-F basis only.

**Credit Hours:** 3**GEOL 7370: Conservation Paleobiology**

(cross-leveled with GEOL 4370). Humans are having an undeniable influence on Earth systems, including the biosphere. Climate change, habitat destruction, over-hunting/harvesting, pollution, and invasive species are among the primary stressors of modern biodiversity. How have ecosystems responded to such stressors in the past? How do we determine what a "pristine" ecosystem looks like when planning ecosystem restoration? Paleontologists are uniquely equipped to address these questions using the fossil record. In this course we will review the important questions in this emerging discipline, learn about the tools used to address these questions, and learn from case studies involving invertebrate, vertebrate, and plant fossils from a variety of environments.

**Credit Hours:** 3**GEOL 7650: Plate Tectonics**

(cross-leveled with GEOL 4650). Formation, evolution, and structure of the earth. Rules, causes, and implications of plate tectonics with emphasis on present-day features.

**Credit Hours:** 3**Prerequisites:** GEOL 3250, GEOL 4150 or instructor's consent**GEOL 7680: Neotectonics and Earthquake Geology**

(cross-leveled with GEOL 4680). Introduction to techniques and concepts of active crustal deformation from the geological and geodetic perspectives. Topics include tectonic geomorphology, paleoseismology, Quaternary dating, tectonic geodesy, numerical models of faults, and earthquake hazard assessment.

**Credit Hours:** 3**Prerequisites:** GEOL 4150 or GEOL 4650**GEOL 7700: Theoretical Geochemistry**

Introduction to theoretical concepts in low and high temperature geochemistry. Topics include thermodynamics of fluids, gases and solids in geological materials, phase diagrams, equilibrium constants, electrolyte theory, oxidation-reduction reactions.

**Credit Hours:** 3

**Prerequisites:** GEOL 3250, CHEM 1330 and MATH 1700

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**GEOL 7750: Microanalysis for Geological Sciences**

(cross-leveled with GEOL 4750). This course is intended to provide a working knowledge of electron and X-ray microbeam analytical instruments - both in principle and in practice. Lectures will focus on the physics of how these instruments collect data, and how these data can be interpreted. In addition, students will gain hands-on experience with operating these instruments, specifically on their own samples, as well as preparing their samples for microanalysis and interpreting/manipulating the resulting data. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** Instructor's consent (Instrument time is limited; graduate students who will use the instruments in their research will have priority)

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**GEOL 7800: Introduction to Geophysics**

(cross-leveled with GEOL 4800). Introduction to the fundamentals of geophysical methods and their applications in geology, environmental studies, and exploration. Topics include seismic, gravity, magnetic, and electric methods.

**Credit Hours:** 3

**Prerequisites:** GEOL 1100 or GEOL 2130 or GEOL 1200 and MATH 1700 or instructor's consent

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**GEOL 7990: Research in Geological Sciences-Masters**

Does not lead to dissertation.

**Credit Hour:** 1-8

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**GEOL 8002: Topics in Geological Sciences**

Organized study of selected topics. May be repeated with departmental consent.

**Credit Hour:** 1-99

**Prerequisites:** PhD standing, instructor's consent

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**GEOL 8050: Research in Geological Sciences-Masters Non-Thesis**

Research leading to a non-thesis Masters project. Graded on S/U basis only.

**Credit Hour:** 1-3

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**GEOL 8085: Problems in Geological Sciences**

**Credit Hour:** 1-8

**Prerequisites:** instructor's consent

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**GEOL 8090: Research in Geological Sciences-Masters Thesis**

Preparation of dissertation. Graded on a S/U basis only.

**Credit Hour:** 1-99

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**GEOL 8100: Continental Tectonics**

The structural, metamorphic, and igneous evolution of mountain belts and continental rifts with emphasis on convergent margin settings and terrane accretion processes and products. Case studies are considered from the Precambrian to the recent.

**Credit Hours:** 3

**Prerequisites:** GEOL 4150 and GEOL 4900

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**GEOL 8140: Metamorphic Petrology**

Petrography and petrology of metamorphic rocks. Emphasis on textures, mineral assemblages, and mineral chemistry in order to determine the physico-chemical condition of metamorphism.

**Credit Hours:** 3

**Prerequisites:** GEOL 3250 and GEOL 4900

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**GEOL 8150: Earthquake Seismology**

Theory and techniques used in analyzing earthquake seismograms and seismicity data. Ray theory and phase identification for the whole earth. Epicenter determination. Frequency-magnitude relationships. Earthquake source mechanisms and parameters.

**Credit Hours:** 3

**Prerequisites:** GEOL 8320

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**GEOL 8160: Igneous Petrology**

Studies of the origin and evolution of magmas with use of phase equilibria, physical properties, and kinetics.

**Credit Hours:** 3

**Prerequisites:** GEOL 3250 and GEOL 4900

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**GEOL 8170: Radiogenic Isotope Geochemistry**

Studies of the application of trace element and radiogenic isotope systematics to petrogenesis of rocks.

**Credit Hours:** 3

**Prerequisites:** GEOL 4900

**GEOL 8190: Advanced Paleontology**

Principles of taxonomy, biostratigraphy, functional morphology and paleoecology are illustrated by individual projects that combine field collecting, laboratory examination and literature research.

**Credit Hours:** 3

**Prerequisites:** GEOL 3550

**GEOL 8200: Advanced Structural Geology**

Advanced analysis of deformation structures in rocks. Theory and techniques of stress and strain analysis and their application to the mechanics of formation of faults, folds, shear zones, and rock fabric. Techniques of multideformation structural analysis.

**Credit Hours:** 3

**Prerequisites:** GEOL 4150

**GEOL 8240: Hydrogeologic Processes**

Quantitative analysis of role of groundwater in major geologic processes. Theory review of fluid flow, heat transport, reactive solute transport in porous media. Applications to sedimentary diagenesis, hydrothermal ore deposits, petroleum migration, earthquakes, magmatism, metamorphism.

**Credit Hours:** 3

**Prerequisites:** GEOL 4100 or GEOL 7100 or equivalent

**GEOL 8300: Precambrian History**

Coupled evolution of the biosphere, lithosphere, hydrosphere, and atmosphere over the span of Precambrian history. Topics will be discussed largely in the context of biological evolutionary events and the fossil record, as well as with a focus on geochemical records.

**Credit Hours:** 3

**GEOL 8320: Introduction to Seismology**

Principles of wave propagation in layered elastic media. Applications of digital signal processing to seismological problems. Emphasis on theoretical basis behind modern analysis techniques.

**Credit Hours:** 3

**Prerequisites:** PHYSCS 2760, MATH 4500 and CMP\_SC 1050

**GEOL 8400: Ancient Greenhouse Climate**

Will explore a wide range of data concerning greenhouse climates and different techniques used in paleoclimatology. Graded on A/F basis only.

**Credit Hours:** 3

**Prerequisites:** GEOL 3800, GEOL 3550 and GEOL 4300

**GEOL 8450: Tectonics and Sedimentation**

Global survey of modern and ancient convergent plate boundaries with an emphasis on sedimentary facies and structural styles.

**Credit Hours:** 3

**Prerequisites:** GEOL 4150, GEOL 3800 and instructor's consent

**GEOL 8510: Geodynamics**

This course is designed to cover the fundamentals of the quantitative aspects of Plate Tectonics. The study of these subjects is generally referred to as Geodynamics or Geodynamic Theory. This theory revolutionized the earth sciences and the way people think of earth processes. By definition Geodynamics is an interdisciplinary paradigm therefore it is necessary to cover a wide range of topics from heat transfer to gravity. This course will overlap with subjects covered in both Plate Tectonics and Geophysics but we will emphasize the quantitative aspects of this theory in this course.

**Credit Hours:** 3

**Prerequisites:** MATH 1700, PHYSCS 2760

**GEOL 8550: Stable Isotope Geochemistry**

Mechanisms and fundamental concepts of fractionation of light stable isotopes in nature. Emphasizes application of hydrogen, carbon, oxygen and sulfur isotopes to igneous, metamorphic and sedimentary rocks, metallic ore deposits, and to natural waters.

**Credit Hours:** 3

**Prerequisites:** instructor's consent

**GEOL 8650: Thermal Processes in the Solid Earth**

Principles of heat transfer in solid earth by conduction, advection and convection. Basic analytic and numerical solutions. Application in Earth's dynamic system, environmental sciences, and geological problems.

**Credit Hours:** 3

**Prerequisites:** MATH 1700, PHYSCS 1220 or PHYSCS 2750

**GEOL 8750: Silicate Glasses, Liquids and Magmas**

Theory of silicate liquid viscosity, heat capacity and configurational entropy, emphasizing the role of volatile components. Applications to magma rheology and eruptive behavior. Lab instruction in viscometry techniques.

**Credit Hours:** 3

**Prerequisites:** GEOL 4900 and GEOL 4700, or instructor's consent

**GEOL 8800: Applied Numerical Analysis**

A study of applied mathematical analysis of spatial and temporal data as applied in the geosciences.

**Credit Hours:** 3

**Prerequisites:** MATH 1700 or MATH 2300, PHYSCS 1220 or PHYSCS 2760

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**GEOL 8990: Research**

Does not lead to dissertation.

**Credit Hour:** 1-8

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**GEOL 9090: Research in Geological Sciences-Doctoral Dissertation**

Preparation of dissertation. Graded on a S/U basis only.

**Credit Hour:** 1-99

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