

Earth and Environmental Sciences

Why study earth science?

What is it?

- ◆ *Continents adrift and colliding*
- ◆ *Natural resources*
- ◆ *Energy resources and waste disposal*
- ◆ *Floods and landslides*
- ◆ *Construction siting and materials*
- ◆ *Fossils and evolution*
- ◆ *Surface and underground waters*
- ◆ *Volcanoes and earthquakes*
- ◆ *Mountain building and erosion*
- ◆ *4.6 billion years of earth history*
- ◆ *Environmental education*
- ◆ *Remote sensing and spacial information analysis*

Earth and Environmental Sciences

The Department of Earth and Environmental Sciences at California State University, Fresno offers courses leading to the Bachelor of Science and Master of Science in Geology — as well as the Bachelor of Arts in Natural Sciences and the Minor in Geology — which are especially well-suited for primary and secondary teachers.

Collaborating with the Department of Environmental Sciences at the University of California, Riverside, the department also offers a special program leading to the Bachelor of Science in Environmental Sciences. The degree is jointly conferred by California State University, Fresno and the University of California, Riverside.

Coursework and research emphasize field and laboratory investigations of geologic and environmental problems. Our field orientation takes advantage of the university's proximity to the Sierra Nevadas, the California Coast Ranges, coastal California, and the desert provinces. This unique location gives faculty and students access to an unparalleled outdoor laboratory all within short trips from the university.

The department's close relationship with state agencies and the private sector enables many students to pursue internships or part-time employment in geologic and environmental work while they complete their degrees.

The Bachelor of Science in geology prepares students for employment in petroleum geology, mineral exploration, land-use planning, environmental assessment, hydrology, and engineering geology, or for teaching earth science or physical science at the secondary level. The Master of Science

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program provides a graduate degree for students who want to work in industry or government on the professional level, for students who want to teach earth science in junior college, or for students who wish to pursue further graduate study.

Our applied geology option specializes in engineering geology, hydrogeology, or exploration geology fields, which have the strongest employment potential.

Students may also participate in coursework and research in marine geology and oceanography offered through Moss Landing Marine Laboratories in Monterey Bay. Consult the chairs of the Earth and Environmental Sciences, and Biology departments. See *Moss Landing Marine Laboratories, Biology Department*.

Facilities and Support

Department equipment includes:

- X-ray fluorescence spectrometer and X-ray diffractometer
- Polarizing microscopes for transmitted and reflected light petrography
- Cathode luminoscope for microscopic study of textures
- Heating-freezing stage for microscopic study of fluid inclusions
- Rock preparation laboratory, which includes crushing and mineral separation facilities, as well as diamond saws and lapping machines for preparing thin and polished sections
- Remote Sensing/Geo Information Systems (GIS)
- Microcomputers and peripherals
- SUN engineering workstations
- Electronic mapping lab
- Fully equipped distance learning instructional lab
- Field and laboratory equipment for water chemistry studies
- Field geophysical instruments: 12 channel seismograph, single channel seismograph DC resistivity meter, magnetometer/radiometer, laptop computer
- Two four-wheel drive vehicles and three other field vehicles

Career Opportunities

Career pathways in earth science can lead to occupations in:

- environmental, planetary, engineering, structural, petroleum, and mining geology

College of Science and Mathematics

Department of Earth and Environmental Sciences

C. John Suen, *Interim Chair*

Evangelina "Vengie" Balli, *Administrative Support Coordinator*

McLane Hall, Room 285

(559) 278-3086

<http://www.csufresno.edu/geology/>

B.S. in Environmental Sciences*

B.S. in Geology

B.A. in Natural Sciences

Option: Earth Science

M.S. in Geology

Minor in Geology

- volcanology, mineralogy, and hydrogeology
- soil science, sedimentology, and geoaerchology
- oceanography, paleontology, and geomorphology

Undergraduate Program

Geology Major. The bachelor's degree with a major in geology consists of 125-133 units, including 44-45 units of geology. For general degree requirements see *Degree Requirements*. Students planning graduate study are advised to meet the foreign language requirements of the institutions they plan to attend.

High School Preparation. Adequate high school preparation for a major in geology will facilitate the progress of students through our program. This preparation should include: algebra (2 years), plane and solid geometry, trigonometry, chemistry, physics or biology, and English (4 years).

Faculty

C. John Suen, *Interim Chair*
Frederika J.M. Harmsen,
Graduate Adviser

Arthur H. Barabas
Bruce A. Blackerby
Roland H. Brady
Stephen D. Lewis
Robert D. Merrill

Earth and Environmental Sciences

Bachelor of Science Degree Requirements

Geology Major *Units*

Major requirements 44-45

Lower-division requirements
 GEOL 1 or 15, 12 and 13
 concurrently, 30 (10-11)
 Upper-division requirements
 GEOL 100, 101, 102, 104,
 106, 107, 108A, 108B; two
 of the following: GEOL
 105, 110, 122 (28)

Upper-division geology
 electives (see *Note 2*) (6)

Additional requirements 29-30

CHEM 1A, 1B; MATH 75;
 MATH 76 or GEOL 177
 and one of MATH 77,
 GEOL 180 or C SCI 101;
 PHYS 2A, 2B

Remaining General Education 45*

Electives and remaining degree requirements 4-6

(see *Degree Requirements*); may
 be used toward a minor

Total 124

*Of the 51 required General Education units, 6 units will be satisfied by the following two courses in additional requirements: 3 units of CHEM 1A in G.E. Breadth B1 and 3 units of MATH 75 in G.E. Foundation B4. Consult the department chair or faculty adviser for details.

Advising Notes

1. "Additional requirements" courses may be applied to satisfy requirements of General Education, or a minor, as appropriate. They also may be taken *CR/NC* (see *Credit/No Credit Grading*).
2. No more than 1 unit of GEOL 160 may be used to fulfill the upper-division elective requirement. GEOL 154, 155, and 168 are not applicable toward geology major requirements.
3. No General Education Integration course offered by the Department of Earth and Environmental Sciences may be used to satisfy the General Education requirements for geology majors.
4. *CR/NC* is not permitted in the geology major with the exception of GEOL 3, 30, and 160.
5. No more than 1 unit of GEOL 3 will be permitted.
6. General Education and elective units may be used toward a dual major or minor (see *Dual Major* or departmental minor). Consult the appropriate department chair, program coordinator, or faculty adviser for further information.

Geology Minor

The minor consists of 20 units of coursework approved by a departmental faculty member and must include 6 upper-division units in residence. Minimum GPA is 2.0.

Bachelor of Arts in Natural Sciences

Earth Science Option

The B.A. in Natural Sciences is designed primarily to meet the needs of students interested in pursuing a teaching career in the sciences at the secondary level. Students interested in satisfying the waiver program in the natural sciences should consult an appropriate adviser in their academic program. Contact either the Department of Earth and Environmental Sciences or the Office of the Dean, College of Science and Mathematics.

The degree is also a suitable choice for students with a general interest in earth science and interest in pursuing a career in environmental science, law, medicine, dentistry, optometry, and other areas for which the breadth of scientific coverage of this degree is advantageous.

For a full description of the degree, including all of the emphases, see the *Natural Science Interdisciplinary Courses* section in this catalog. The B.A. in Natural Sciences with the Earth Science Emphasis is as follows:

Units

Core requirements 37-38

*Biology*¹ (12-13)

BIOSC 1A or BIOL
 15¹, BIOSC 1B,
 BIOSC 130

Chemistry (10)

CHEM 1A, 1B

*Geology*¹ (8)

GEOL 1 and 3 (or 15),
 GEOL 168

Natural Science (3)

N SCI 106

Physical Science (4)

P SCI 21

Earth Science Option 47

CHEM 8 or P SCI 168 (3)

PHYS 2A, 2B² (8)

MATH 70 or 75 (4)

GEOL 12, 30, 100, 101, 102,
 105, 106, 112, 155 (26)

Select two courses:

GEOL 110, 114, 117,
 124; GEOG 111 (6)

General Education 51

Total^{3,4} 126

Advising Notes for the Natural Sciences Major

1. BIOL 15 and GEOL 15 are part of the Humans and the Natural Environment Cluster. See the *Natural Science Interdisciplinary Courses* section in this catalog. GEOL 15 is equivalent to GEOL 1 and 3.
2. Substitutions may be made with the permission of the appropriate department chair. PHYS 4A-B-C with labs 4AL, 4BL is recommended instead of PHYS 2A-B for those students well prepared for physics.
3. This total assumes that students in this option will maximize the 12 units required for the major that also may be applied to fulfill General Education requirements as follows: CHEM 1A (3 units), BIOSC 1A or BIOL 15 (3 units), GEOL 168 (3 units), and MATH 75 (3 units). Consult your major adviser for details.
4. Students should be sure to take sufficient upper-division units in their General Education courses and electives to satisfy the graduation requirements of 40 upper-division units and Upper-division Writing Skills.

B.S. in Environmental Sciences*

This special interdisciplinary program leads to a B.S. in Environmental Sciences jointly conferred by California State University, Fresno and UC Riverside. Qualified students admitted into this program are concurrently registered at both universities but pay student fees only to the campus where they are in residence. There are minimum residence requirements by both universities. Students can take courses at both campuses in person or through distance learning. The B.S. in Environmental Sciences has three degree options: (1) earth science, (2) life science, and (3) behavioral, policy, and health sciences. The curriculum is designed to provide an interdisciplinary education in life, physical, or social sciences directed towards the understanding and the solution of today's environmental problems. For further information call Dr. John Suen, Earth and Environmental Sciences Department, (559) 278-7888 or (559) 278-3086.

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Graduate Program

The Department of Earth and Environmental Sciences offers graduate courses of instruction and research leading to the Master of Science degree. The graduate

courses are designed to meet the needs of individuals with several different career goals. Accordingly, the objectives of the program are as follows: (1) to prepare students for enrollment in Ph.D. programs in geology and related sciences, (2) to prepare students for employment as professional geoscientists with industry or government, and (3) to further the content knowledge and teaching skills of secondary school and junior college teachers in the earth sciences.

Graduate studies offered in traditional geology include sedimentary geology (paleoecology, diagenesis, depositional environments, basin analysis, stratigraphy); structural geology and field mapping; petrology (plutonic, volcanic, sedimentary, metamorphic, and mineralized and hydrothermally altered rocks); and geochemistry.

In addition to classical geology, the graduate program offers studies in applied geology. The curriculum is usually interdisciplinary with an environmental focus, involving coursework in geology, civil engineering, chemistry, soil sciences, and other areas. Three applied geology emphases are offered: (1) engineering and geotechnical geology, (2) hydrogeology (physical or chemical options), and (3) ore deposits. Students of applied geology are encouraged to undertake theses involving support and supervision by professionals in private and public sectors.

University requirements are met through satisfactory completion of core courses and specialty courses in the curriculum emphasis.

Core courses. All students in the graduate program are required to complete the following core courses:

- GEOL 201 Seminar in Geology (3 units)
- GEOL 299 Thesis (6 units)

In addition, students studying applied geology should take the following courses before or during their graduate experience:

- GEOL 114 Engineering Geology (3 units)
- GEOL 117 Hydrogeology (3 units)
- GEOL 124 Geochemistry (3 units)

All other students not in applied geology must complete GEOL 201 and one of the following three courses: GEOL 114, GEOL 117, or GEOL 124.

Master of Science Degree Requirements

The graduate program for the Master of Science degree in Geology is based on the equivalent of the undergraduate major in geology at California State University,

Fresno. Two-thirds of the 30 units required for the degree must be in geology, and at least 21 of the 30 units must be 200-series courses. For specific requirements consult the geology graduate program coordinator; for general requirements see *Division of Graduate Studies*. (See also *Admission to Graduate Standing, Advancement to Candidacy, Program Requirements, Foreign Language Requirements, and Criteria for Thesis and Project.*)

Under the direction of his/her graduate faculty adviser, each student prepares and submits an individually designed program within the following framework: courses including at least 21 units in 200-series.

Units

Specific requirements	20
(see next section)	20
Approved upper-division or graduate course electives in geology or related fields such as biology, chemistry, physics, engineering, and mathematics. Electives determined in consultation with graduate adviser	10
Approved electives in geology or related fields	0-6
Total	30

Specific Requirements. Students in applied geology should follow the curriculum specified for each of the three emphases. Modifications may be made with approval of the graduate faculty adviser. GEOL 299 (may be taken in 2-6 unit increments, 6 units total). An oral presentation of thesis is required. Graduate students of geology doing a thesis on a foreign country must be proficient in the language in which source materials are published.

COURSES

Environmental Science (ENSC)

1. Environmental Science (4)

Introduction to environmental science, focusing on environmental principles and processes. Topics include global systems and change, resource management and conservation, energy and mineral resources, population dynamics, ecosystems and biodiversity, environmental degradation and pollution, and environmental economics and ethics.

Geology (GEOL)

1. Natural Disasters and Earth Resources (4)

Prerequisite: MATH 4R or second-year high school algebra. Processes and materials that produce the different geologic resources and hazards (earthquakes, volcanoes, floods, landslides). Plate tectonic theory (including

continental drift) as the unifying model to explain geologic phenomena. Emphasizes the relationship between geology and humans. G.E. Breadth B1. (3 lecture, 2 lab hours; optional field trips) (CAN GEOL 2)

3. Geology Field Trip (1; max total 3)

Extended weekend field trip to areas of geologic interest including Yosemite National Park, Death Valley, or coastal California. May be repeated. Nonmajors encouraged. *CR/NC* grading only. (Field trip fee may be required.)

12. Mineralogy (3)

GEOL 13 concurrent in the geology major. Prerequisite: high school chemistry. Properties, relationships, uses origin of minerals; determination of common minerals by physical and other tests. Field trips may be required. (2 lecture, 3 lab hours)

13. Crystallography (1)

GEOL 12 concurrent in the geology major. Prerequisite: MATH 5 or 72 or 75. Symmetry, structure, standard nomenclature, reference systems of crystals. (3 lab hours)

15. The Earth and Its History (5)

Portion of *Humans and the Natural Environment* Cluster. Physical and historical geology, including man's use of the earth and the impact of that use on the earth. Lecture, lab, and fieldwork. G.E. Breadth B1. (HNE program field trip fee, \$300)

20. Atmospheric Science and Pollution (4)

Physical and chemical principles applied to the study of the atmosphere, evolution of Earth and its atmosphere, biogeochemical cycles, atmospheric pollution, and global atmospheric change and the environmental crisis. Field trips may be required. (3 lecture hours, 2 lab hours.)

30. Introductory Field Methods (2)

Prerequisites: GEOL 1 or 15, MATH 5. Introduction to methods and instruments used in geologic fieldwork. *CR/NC* grading only. (6 lab/field hours) (Weekend field trips required; field trip fee may be required)

100. Optical Mineralogy (2)

Prerequisites: GEOL 12, 13. Optical properties of minerals; identification of minerals by optical methods. Theory and use of petrographic microscope. (1 lecture, 3 lab hours)

101. Igneous and Metamorphic Petrology (4)

Prerequisites: GEOL 30, 100; CHEM 1B (or concurrently). Origin classification, textures, structures, and geologic setting of igneous and metamorphic rocks; examination of samples in outcrop, hand specimen, and thin section. Weekend field trips required. (3 lecture, 3 lab hours)

Earth and Environmental Sciences

102. Sedimentology (3)

Prerequisites: GEOL 30, 100, 101 (or concurrently). Origin, classifications, textures, and structures of sedimentary rocks; examination of samples in hand specimen and thin section. Weekend field trips required. (2 lecture, 3 lab hours)

104. Scientific Writing (2)

Prerequisite: A passing grade on the Upper-Division Writing Exam, or completion of an upper-division writing course with a C or higher. Organizing and writing the scientific report. Critical evaluation of literature. Presentation of maps, charts, illustrations. Peer reviews. Oral presentation and term paper required. (1 lecture, 3 lab hours)

105. Geomorphology (3)

Prerequisite: GEOL 1 or 15. Landforms, climates, geologic processes, and their interrelation in shaping the earth's surface today and in the geologic past. Interpretation of topographic maps and aerial photographs. Field trips required. (2 lecture, 3 lab hours)

106. Structural Geology (3)

Prerequisites: GEOL 30, MATH 5, PHYS 2A (or concurrently); GEOL 104 (concurrently). Recognition, representation, and interpretation of structural features of the earth's crust. Includes theoretical and mechanical principles. Study of regional tectonics and major structural provinces. Field trips required. (2 lecture, 3 lab hours)

107. Advanced Field Methods (3)

Prerequisites: GEOL 30, 101, 102, 104, 106. Field trips to areas of diverse geology; observation, description, and mapping of geologic phenomena. Includes written reports of areas selected for study. Students should contact the department for details. (9 lab hours usually including fieldwork on weekends or during January intercession and spring vacation) (Field trip fee may be required)

108A. Field Geology (4)

Prerequisites: senior standing or permission of instructor; GEOL 107; GEOL 108B concurrently. Geologic reconnaissance and mapping in field groups. *Usually conducted in early summer.* When taken concurrently, GEOL 108A and 108B satisfy the senior major requirement for the B.S. in Geology. Approved for *SP* grading. (Field trip fee may be required)

108B. Field Geology — Reports (1)

Prerequisites: senior standing or permission of instructor; GEOL 108A concurrently. Written presentation of fieldwork conducted in GEOL 108A. When taken concurrently, GEOL 108A and 108B satisfy the senior major requirement for the B.S. in Geology. Approved for *SP* grading. (1 lecture hour)

110. Invertebrate Paleontology (3)

Prerequisites: GEOL 112 and ZOO 10. Invertebrate structures and development of prehistoric animals; introduction to stratigraphic importance of fossils. Field trips may be required. (2 lecture, 3 lab hours)

112. Planet Earth through Time (3)

Credit not allowed after completion of GEOL 2. Prerequisite: MATH 4R or second-year high school algebra. Principles of geology used in the interpretation of the history of Earth as revealed in rocks and their fossils. Includes origin of the solar system, evolution of atmosphere and oceans, origin of life, rise and fall of the dinosaurs, plate tectonics, and ice ages. G.E. Integration IB. *Does not satisfy Division 1 pre-1999 G.E. curriculum.*

113. Stream Habitat Restoration (3)

Prerequisites: GEOL 1 or BIOL 10 or BIOSC 1A or instructor's consent. Investigation of stream geology, hydrology, and biology relevant to restoring stream habitat. Includes collecting and interpreting lab and field data. Field trips required. (2 lecture, 3 lab hours) (Formerly GEOL 150T)

114. Engineering Geology (3)

Prerequisites: GEOL 1 and MATH 5 or 72 or 75. Introduction to techniques and theory of geotechnical investigations. Includes field and lab techniques in soil and rock mechanics, rock logging, geophysics, slope stability, engineering hydrogeology, stereo analysis, seismic engineering. Recommended for students in geology or civil engineering. Field trips required. (2 lecture, 3 lab hours)

115. Ore Deposits (3)

Prerequisites: GEOL 101, 106, CHEM 1A. Geology, mineralogy, distribution, and occurrence of common ore minerals essential in industry; genesis and localization of metallic minerals. Field trips may be required. (2 lecture, 3 lab hours)

117. Hydrogeology (3)

Prerequisites: GEOL 1 or 15; MATH 72 or 75; and GEOL 124 and MATH 76 recommended. The hydrologic cycle; surface water processes; stream flow and hydrograph; properties of porous geologic materials; principles of groundwater flow; water wells; geology of groundwater occurrence; water quality and pollution. Field trip required. (2 lecture, 3 lab hours)

118. Applied Geophysics (3)

Prerequisites: GEOL 1, PHYS 2A and completion of or concurrent enrollment in PHYS 2B. Presents an overview of geophysics as applied to problems in exploration, engineering, and environmental geology.

Emphasizes hands-on methods of data acquisition and interpretation that entry-level geologists will most likely encounter including gravity, magnetics, seismic refraction, ground-penetrating radar, down-hole surveys, and electrical resistivity. Field instrumentation is used throughout. (2 lecture, 3 lab hours) (Formerly GEOL 130T)

122. Stratigraphy (3)

Prerequisites: GEOL 30, 102. Stratigraphic principles and recognition of stratigraphic units. Emphasis on tectonostratigraphic concepts. (2 lecture, 3 lab/field hours)

124. Geochemistry (3)

Prerequisites: CHEM 1A and 1B and GEOL 1 or 15; GEOL 12 and 101 recommended. Chemistry applied to earth processes and evolution. Reactions involved in origin and transformations of natural waters, rocks, and minerals. Crystal chemistry and behavior of elements and isotopes. Field trip required; laboratory project. (2 lecture, 3 lab hours)

130T. Advanced Problems in Geology (1-3; max total 6 if no topic repeated)

Prerequisite: senior standing in geology. Topics or problems in the following fields: engineering geology, geology of North America, field geology, micropaleontology, advanced ground water geology, sedimentation and sedimentary rocks, geochemistry, geophysics, volcanic geology and marine geology. Some topics may have labs.

150T. Studies in Earth Science (1-3; max total 6)

Applicable to the geology major only with prior departmental approval. Prerequisite: GEOL 1. Earth science topics designed for students minoring in geology, with an interest in earth science, in teacher training, and for elementary and secondary teachers.

154. Introductory Earth Science (3)

Not applicable to the B.S. in Geology. Appropriate for liberal studies majors and K-6 teachers. Earth systems interactions demonstrated through hands-on activities, experiments, and field work. Topics include recognition, origin, and use of rocks and minerals; geologic time and fossils; interpretation of landscapes and the rock record; and plate tectonics. (2 lecture, 2 lab hours, 1 hour arranged) (Formerly GEOL 151)

155. Discovering Earth Science (3)

Not applicable to the B.S. in Geology. Prerequisites: GEOL 1, 15, or 112, or instructor's permission. Appropriate for students and 7-12 teachers seeking a secondary school science credential. Activity-based discovery of earth science and its integration with other sciences. Topics include

energy in the earth system, geochemical cycles, dynamic interactions between the lithosphere, atmosphere, and hydrosphere, and origin/evolution of the earth. (2 lecture, 2 lab hours, 1 hour arranged)

160. Field Studies (1-4; max total 4)

Prerequisite may be specified by instructor. Field trips during weekends or winter/spring recess to geologically important and significant areas such as the Grand Canyon, Baja California, the Sierra Nevada, Death Valley. (Field trip fee may be required.)

167. Oceans and Atmosphere (3)

Integrated introduction to sciences of oceans and atmosphere: their origin and evolution; plate tectonics; ocean currents, waves, and tides; atmospheric circulation and El Niño; production and life; and environmental issues and concerns. G.E. Integration IB.

168. California's Earth System (3)

Not applicable to B.S. in Geology. Interaction of earth, water, air, and life in California's earth system over geologic time. Human interaction with the environment. G.E. Integration IB.

169. Environmental Geology (3)

Prerequisite: GEOL 1. Examination of the interaction between humans and earth, with emphasis on earth features and processes that are hazardous to humans. Field trips required. (2 lecture, 3 lab hours)

177. Quantitative Methods for Earth Science (3)

Prerequisites: GEOL 1; MATH 75. Applications of mathematical techniques and quantitative methods in earth science; introduction to basic skills, including statistical methods, numerical techniques, matrix operations, and spatial analysis. (2 lecture, 3 lab hours) (Formerly GEOL 150T section)

180. Computer Applications in Geology (3)

Use of computers in geology, focusing on such applications as multi-dimensional graphics, desktop mapping, communications, online resources, modeling. (2 lecture, 3 lab hours) (Formerly GEOL 130T section)

185. Remote Sensing for the Natural Sciences (3)

Prerequisite: General Education Breadth, Area B; GEOG 105 recommended. Introduction to remote sensing techniques, including ultraviolet, visible, and infrared electromagnetic sensors, both space and aircraft based, and acoustic methods. Laboratory exercises will use examples from geology, agriculture, and society. Familiarity with computers required. (2 lecture, 3 lab hours)

186. Earth Science Applications of GIS (3)

Prerequisite: GEOG 107 recommended. Spatial information management, analysis, interpretation, and display using computer methods. Map concepts, spatial relationships, database design, and spatial analysis of data. Laboratory exercises using geologic map data, faults, earthquake epicenters, stream habitats and restoration, and endangered species. Familiarity with computers required. (2 lecture, 3 lab hours)

190. Independent Study

(1-3; max total 6)

See *Academic Placement — Independent Study*. Approved for *SP* grading.

GRADUATE COURSES

(See *Course Numbering System*.)

Geology (GEOL)

201. Seminar in Geology (3)

Prerequisite: graduate standing. Seminar covering advanced and evolving topics in the earth sciences. Requirements include active discussion participation, frequent oral presentation, and written research papers. Satisfies Graduate Writing Skills requirement. (3 seminar hours)

202. Geology Laboratory Teaching Techniques (1)

Laboratory safety, lab lecture techniques, earth and environmental science activity design, equipment setups, student evaluation methods and grading, peer teaching assessment, leading field trips, etc. Primarily for teaching associates in geology. *CR/NC* grading only. (One 2-hour lab)

210. Analysis of Faults and Earthquakes (3)

Prerequisites: GEOL 106 and 107. Includes plate tectonic theory; kinematics and dynamics of fracturing and faulting; formation and propagation of seismic waves; recognizing and quantifying seismic potential; remote sensing and geophysics in applied fault studies. Field projects and oral presentations required. (2 lecture, 3 lab hours)

217T. Topics in Hydrogeology and Environmental Geology

(2-3; max total 6 if no topic repeated)

Prerequisite: major in geology and/or permission of instructor. Studies of current issues and recent research topics which may include groundwater contamination, environmental pollution, and hazardous and nuclear waste management. Readings from books, journals, and government publications. Independent research and oral presentation required. Laboratory activities may be required. (Formerly GEOL 217)

220. Groundwater Hydrology (3)

Prerequisites: GEOL 117. MATH 77 recommended. Principles of flow through porous and fractured media; groundwater hydraulics in the saturated and unsaturated zones; contaminant transport; introduction to groundwater models. (2 lecture, 3 lab hours)

224. Geochemistry of Natural Waters (3)

Prerequisite: GEOL 124. Chemical evolution of natural waters through water-rock interactions, mixing, evaporation, and contamination. Modeling using solution chemistry, equilibrium thermodynamics, and kinetics. Field methods, laboratory analysis, and computer manipulation of data. Field trip required; library and laboratory projects. (2 lecture, 3 lab hours)

231. Depositional Systems (3)

Prerequisites: GEOL 102 and 105. Investigation of modern and ancient depositional systems. Field trip required. (2 lecture, 3 lab hours) (Formerly GEOL 206)

232. Basin Analysis Seminar (3)

Prerequisites: GEOL 102 and 106. Topics may include: basin styles, tectonics and sedimentation, seismic stratigraphy, subsidence and thermal history, and petroleum plays. Research paper and oral presentation required. (Formerly GEOL 250T)

250T. Topics in Geology (1-3)

Prerequisite: major in geology and/or permission of instructor. Advanced studies of such areas as petrology, marine geology, and regional stratigraphy. Some topics may have labs and field trips.

251T. Topics in Engineering Geology (1-3)

Prerequisites: major or minor in geology; permission of instructor. Advanced studies in areas such as slope stability, ground water monitoring, drilling and core logging, water sampling, hazardous waste site investigations, and geophysical instrumentation.

271. Volcanology (3)

Prerequisite: GEOL 101. A study of volcanic activity, including classification, characteristics, products of eruptions, man's interactions with volcanoes and related phenomena. Field trips required. (1 lecture, 6 lab hours)

290. Independent Study

(1-3; max total 6)

See *Academic Placement — Independent Study*. Approved for *SP* grading.

299. Thesis (2-6; max total 6)

Prerequisite: See *Criteria for Thesis and Project*. Preparation, completion, and submission of an acceptable thesis for the master's degree. Approved for *SP* grading.