



**Bachelor of Arts • Bachelor of Science
Minor • Subject Matter Program (Pre-Credential Preparation)
Master of Science**

PROGRAM DESCRIPTION

Geology is the study of the earth, its environments, and its history. It is an interdisciplinary science that combines geological observations and concepts with those of biology, chemistry, physics and mathematics. Its goals are to study rocks, minerals, fossils, and energy and water resources, and to understand geologic principles and processes that shape the earth and its environments.

The Sacramento State Geology program has three objectives: 1) to encourage students to think scientifically, 2) to provide students with the knowledge base to make progress in geology after leaving Sacramento State, and 3) to teach students basic skills such as using a petrographic microscope and field equipment, how to construct a geologic map, and how to write a technical geologic report.

Career Possibilities

Geologist • Geophysicist • Groundwater Geologist • Oil and Gas Geologist • Mineralogist • Paleontologist • Marine Geologist • Environmental Geologist • Photogeologist • Seismologist • Consulting Geologist • Soils Engineer • Land Use Planner • Volcanologist • Astrogeologist • Geochemist • Economic Geologist • Mining Geologist • Hydrologist • Government Geologist • Coal Geologist • Glacial Geologist • Vertebrate Paleontologist • Geology Professor • Earth Science Teacher

Faculty

Diane Carlson, Kevin Cornwell, David Evans, Lisa Hammersley, Brian Hausback, Tim Horner, Judi Kusnick

Contact Information

David Evans, Department Chair
Stacy Sinz, Administrative Assistant
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The BA degree program is designed as a shorter, more flexible preparation for some geology jobs, earth science teaching in high school (see Teaching Credential), and jobs such as park naturalist, environmentalist, geologic planning specialist, or in geology-related businesses. The BA degree can be used in dual-track majors combining geology with biological sciences, chemistry, physics, or engineering.

The BS degree program is designed to be the best possible preparation for advanced work in geology in graduate school or for professional employment as a geologist. The Geology program offers a strong background in the major areas of geology including: mineralogy, petrology, paleontology, stratigraphy, structural geology, field mapping, hydrogeology and report writing.

Special Features

- Among the greatest attractions for studying geology at Sacramento State is the University's location in a dynamic geologic environment; just 70 miles to the west is the San Francisco Bay Area and the San Andreas fault. About equidistant to the east is the magnificent Sierra Nevada mountain range. The active geology faculty conducts field trips in almost every course in the Geology major, providing excellent opportunities for students to learn field skills and to apply classroom knowledge to field situations.
- A small student/teacher ratio, plus a rigorous course of study, contributes to the excellent reputation of the Sacramento State Geology Department with employers and graduate schools. Contact the Department office for assistance in obtaining a faculty advisor.
- The Geology Department operates the largest on-campus well field in the nation, with twenty engineered wells for teaching and student research. The well field is complemented by a comprehensive collection of state-of-the-art geophysical and hydrological field equipment.
- The Geology Department shares Placer Hall with the United States Geological Survey (USGS). Students benefit from this unique collaborative enterprise between a university and a federal agency because of the educational, research, and employment opportunities provided by the combined scientific and educational resources of the Geology Department and the USGS.
- Students interested in marine geology may take courses at Moss Landing Marine Laboratories at Moss Landing, CA, 180 miles from the Sacramento State campus. The labs and available courses are described under the Marine Sciences section of this catalog. A program including Moss Landing courses may be formulated with a Geology advisor. Such a program usually requires living in or near Moss Landing for one or more semesters.

Requirements • Bachelor of Arts Degree

Units required for Major: 56-59

Minimum total units required for BA: 120

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (21-24 units)

- (5) CHEM 1A General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent)
- (3) GEOL 10 Physical Geology
- (1) GEOL 10L Physical Geology Lab (GEOL 10; may be taken concurrently)
- (3) GEOL 12 Historical Geology (GEOL 10, GEOL 10L)
- (1) GEOL 12L Historical Geology Lab (GEOL 12; may be taken concurrently; GEOL 10L)
- (4-7) MATH 26A Calculus I for the Social and Life Sciences (MATH 11 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test)
AND
- MATH 29 Pre-calculus Mathematics (MATH 11 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and Intermediate Algebra Diagnostic Test) **OR**
- MATH 30 Calculus I (MATH 29 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) PHYS 5A General Physics: Mechanics, Heat, Sound (Recently completed three years of high school algebra and geometry; and a college course in algebra and trigonometry [MATH 9 recommended] for those having an inadequate mathematics background) **OR**
- PHYS 11A General Physics: Mechanics (MATH 30, MATH 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently.)

B. Required Upper Division Courses (35 units)

- (5) GEOL 100 Mineralogy (CHEM 1A, GEOL 10, GEOL 10L)
- (4) GEOL 102A Igneous/Metamorphic Petrology (GEOL 100, GEOL 103A, GEOL 110A)
- (4) GEOL 103A Sedimentology/Stratigraphy (GEOL 10, GEOL 10L, GEOL 12, GEOL 100; ENGL 1A or demonstrated writing ability. Corequisite: GEOL 103B for BS students)
- (4) GEOL 105 Paleontology (GEOL 10, GEOL 10L, GEOL 12 and GEOL 12L)
- (4) GEOL 110A Structural Geology and Tectonics (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100, GEOL 103A, GEOL 111A and GEOL 111B; PHYS 5A or PHYS 11A; MATH 30 or MATH 26A)

- (2) GEOL 111A Field Geology (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L; GEOL 100. Corequisite: GEOL 103A, GEOL 103B, GEOL 111B)
- (2) GEOL 111B Field Techniques (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. Corequisite: GEOL 103A, GEOL 103B, GEOL 111A)
- (10) Electives. Consult Geology advisor for list of approved electives

Note: Attendance at 16 colloquia, verified by faculty signature, is required.

Requirements • Bachelor of Arts Degree - Earth Science

Units required for Major: 63-72

Minimum total units required for BA: 120

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (35-43 units)

Select one of the following introductory Geology lecture-lab combinations:

- (4) GEOL 5 Geology of Mexico **OR**
- (3) GEOL 7 Natural Disasters **AND**
- (1) GEOL 8L Earth Science Lab (GEOL 8; may be taken concurrently) **OR**
- (3) GEOL 8 Earth Science **AND**
- (1) GEOL 8L Earth Science Lab (GEOL 8; may be taken concurrently) **OR**
- (3) GEOL 10 Physical Geology **AND**
- (1) GEOL 10L Physical Geology Lab (GEOL 10; may be taken concurrently)

Each of the remaining courses as follows:

- (3) ASTR 4 Introduction to Astronomy (One year high school geometry or instructor permission)
- (1) ASTR 6 Astronomical Observation Laboratory (ASTR 4; may be taken concurrently)
- (5) BIO 1 Biodiversity, Evolution and Ecology (Corequisite: CHEM 1A suggested) **AND**
- (5) BIO 2 Cells, Molecules and Genes (BIO 1, CHEM 1A) **OR**
- (4) BIO 7 Introduction to the Science of Biology
- (5) CHEM 1A General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent) **OR**
- (5) CHEM 6A Introduction to General Chemistry (One year high school algebra; high school chemistry recommended)
- (3) GEOL 12 Historical Geology (GEOL 10, GEOL 10L)
- (1) GEOL 12L Historical Geology Lab (GEOL 12; may be taken concurrently; GEOL 10L)
- (4) GEOL 17 Earth Materials (GEOL 5, GEOL 7, GEOL 8, or GEOL 10; GEOL 8L or GEOL 10L may be taken concurrently)
- (3) MATH 26A Calculus I for the Social and Life Sciences (MATH 11 or three years of high school mathematics which includes two years of algebra and one year of geometry; completion of ELM requirement and the Intermediate Algebra Diagnostic Test)
- (4) PHYS 5A General Physics: Mechanics, Heat, Sound (Recently completed three years of high school algebra and geometry; and a college

course in algebra and trigonometry [MATH 9 recommended] for those having an inadequate mathematics background) **AND** General Physics: Light, Electricity and Magnetism, Modern Physics (PHYS 5A or instructor permission)

(4) PHYS 5B

B. Required Upper Division Courses (26 units)

- (3) GEOG 111 Elements of Meteorology (GEOG 1 or instructor permission)
- (4) GEOL 103A Sedimentology/Stratigraphy (GEOL 10, GEOL 10L, GEOL 12, GEOL 100; ENGL 1A or demonstrated writing ability. Corequisite: GEOL 103B for BS students)
- (2) GEOL 111A Field Geology (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. Corequisite: GEOL 103A, GEOL 103B, GEOL 111B)
- (2) GEOL 111B Field Techniques (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. Corequisite: GEOL 103A, GEOL 103B, GEOL 111A)
- (3) GEOL 130 Oceanography
- (6) Select six units from the following:
- GEOL 105 Paleontology (GEOL 10, GEOL 10L, GEOL 12 and GEOL 12L)
- GEOL 110A Structural Geology and Tectonics (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100, GEOL 103A, GEOL 111A and GEOL 111B; PHYS 5A or PHYS 11A; MATH 30 or MATH 26A)
- GEOL 114 Volcanology (GEOL 10 or instructor permission)
- GEOL 120 Surficial Processes (GEOL 10, GEOL 10L, GEOL 103A, GEOL 110A, GEOL 111A, GEOL 111B, or instructor permission)
- GEOL 121 Geology of California (GEOL 10 or equivalent)
- GEOL 140 Geology and the Environment
- GEOL 170 Geology of the Planets (An introductory Geology course or instructor permission)
- GEOL 184 Geological Field Trip
- (6) Select six units from the following but not taken previously:
- ANTH 124 Environmental Archaeology
- ANTH 151 Human Paleontology (ANTH 1, ANTH 1A or instructor permission)
- ENGL 120P Professional Writing (ENGL 20 or ENGL 120A)
- GEOG 113* Climate (Knowledge of general world distribution of climatic elements as given in an introductory physical geography course.)
- GEOG 116 Global Climate Change (GEOG 1 or instructor permission)
- GEOG 117 Landforms (GEOG 1 or instructor permission)
- GEOG 161 California's Water Resources
- JOUR 131 Column and Review Writing
- PHIL 125 Philosophy of Science
- RPTA 153 Environmental Interpretation and Outdoor Education

3-5 other upper-division geology courses with permission of instructor

*Indicates courses recommended for students wishing to prepare for CSET Exam for teaching high school science.

Requirements • Bachelor of Science Degree

Units required for Major: 79

Minimum total units required for BS: 124

Note: Additional units may be required to meet the Sacramento State foreign language requirement.

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (34 units)

- (5) CHEM 1A General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent)
- (5) CHEM 1B General Chemistry II (CHEM 1A with a passing grade of C or better)
- (3) GEOL 10 Physical Geology
- (1) GEOL 10L Physical Geology Lab (GEOL 10; may be taken concurrently)
- (3) GEOL 12 Historical Geology (GEOL 10, GEOL 10L)
- (1) GEOL 12L Historical Geology Lab (GEOL 12; may be taken concurrently; GEOL 10L)
- (4) MATH 30 Calculus I (MATH 29 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
- (4) MATH 31 Calculus II (MATH 30 or appropriate high school based AP credit)
- (4) PHYS 5A General Physics: Mechanics, Heat, Sound (Recently completed three years of high school algebra and geometry; and a college course in algebra and trigonometry [MATH 9 recommended] for those having an inadequate mathematics background **OR**
- PHYS 11A General Physics: Mechanics (MATH 30, MATH 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently)
- (4) PHYS 5B General Physics: Light, Electricity and Magnetism, Modern Physics (PHYS 5A or instructor permission) **OR**
- PHYS 11B General Physics: Heat, Light, Sound (MATH 31, PHYS 11A)

B. Required Upper Division Courses (45 units)

- (5) GEOL 100 Mineralogy (CHEM 1A, GEOL 10, GEOL 10L)
- (4) GEOL 102A Igneous/Metamorphic Petrology (GEOL 100, GEOL 103A, GEOL 110A)
- (1) GEOL 102B Igneous Field Techniques (GEOL 100, GEOL 103A, GEOL 110A, GEOL 111A, GEOL 111B)
- (4) GEOL 103A Sedimentology/Stratigraphy (GEOL 10, GEOL 10L, GEOL 12, GEOL 100; ENGL 1A or demonstrated writing ability. Corequisite: GEOL 103B for BS students)
- (1) GEOL 103B Sedimentary Petrology/Stratigraphy Field (GEOL 103A, concurrent enrollment is recommended)
- (4) GEOL 105 Paleontology (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L)
- (4) GEOL 110A Structural Geology and Tectonics (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L,

- GEOL 100, GEOL 103A, GEOL 111A, GEOL 111B; PHYS 5A or PHYS 11A; MATH 30 or MATH 26A)
- (1) GEOL 110B Structural Geology Field (GEOL 100, GEOL 103A, GEOL 111A, GEOL 111B. Corequisite: GEOL 110A)
- (2) GEOL 111A Field Geology (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. Corequisite: GEOL 103A, GEOL 103B; GEOL 111B)
- (2) GEOL 111B Field Techniques (GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. Corequisite: GEOL 103A, GEOL 103B; GEOL 111A)
- (4) GEOL 112 Geophysics for Geologists (GEOL 103A, GEOL 111A, GEOL 111B, PHYS 5A, PHYS 5B, or PHYS 11A, PHYS 11B, MATH 26A or MATH 30)
- (4) GEOL 120 Surficial Processes (GEOL 10, GEOL 10L, GEOL 103A, GEOL 110A, GEOL 111A, GEOL 111B, or instructor permission)
- (9) Electives Consult Geology advisor for approval of all major electives

Note: Completion of the degree requires attendance at 16 colloquia to be verified by faculty signature. A geology summer field camp is also mandated (in senior year). This is usually a four- to six-week commitment.

Requirements • Minor

Total units required for Minor: 18

Courses in parentheses are prerequisites.

- (3) GEOL 10 Physical Geology
- (1) GEOL 10L Physical Geology Lab (GEOL 10; may be taken concurrently)
- (3) GEOL 12 Historical Geology (GEOL 10, GEOL 10L)
- (1) GEOL 12L Historical Geology Lab (GEOL 12; may be taken concurrently; GEOL 10L)
- (10) Electives - select 10 units of upper division courses in Geology

Students wishing a Geology minor must contact a Geology advisor before beginning upper division work in Geology.

Requirements • Subject Matter Program (Pre-Credential Preparation)

Geology majors who intend to pursue a teaching credential must complete the science subject matter program which is described in this catalog. Successful completion of this program fulfills the subject matter competence requirement and qualifies students to enter the teaching credential program in the College of Education. The Science Teaching Credential allows graduates to teach all four of the sciences (Geoscience, Biology, Chemistry and Physics) at the General Science level in 7-12 grades, and Geoscience at an advanced level in high school.

Currently there is a great need for K-12 teachers educated in science. Changes in State Board of Education Standards and increasing interest in earth and space sciences has created significant demand for students with this credential. Geology majors who have an interest in teaching should contact the credential advisors in the Geology Department (Dave Evans or Judi Kusnick).

GRADUATE PROGRAM

The graduate program in Geology offers course work, field-work experience and research that will lead to a Master of Science degree in geology. It allows students who successfully complete the program to upgrade their educational qualifications and advance to doctoral programs or professional positions that require an in-depth knowledge of hydrogeology, environmental geology, and geologic hazards. The University's location in the state capital provides direct access to many local, federal, and state agencies through internship and field-work opportunities.

Each student should plan a program according to his/her background, interests and objectives, in consultation with a faculty advisor. Students are required to consult with an advisor prior to admission to the program or initiation of graduate study. For information on how to select an advisor, students should contact the Geology Department Office. Graduate students who want to engage in teaching as professionals can apply for an appointment as a Graduate Teaching Associate. Graduate Teaching Associates have the opportunity to teach one to three lower division laboratory courses per semester and are paid at a rate commensurate with their teaching load.

All work toward the degree must be completed within a seven-year period. The general University requirements for graduate degrees are explained in the "Graduate Studies" section of this Catalog or visit the website <http://www.csus.edu/geology>.

Admission Requirements

Admission as a classified graduate student in Geology requires:

- a degree in Geology, or 24 units of equivalent upper-division course work in geology which must have been passed with a grade of "C-" or better and includes: GEOL 10, GEOL 10L, GEOL 100, GEOL 102A, GEOL 103A, GEOL 110A, GEOL 111A, and GEOL 111B. These core undergraduate courses cannot be used as graduate electives by students who do not hold a degree in Geology or equivalent;
- a minimum 2.75 GPA in all geology, chemistry, math and physics courses, and a minimum 3.0 GPA in upper division geology courses;
- three letters of recommendation from persons familiar with your academic record and professional capabilities, sent directly to the department;
- a brief statement of interest, faculty sponsorship, area of specialty and long-term goals;
- two semesters of inorganic chemistry with a lab (CHEM 1A and CHEM 1B);
- two semesters of physics with a lab (PHYS 11A and PHYS 11B or PHYS 5A and PHYS 5B); and
- two semesters of math (MATH 30 and MATH 31).

Students who have deficiencies in Admission Requirements that can be removed by specified additional preparation may be admitted with conditionally classified graduate status. Any deficiencies will be noted on a written response to the admission application. You must be admitted to the degree program before graduate level courses will count toward the degree.

Admission Procedures

All prospective classified graduate students, including Sacramento State graduates, must file the following with the Office of Graduate Studies:

- an online application for admission;
- an application for admission to the Geology Graduate Program; and
- two sets of official transcripts from all colleges and universities attended, *other than Sacramento State*.

Applications are accepted as long as space for new students exists. However, students are strongly urged to apply by February 1 for the following fall or October 1 for the following spring in order to allow time for admission before registration. A decision regarding admission will be mailed to the applicant upon receipt of all items listed above.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy, indicating a proposed program of graduate study. This procedure should begin as soon as the classified graduate student has:

- removed any deficiencies in admission requirements;
- completed at least 12 units in the graduate program with a minimum 3.0 GPA, including at least two courses at the 200-level;
- obtained the graduate committee's acceptance of the thesis proposal; and
- passed the Writing Proficiency Examination (WPE) or secured approval for a WPE waiver.

Advancement to Candidacy forms are available in the Office of Graduate Studies, River Front Center 206, (916) 278-6470. The student must fill out the form after planning a degree program in consultation with his/her faculty advisor. After approval by the Geology Department Graduate Committee, the completed form is returned to the Office of Graduate Studies for approval.

Requirements • Master of Science Degree

Units required for MS: 30

Minimum required GPA: 3.0

Courses in parentheses are prerequisites.

A. Required Core Courses (9 units minimum)

Required of all students:

- (3) GEOL 200 Graduate Research Methods Seminar
- (3) GEOL 220 Surficial Processes (GEOL 120 or equivalent)

Remaining core units to be taken from the following approved specialty courses:

- (4) GEOL 212 Geologic Remote Imaging (PHYS 5B or PHYS 11B or equivalent; GEOL 102A, GEOL 110A or equivalent; and proficiency using a personal computer)
- (3) GEOL 218 Applied Geophysics (PHYS 5B or PHYS 11C and GEOL 112)
- (3) GEOL 227 Advanced Hydrogeology (GEOL 127, graduate level status in Geology)
- (3) GEOL 293 Engineering Geology (GEOL 193C)

B. Graduate Electives (15 units minimum)

- (3) GEOL 202 Aqueous Geochemistry (CHEM 1B; or instructor permission)
- (3) GEOL 204 Contaminant Hydrogeology (CHEM 1B and CHEM 6B or CHEM 20, GEOL 202)
- (3) GEOL 208 Groundwater Modeling (GEOL 127, MATH 45)
- (3) GEOL 210 Field Characterization of Aquifer Systems (GEOL 127 and CHEM 1B or instructor permission)
- (1-3) GEOL 240 Special Topics (Varies with each special topic course)
- (1-4) GEOL 299 Special Problems in Geology (Graduate-level status in geology; approval of project by a faculty sponsor and Department Chair; instructor permission)

Courses taken to meet the graduate core requirement will not count as elective courses. Elective courses (including GEOL 299) will be selected with prior approval of the student's faculty advisor in the area of interest. In addition to 200-level courses, these may also include up to 6 units of approved technical electives (but not the required courses) from the undergraduate curriculum. Not more than 3 units of GEOL 299 may be taken without prior approval of the Graduate Coordinator.

C. Culminating Requirements (6 units)

- (6) Master's Thesis

Lower Division Courses

GEOL 5. Geology of Mexico. Introduction to Geology through examination of aspects of the geology of Mexico. Emphasizes problem-based approach to learning Geology and the process of scientific investigation. Topics include a wide range of geological concepts including plate tectonic setting of Mexico, living with volcanoes: the Mexican volcanic belt, the Mexico City earthquake, issues of water supply, flooding and atmospheric pollution in Mexico City, the Chicxulub crater and geologic time, ore deposits of Mexico. Lecture three hours; laboratory three hours. **Units:** 4.0.

GEOL 5A. Geology of Mexico Field Trip. Focuses on fundamental geologic concepts as seen from real world examples in Mexico that will be visited during several strategic field stops. Field stops will emphasize a problem-based approach to learning geology and the process of scientific investigation. Topics include a wide range of geological concepts including plate tectonic setting of Mexico, living with volcanoes, the Mexico City earthquake, issues of water supply, flooding, climate change and atmospheric pollution in Mexico City, the Chicxulub meteor impact crater, geologic time, ore deposits of Mexico, and natural hazards. Field trip ten days. **Prerequisite:** GEOL 5 **Units:** 2.0.

GEOL 7. Natural Disasters. Examination of earth materials and earth processes through the study of natural disasters. Topics include earthquakes, volcanoes, landslides, floods, tsunamis, hurricanes, tornadoes and meteorite impacts. Examination of causes, effects and mitigation of natural disasters. **Units:** 3.0.

GEOL 8. Earth Science. Earth and its neighbors in space. Scientific method and discovery in the study of stars, planets, weather, rivers, glaciers, oceans, rocks, volcanoes, earthquakes, landslides, mountains, drifting continents, the earth in time. **Note:** Students contemplating a geology major or minor in geology should enroll in GEOL 10, not in GEOL 8. No credit for those who have taken GEOL 10 or equivalent. **Units:** 3.0.

GEOL 8L. Earth Science Lab. Emphasizes scientific methods and systematic laboratory procedures. Includes weather analysis, rock and mineral identification, study of geologic concepts by means of topographic maps, and exercises in astronomy and oceanography. Laboratory three hours. **Prerequisite:** GEOL 8; may be taken concurrently. **Units:** 1.0.

GEOL 8T. Earth Science Lab for Teachers. Exploration of the solid Earth, its atmosphere and oceans, and the Earth's place in the solar system. Emphasizes learning Earth science through investigation, and uses Earth science to understand the processes of science. Laboratory three hours. **Prerequisite:** GEOL 8; may be taken concurrently. **Units:** 1.0.

GEOL 10. Physical Geology. Rocks and their mineral constituents, geological processes such as weathering, erosion, glaciation, mountain building, etc., volcanoes, earthquakes, folds, faults, the earth's interior, plate tectonics and earth resources. Field trip. Fee course. **Units:** 3.0.

GEOL 10L. Physical Geology Lab. Laboratory supplement to GEOL 10. Emphasizes scientific method and systematic laboratory procedures. Identification of common minerals and rocks. Introduction to and analysis of topographic and geologic maps. Field trip. Laboratory three hours. Fee course. **Prerequisite:** GEOL 10; may be taken concurrently. **Units:** 1.0.

GEOL 12. Historical Geology. Origin and geological history of the earth and the evolution of its animal and plant inhabitants. Fee course. **Prerequisite:** GEOL 10; GEOL 10L. **Units:** 3.0.

GEOL 12L. Historical Geology Lab. Supplements GEOL 12. Use of sedimentary rocks, fossils, geologic maps, and structural sections in interpreting ancient environments, tectonic settings, and geologic history. Age relations and correlation of rock and time-rock units. Introduction to fossil identification and biostratigraphy. Laboratory three hours. **Prerequisite:** GEOL 12; may be taken concurrently; GEOL 10L. **Units:** 1.0.

GEOL 17. Earth Materials. Properties and identification of minerals and rocks; rock formation and the rock cycle. Field trip. Lecture three hours; laboratory three hours. Fee Course **Prerequisite:** GEOL 5, GEOL 7, GEOL 8, or GEOL 10; GEOL 8L or GEOL 10L (may be taken concurrently). **Units:** 4.0.

GEOL 77. Age of Dinosaurs. Applies the fundamental principles of geology, biology, and ecology to the exploration of the Mesozoic world. Emphasis is placed on the nature and evolution of dinosaurs in the context of the global and regional changes in the Mesozoic ecosystem. Included are considerations of the data, methods, and uncertainties in paleontology and other historical sciences. **Units:** 3.0.

Upper Division Courses

GEOL 100. Mineralogy. Introduction to mineral identification by physical and optical properties. Techniques and theory of optical mineral analysis, crystallography and mineral formation. **Note:** Lecture 3 hours = 3 units; laboratory 6 hours = 2 units. **Prerequisite:** CHEM 1A; GEOL 10; GEOL 10L. **Units:** 5.0.

GEOL 102A. Igneous/Metamorphic Petrology. Study of the origin, evolution, occurrence, geochemistry, dynamics and physical characteristics of igneous and metamorphic systems. The laboratory will focus on both hand-specimen and petrographic-microscope studies. **Note:** 150 minutes Lecture = 3 units, 150 minutes Lab = 1 unit. Fee course. **Prerequisite:** GEOL 100, GEOL 103A, GEOL 110A. **Units:** 4.0.

GEOL 102B. Igneous Field Techniques. Mapping, description, sampling, and interpretation of the characteristics of igneous rocks in the field. Field work will be documented by way of a written report, maps, and other illustrations. Fee course. **Prerequisite:** GEOL 100, GEOL 103A, GEOL 110A, GEOL 111A and GEOL 111B. **Units:** 1.0.

GEOL 103A. Sedimentology/Stratigraphy. Compositions, textures, classification, origins and structures of sediments and sedimentary rocks. Hand specimen observation and interpretation. Facies models, classification and correlation of stratigraphic units, subsurface techniques. Lab emphasizes hand specimen and microscope identification and subsurface techniques. **Note:** Field trip. Lecture 3 hours; laboratory 3 hours. Fee course. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, GEOL 100; ENGL 1A or demonstrated writing ability. **Corequisite:** GEOL 103B required as co-requisite for B.S. students. **Units:** 4.0.

GEOL 103B. Sedimentary/Pet/Stratigraphy Field. Measuring stratigraphic sections, mapping and field correlation of sedimentary units, outcrop description. Emphasis on macroscopic interpretation, geologic map making and report writing. Consists of off-campus fieldwork. **Note:** Fee course. **Prerequisite:** GEOL 103A, concurrent enrollment is recommended. **Units:** 1.0.

GEOL 105. Paleontology. Biology, evolution, classification and paleoecology of important groups of fossil organisms. Uses of fossils in solving geologic problems. **Note:** 150 minutes Lecture = 3 units, 150 minutes Lab = 1 unit. Fee Course. Field Trip. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, GEOL 12L. **Units:** 4.0.

GEOL 110A. Structural Geology and Tectonics. Description, analysis and interpretation of geologic structures and tectonic settings. Theory of stress and strain as it pertains to the origin of folds, faults, joints, cleavage, and other structural elements. Laboratory includes techniques of structural analysis such as orthographic projections, stereonet, structure contours, Mohr diagrams, interpretation of maps and cross sections. **Note:** 150 minutes Lecture = 3 units, 150 minutes Lab = 1 unit. Fee Course. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100, GEOL 103A, GEOL 111A and GEOL 111B, PHYS 5A or PHYS 11A, MATH 30 or MATH 26A. **Units:** 4.0.

GEOL 110B. Structural Geology Field. Field description, mapping and interpretation of geologic structures. Includes techniques of taking detailed field notes, field photography measurement of structures using a pocket transit, geologic map and cross section construction, stereonet analysis, and report writing. Consists of off-campus fieldwork. **Note:** Fee course. **Prerequisite:** GEOL 100, GEOL 103A, GEOL 111A and GEOL 111B. **Corequisite:** GEOL 110A. **Units:** 1.0.

GEOL 111A. Field Geology. Science and art of recognizing, describing and interpreting geologic features in the field. Lecture and laboratory course on the preparation and use of topographic and geologic maps, stratigraphic and cross sections, compass and GPS instrument. **Note:** Lecture one hour; laboratory three hours. Fee course. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100 **Corequisite:** GEOL 103A, GEOL 103B, GEOL 111B. **Units:** 2.0.

GEOL 111B. Field Techniques. Introduction to geologic field methods including descriptions of rocks, geologic mapping, observation, interpretation and geologic report writing. Detailed mapping techniques will also be covered; these may include the use of plane table, total station theodolite and global position systems. Consists of off-campus fieldwork. **Note:** Fee course. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, GEOL 12L, GEOL 100. **Corequisite:** GEOL 103A, GEOL 103B, GEOL 111A. **Units:** 2.0.

GEOL 112. Geophysics for Geologists. Introduction to the principal geophysical concepts and techniques useful to geologists in the study of tectonics and the Earth's interior and in prospecting. Includes the study of seismology and earthquakes, heat flow, gravitation, magnetism and electrical properties. **Note:** 150 minutes Lecture = 3 units, 150 minutes Lab = 1 unit. Fee Course/Field Trip. **Prerequisite:** GEOL 103A, GEOL 111A, GEOL 111B and PHYS 5A and PHYS 5B or PHYS 11A and PHYS 11B, MATH 26A or MATH 30. **Units:** 4.0.

GEOL 114. Volcanology. Seminar and lecture in physical volcanic processes, interpretation of volcanic deposits, historic eruptions and hazard assessment. Fee course. **Prerequisite:** GEOL 10 or instructor permission. **Units:** 3.0.

GEOL 120. Surficial Processes. Focused study on the basic forces that drive surficial processes such as wind water and gravity and the role of weathering, sediment transport and deposition on landform and landscape development. A laboratory component will enhance student understanding by solving applied problems as well as develop proficiencies with various geologic tools. **Note:** 150 minutes Lecture = 3 units, 150 minutes Lab = 1 unit. Fee Course. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 103A, GEOL 110A, GEOL 111A GEOL 111B or instructor permission. **Units:** 4.0.

GEOL 121. Geology of California. Regional study of California and certain surrounding areas with regard to geologic development, plate tectonics, economic resources and geologic hazards. Lecture and field trip(s). Fee course. **Prerequisite:** GEOL 10 or equivalent. **Units:** 3.0.

GEOL 123. Geochemistry. Fundamentals of the geochemistry of Earth materials. Thermodynamics and kinetics of geological environments, silicates and carbonates, major element geochemistry, trace and rare earth element geochemistry, stable and radiogenic isotopes. Applications to studies of aqueous, pedogenic, igneous, sedimentary, and metamorphic environments. Analysis of geochemical aspects of contemporary resource, environmental, and paleoenvironmental problems. **Note:** Lecture 3 hours = 3 units; laboratory 170 minutes = 1 unit. **Prerequisite:** CHEM 1A, MATH 30, GEOL 100, or instructor permission. Geology undergraduate/graduate cross listing. Will meet together. Students using this course for an undergraduate elective will not be allowed to take it subsequently for graduate credit. **Units:** 4.0.

GEOL 125. Metallic Ore Deposits. Origin, geology, and distribution of metallic ore deposits. Introduction to ore minerals. Exploration methods. Field trip. Fee course. **Prerequisite:** GEOL 100, CHEM 1A. **Units:** 3.0.

GEOL 127. Hydrogeology. Presents fundamentals of groundwater flow, as influenced by topography and geology; geological aspects of groundwater supply, contamination, remediation, and protection of hydrogeological regions of the U.S. and their critical groundwater issues. Laboratory, homework and field exercises will be included. **Prerequisite:** CHEM 1A; GEOL 10, GEOL 10L, GEOL 12; MATH 26A or MATH 30; PHYS 5A; or instructor permission. **Units:** 3.0.

GEOL 130. Oceanography. Survey of geological, physical, chemical and biological oceanography including the sea floor; waves, tides, currents; the physical and chemical properties of seawater and their distribution in the sea; planktonic life and its relation to nutrients. **Units:** 3.0.

GEOL 135. Forensic Geology. Survey of geological approaches to forensic investigation. Origin and distribution of rocks, soils, and sediments in California and North America. Origin and microanalysis of mineral, microfossils, pollen, and spores. Environmental forensics and investigating pollution. Geophysics and remote sensing. Geology of the urban environment. Modern analytical technique. Case studies in criminal justice, national security, and environmental contamination. **Units:** 3.0.

GEOL 140. Geology and the Environment. Applies geologic data and principles to situations affecting our environment. The geologic study of earthquakes, volcanoes, floods, landslides, groundwater and similar topics supplies the background data for lectures on land use and other social choices. Topics such as geopolitics and mineral supply provide a basis for understanding international politics, social costs, and world economics. Fee course. **Units:** 3.0.

GEOL 170. Geology of the Planets. Study of the Earth-like planets and satellites, and the meteorites, from the point of view of a geologist. Includes a survey of geologic methods and the application of these methods to the study of cratering; volcanic activity; weathering; rock formation; landsliding; erosion by wind, water, and ice; faulting, and so forth; with emphasis on members of the Solar System other than the Earth. **Prerequisite:** An introductory Geology course or instructor permission. **Units:** 3.0.

GEOL 184. Geological Field Trip. 10-day field trip to a region of outstanding geology. Attendance at preliminary meetings is required. Analyzes and interpretation of geologic features is emphasized. Fee course. **Note:** Student should consult the Geology Department during the semester before planning to take the course. May be taken more than once for credit. **Graded:** Credit / No Credit. **Units:** 2.0.

GEOL 190A. Geology and Tectonic Development of California Seminar. Seminar in the geologic and tectonic development of California. **Prerequisite:** GEOL 10, GEOL 12; GEOL 110A recommended. **Units:** 3.0.

GEOL 193C. Engineering Geology. Investigates the engineering properties of earth materials, the engineering considerations required to build safe and durable structures on and within the Earth, and problems associated with structures designed and built neglecting physical environmental conditions. Designed to introduce engineering concepts to students who have a competent grasp of general geologic principles and processes. Lecture 3 hours. **Prerequisite:** GEOL 10, GEOL 10L, GEOL 12, PHYS 5A or PHYS 11A, MATH 29 or high school trigonometry. **Units:** 3.0.

GEOL 194. Geology - Related Work Experience. Supervised employment in a geology related company or agency. Placement is arranged through the Department of Geology and the Cooperative Education Program office. Requires completion of a three to six month work assignment and a written report. **Note:** Units may not be used to meet major requirements in Geology. **Prerequisite:** Open only to upper division students with consent of the Geology Department Chair. **Graded:** Credit / No Credit. **Units:** 6.0-12.0.

GEOL 195. Geology Internship. Supervised unpaid work experience in government or industry. Supervision is provided by the faculty instructor and responsible officials in the work situations. **Note:** Open to all upper division Geology majors with instructor permission. Number of units earned depends on number of hours worked. **Graded:** Credit / No Credit. **Units:** 1.0-3.0.

GEOL 196. Experimental Offerings in Geology. Offerings in various fields of geology in response to student demand. **Prerequisite:** Appropriate upper division course work and instructor permission. **Units:** 1.0-3.0.

GEOL 197. Advanced Laboratory Techniques for Geology. Supervised individual instruction on techniques applied in geology laboratories for advanced research in mineralogy, petrology, geochemistry, geophysics, and paleontology. **Prerequisite:** Appropriate upper division courses and instructor permission. **Graded:** Credit / No Credit. **Units:** 1.0-3.0.

GEOL 198A. Senior Research Preparation. Selection and design of an independent research project. A final written report is required and includes: research proposal, bibliography, and results of preliminary review of the literature. Student must choose a supervising instructor. **Prerequisite:** Senior status and appropriate courses as determined by a Departmental faculty committee. The proposed project must be approved by a Department committee; instructor permission. **Units:** 1.0.

GEOL 198B. Senior Research Project. Completion of an independent research project. A final written report is required. Progress reports may be required by the supervision instructor. Presentation of an oral report on the research project during the same semester is required. **Prerequisite:** Senior status and appropriate courses as determined by a Departmental faculty committee. The proposed project must be approved by the Department committee; instructor permission. **Units:** 2.0.

GEOL 199. Special Problems. Individual projects or special studies. The advisor and the faculty member concerned must approve the course. **Note:** Open only to students judged competent to carry on individual work. **Graded:** Graded (CR/NC Available). **Units:** 1.0-3.0.

Graduate Courses

GEOL 200. Graduate Research Methods Seminar. Developing a research proposal, library and internet searches, seeking external funding, presentation graphics, and publication formats. Students will develop a research project in preparation for thesis requirement. Seminar three hours. **Units:** 3.0.

GEOL 202. Aqueous Geochemistry. Low temperature geochemical reactions in aqueous environments. Chemical kinetics, thermodynamics, mixing and dilution, mineral stability, chemical composition of surface water, stable isotopes. Three hours lecture. **Prerequisite:** CHEM 1B; instructor permission. **Units:** 3.0.

GEOL 204. Contaminant Hydrogeology. Contaminants and contaminant transport in near-surface environments. Fluid-sediment interaction, fluid partitioning, common geochemical reactions, stability and mobility of groundwater contaminants, multiphase systems, sampling considerations and overview of analytical techniques. **Prerequisite:** CHEM 1B and CHEM 6B or CHEM 20, GEOL 202. **Units:** 3.0.

GEOL 208. Groundwater Modeling. Computer modeling of groundwater systems using 2 and 3 dimensional numerical solutions and common software packages. Topics will include data acquisition, constructing a numerical model, model calibration, flow paths, particle tracking and model output. **Prerequisite:** GEOL 127, MATH 45. **Units:** 3.0.

GEOL 210. Field Characterization of Aquifer Systems. Advanced field analysis of aquifer systems including aquifer testing (pumping tests, slug tests, step tests), well construction, aquifer characterization and field geochemistry. Lecture 2 hours, lab 3 hours. **Note:** 100 minutes lecture = 2 units, 150 minutes lab = 1 unit. **Prerequisite:** GEOL 127 and CHEM 1B; instructor permission. **Units:** 3.0.

GEOL 212. Geologic Remote Imaging. Use of remote imaging in geologic applications. Types of imagery, acquisition, production, processing, and interpretation are covered. Lecture three hours; laboratory three hours. **Prerequisite:** PHYS 5B or PHYS 11B or equivalent; GEOL 102A, GEOL 110A or equivalent; and proficiency using a personal computer. **Units:** 4.0.

GEOL 218. Applied Geophysics. Advanced field techniques used for geophysical exploration. Data collection and problem solving using resistivity, conductivity, seismic reflection, seismic refraction, gravity, magnetics and borehole geophysical techniques. Lecture two hours, laboratory three hours. **Prerequisite:** PHYS 5B or PHYS 11C and GEOL 112. **Units:** 3.0.

GEOL 220. Surficial Processes. Dynamics of geological processes and the landscapes they carve. System thresholds, linked processes, data generation and evaluation that characterize landscape development. **Prerequisite:** GEOL 120 or equivalent. **Units:** 3.0.

GEOL 223. Geochemistry. Fundamentals of the geochemistry of Earth materials. Thermodynamics and kinetics of geological environments, silicates and carbonates, major element geochemistry, trace and rare earth element geochemistry, stable and radiogenic isotopes. Applications to studies of aqueous, pedogenic, igneous, sedimentary, and metamorphic environments. Analysis of geochemical aspects of contemporary resource, environmental, and paleoenvironmental problems. **Note:** Lecture 3 hours = 3 units; laboratory 170 minutes = 1 unit. **Prerequisite:** CHEM 1A, MATH 30, GEOL 100, or instructor permission. Geology undergraduate/graduate cross listing. Will meet together. Students using this course for an undergraduate elective will not be allowed to take it subsequently for graduate credit. **Units:** 4.0.

GEOL 227. Advanced Hydrogeology. Water budgets, theories of groundwater flow to wells, hydrogeologic regimes, fracture flow, dewatering, salt water intrusion, dating and chemical identification of water. Lecture 3 hours. **Prerequisite:** GEOL 127, graduate level status in Geology. **Units:** 3.0.

GEOL 230. Seminar in Geology. Reading, analysis and discussion of the geologic literature on selected topics in geology. Student presentations and reports are required. **Note:** May be taken twice for credit. **Units:** 3.0.

GEOL 240. Special Topics. Advanced special topics in Geology that may include structural geology, volcanology, hydrogeology, engineering geology or other specialized topics selected to meet student demand or respond to industry trends in geology. **Prerequisite:** Will vary with each special topic course. **Units:** 1.0-3.0.

GEOL 240C. Advanced Volcanology.

GEOL 240D. Field Volcanology.

GEOL 293. Engineering Geology. Takes a geological approach to evaluating engineering issues associated with building with or on natural earthen materials. Rock and soil mechanics, slope stability, geophysical investigation of rock and soil properties. **Note:** 150 minutes Lecture = 3 units. **Prerequisite:** GEOL 193C. **Units:** 3.0.

GEOL 299. Special Problems in Geology. Graduate research. Independent research in geology that may include library research, short-term original research, technique development, fieldwork, or laboratory research. May include research toward thesis proposal. Culminating experience will be in the form of a written report, oral presentation, or scientific paper. **Prerequisite:** Graduate-level status in geology; approval of project by a faculty sponsor and Department Chair; instructor permission. **Units:** 1.0-4.0.

GEOL 500. Master's Thesis. Completion of a thesis approved for the Master's degree. Should be taken in the final semester prior to the completion of all requirements for the degree. **Prerequisite:** Advanced to candidacy and chair permission of his/her thesis committee. **Graded:** Thesis in Progress. **Units:** 6.0.