Department of Geological Sciences

Department of Geological Sciences
Biological Sciences Building, Room 113A
(909) 537-5336 Department of Geological Sciences (http://geology.csusb.edu)

Bachelor of Arts
- Geology

Bachelor of Science
- Geology
  - General Geology Option
  - Environmental Geology Option

Master of Science
- Earth and Environmental Sciences

Minor
- Geology

The study of geology includes working to understand the chemical, physical and biological processes that affect and are recorded in rocks, minerals, and earth materials, and using that information to decipher the development of our planet. In addition, understanding geology is essential for locating necessary earth resources (oil, minerals, water) and solving those environmental problems that affect the Earth's surface. Much of the information geologists use is obtained by careful, systematic field work and laboratory work, the former being an inherent requirement for geological studies.

The mission of the department is to provide high-quality training in the science of geology so as to equip our students (undergraduate and graduate) to successfully enter the geological workforce, and to contribute to the science of geology through faculty and students conducting and disseminating research in this field. Geology is a broad science that integrates with other classical sciences and disciplines such as astronomy, biology, chemistry, computer science, geography, mathematics, and physics. Course work in those disciplines, integrated within a geological framework, provides students with a broad marketable understanding.

The B.S. degree is recommended for students planning to become professional geologists employed by environmental and geo-technical firms, governmental agencies, oil and mining companies and for those students planning to pursue a graduate degree in geology.

Both the B.S. and B.A. degrees are suitable for students planning a career in K-12 science teaching or environmental law. The B.A. in Geology Integrated Teaching Track will be phased out within the next year.

Geology majors must earn a grade of "C" or better in all required geology courses for those courses to satisfy the degree requirements for a B.A or B.S. degree in Geological Sciences.

Departmental Honors
Students majoring in geological sciences are eligible to earn honors in geological sciences at graduation if the following conditions are met:

1. The student applies to the department for candidacy at the beginning of their senior year;
2. A minimum grade-point average of at least 3.5 in all geology courses has been earned, with a minimum of five geology courses taken at this university.
3. Satisfactory completion of at least 2 units of GEOL 597.

Granting of departmental honors rests with the department faculty.

Current Faculty
Joan E. Fryxell, Professor
B.A. 1977, Earlham College
M.A. 1980, University of Texas
Ph.D. 1984, University of North Carolina

W. Britt Leatham, Associate Professor
B.A. 1981, Weber State College
M.Sc. 1984, The Ohio State
Ph.D. 1987, The Ohio State University

Sally McGill, Professor, Interim Chair
A.B. 1985, Harvard and Radcliffe
M.S. 1989, Ph.D. 1992, California Institute of Technology

Erik B. Melchiorre, Professor
B.S. 1990, University of Southern California
M.S. 1993, Arizona State University
Ph.D. 1998, Washington University

Alan L. Smith, Professor, Chair
B.Sc. 1983, University of London (Kings College)
Ph.D. 1988, University of California, Berkeley

Emeritus
Louis A. Fernández, Professor, Provost and Vice President for Academic Affairs

Undergraduate Degrees

Bachelor of Arts
- Geology (http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/geological-sciences/geology-ba)

Bachelor of Science
- Geology (http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/geological-sciences/geology-bs)
  - General Geology Option
  - Environmental Geology Option

Graduate Degrees

Master of Science
- Earth and Environmental Sciences (http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/chemistry-biochemistry/earth-environmental-sciences-ms)
Minor

- Geology (http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/geological-sciences/geology-minor)

Courses

GEOL 101. Introductory Geology. 5 Units.
Prerequisites: satisfactory score on the Entry Level Mathematics examination (GE=B3)
Offered: Fall, Winter, Spring, Summer
An introduction to the study of the earth, particularly the structure, composition, distribution and modification of earth materials, and processes that shape the surface of the earth. Four hours lecture and three hours laboratory. Materials fee required.

GEOL 102. Introductory Geology Laboratory. 1 Unit.
Prerequisites: satisfactory score on the Entry Level Mathematics examination, and the transferable equivalent to the Introductory Geology lecture, and permission of department
Offered: Fall, Winter, Spring, Summer
Designed for students who have taken an introductory geology lecture elsewhere. Hands-on introduction to the structure, composition, distribution and modification of earth materials, and processes that shape the surface of the earth. Three hours laboratory. Materials fee required.

GEOL 205. Volcanic Hazards, Surveillance and Prediction. 2 Units.
(GE=B4)
An introduction to the study of volcanic eruptions; assessment of their hazards; methods used in their surveillance and in the prediction of eruptions. Effects of volcanic eruptions on humans, buildings, economic activities, and world climate. Two hours lecture.

GEOL 210. Earthquakes: Science and Public Policy. 2 Units.
(GE=B4)
Offered: Fall, Winter, Spring, Summer
An introduction to the scientific study of earthquakes, the assessment of seismic hazards, earthquake engineering, and the physical and sociological effects of earthquakes. Various public policies aimed at mitigating earthquake hazards and attempts at earthquake prediction will also be examined.

GEOL 250. Historical Geology. 5 Units.
Offered: Spring
Study of the origin and evolution of the earth and its life forms as interpreted from the rock and fossil record. Four hours lecture and three hours laboratory. Materials fee required. Overnight field trips may be required.

GEOL 295A. Special Projects in Geology. 1 Unit.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Individual investigation, research, study or survey of selected problems.

GEOL 295B. Special Projects in Geology. 2 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Individual investigation, research, study or survey of selected problems.

GEOL 301. Introduction to Geologic Mapping. 4 Units.
Prerequisites: GEOL 101 or GEOG 103
Offered: Fall
Field identification of igneous, sedimentary, and metamorphic rock units, sample collection, making rock descriptions, use of Brunton compass, pace and compass technique, topographic map reading, location determination, measuring geological features (e.g., strike and dip of bedding, lineation and foliation in metamorphic rocks), plotting geologic features on a topographic map, geologic symbol and notation conventions, topographic profile construction, geologic cross section construction and interpretation, geologic field note taking, and preparing geologic reports. Overnight field trips may be required. Two hours lecture and six hours laboratory. Materials fee required.

GEOL 307A. Service Learning in the Earth Sciences. 1 Unit.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Supervised activities in geology or geological education providing service to campus or community constituents. Minimum of 30 hours required per unit of credit. May be repeated for credit. Graded credit/no credit.

GEOL 307B. Service Learning in the Earth Sciences. 2 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Supervised activities in geology or geological education providing service to campus or community constituents. Minimum of 30 hours required per unit of credit. May be repeated for credit. Graded credit/no credit.

GEOL 309. Earth: The Blue Planet. 5 Units.
Prerequisites: a college-level chemistry course and a college-level physics course, or consent of instructor
Offered: Fall
Tailored for students intending to teach grades K-8. Planet Earth studied as a whole, comprising many separate but interacting systems. Earth's place and role in the solar system; what the planet is made of and how it is changing; surface processes that shape its exterior; influences on its habitable envelope. Four hours lecture and three hours laboratory. Materials fee required.

GEOL 310. Regional Field Geology. 2 Units.
Prerequisites: GEOL 101 or consent of instructor
Investigation of geologic features and their interpretation based on field observations of selected region or locality. Overnight field trips may be required. May be repeated for credit as topics change.

GEOL 312. Geology of California. 4 Units.
Prerequisites: GEOL 101
Offered: Winter
Interpretation of the geological features and evolution of California. Four hours lecture. Overnight field trips may be required. Formerly GEOL 440.
GEOL 320. Mineralogy and Crystallography. 5 Units.
Prerequisites: GEOL 101
Prerequisite/Corequisite: CHEM 205 or CHEM 215
Offered: Fall
Introduction to crystal symmetry, crystallography, crystal chemistry, mineral classification, mineral genesis, physical and chemical properties of minerals, and laboratory identification of important ore and rock-forming minerals. Three hours lecture and six hours laboratory. Materials fee required. Field trips may be required.

GEOL 321. Optical Mineralogy. 3 Units.
Prerequisites: GEOL 320 with a grade of "C" or better
Offered: Winter
Theory and application of petrographic microscopy for the analysis and identification of minerals. One hour lecture and six hours laboratory. Materials fee required.

GEOL 322. Introduction to Geochemistry. 4 Units.
Prerequisites: GEOL 320 with a grade of "C" or better
Offered: Spring
Distribution, migration, and reactions of chemical elements within the earth through space and time. Recommended as an elective for students of chemistry, environmental studies, and life sciences. Four hours lecture.

GEOL 325. Igneous and Metamorphic Petrology. 5 Units.
Prerequisites: GEOL 321 with a grade of "C" or better
Offered: Spring
Description and genesis of igneous and metamorphic rocks, their mineralogic and chemical composition, internal structure, and mode of occurrence. Three hours lecture and six hours laboratory. Materials fee required. Overnight field trips may be required.

GEOL 330. Sedimentary Geology I: Principles and Applications. 5 Units.
Prerequisites: GEOL 101 or equivalent.
Offered: Winter
General processes of sedimentary geology including provenance, sediment production, modification, and transportation; principles of fluid dynamics of water, air, and ice; and introduction to major continental sedimentary systems associated with fluid flow, including fluviatile/alluvial, glacial, and aeolian systems. Laboratory work focuses on description, analytical techniques and interpretation of sedimentary materials including both unconsolidated sediment as well as sedimentary rocks. Techniques introduced include petrographic preparation/observations of both sediment and sedimentary rock; production of stratigraphic sections and the taxonomy of stratigraphic units; representative determinative mineralogy of sedimentary materials; textural analyses and associated descriptive statistics; description, taxonomy, and interpretation of representative sedimentary structures; and introduction to sediment and rock classifications. Four hours lecture and three hours laboratory. Materials fee required.

GEOL 340. Sedimentary Geology II: Principles and Applications. 5 Units.
Prerequisites: GEOL 330 with a grade of "C" or better
Offered: Spring
Introduction to subaqueous sedimentary systems, including deltaic, shallow marine, lacustrine, carbonate, shelf/slope, and deep marine depositional environments. Other course topics include facies relationships; principles of stratigraphic change; correlation methodologies; sequence stratigraphy; the development of stratigraphic thought; biostratigraphic principles and applications; and geophysical/geochemical stratigraphic methodologies and analysis. Laboratory work includes analysis of carbonate and other biogenic/chemically precipitated sediments and rocks; lithostratigraphic and biostratigraphic correlation and analysis, and seismic and sequence stratigraphic analysis. Four hours lecture/discussion and three hours laboratory. Materials fee required.

GEOL 350. Introductory Paleontology. 5 Units.
Prerequisites: an introductory course in either geology, physical geography, chemistry, or biology
Offered: Fall - Even numbered years
Introduction to basic paleobiological concepts and the systematic study of important fossil groups. Course concepts include organization and nature of the biosphere, fossilization, taxonomy and systematics, paleoecology, and evolution as exemplified by commonly represented fossil groups in the rock record. Materials fee required.

GEOL 360. Structural Geology. 5 Units.
Prerequisites: GEOL 101 and PHYS 121 or PHYS 221
Offered: Winter
Mechanics and characteristics of rock deformation and analytical techniques for the solution of structural relationships. Four hours lecture and three hours laboratory. Materials fee required. Overnight field trips may be required.

GEOL 370. Tectonics. 4 Units.
Prerequisites: GEOL 325, 330 and 360
Offered: Spring - Odd numbered years
Interpretation of the geological evidence for plate tectonics; the mechanisms that control it; the structures it produces; its control on igneous, metamorphic, sedimentologic, and biological processes; and plate interactions. Four hours lecture.

GEOL 375. Groundwater Hydrology. 4 Units.
Prerequisites: GEOL 101
Offered: Fall
Occurrence, distribution, and movement of groundwater; properties of aquifers; principles of groundwater flow; effects of well extraction; regional groundwater flow; water quality and contamination. Four hours lecture.

GEOL 376. Field Methods in Hydrology. 4 Units.
Prerequisites: GEOL 375 with a grade of "C" or better
Offered: Winter
Measurement methods and analysis associated with the evaluation of water movement in the field. Sampling methods and use of data loggers and other sampling equipment are emphasized. Two hours lecture and six hours laboratory. Materials fee required. Field trips are required.
GEOL 390. Field Camp. 8 Units.
Prerequisites: GEOL 301, 325, 340, and 360 with a grade of "C" or better in each course and consent of instructor
Geological field work at selected areas in the western United States. Techniques of geologic mapping and structural, petrologic, stratigraphic, and paleontologic interpretation will be used to interpret the geological history and significance of those areas through reports, maps, cross-sections, and diagrams. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 391B. Advanced Field Geology. 2 Units.
Prerequisites: GEOL 301 with a grade of "C" or better and consent of instructor
Offered: Fall, Winter and Spring
Techniques of field geology as applied to selected disciplines within the broad field of geosciences. May be repeated for credit with departmental consent. A total of ten units may be applied towards the degree. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 391C. Advanced Field Geology. 3 Units.
Prerequisites: GEOL 301 with a grade of "C" or better and consent of instructor
Offered: Fall, Winter and Spring
Techniques of field geology as applied to selected disciplines within the broad field of geosciences. May be repeated for credit with departmental consent. A total of ten units may be applied towards the degree. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 391D. Advanced Field Geology. 4 Units.
Prerequisites: GEOL 301 with a grade of "C" or better and consent of instructor
Offered: Fall, Winter and Spring
Techniques of field geology as applied to selected disciplines within the broad field of geosciences. May be repeated for credit with departmental consent. A total of ten units may be applied towards the degree. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 391E. Advanced Field Geology. 5 Units.
Prerequisites: GEOL 301 with a grade of "C" or better and consent of instructor
Offered: Fall, Winter and Spring
Techniques of field geology as applied to selected disciplines within the broad field of geosciences. May be repeated for credit with departmental consent. A total of ten units may be applied towards the degree. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 391F. Advanced Field Geology. 6 Units.
Prerequisites: GEOL 301 with a grade of "C" or better and consent of instructor
Techniques of field geology as applied to selected disciplines within the broad field of geosciences. May be repeated for credit with departmental consent. A total of ten units may be applied towards the degree. Some courses may involve moderate to strenuous physical activity. Depending on course content, additional fitness certification may be needed prior to obtaining the consent of instructor required to register. Field trip fee required.

GEOL 395A. Directed Studies. 1 Unit.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 395B. Directed Studies. 2 Units.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 395C. Directed Studies. 3 Units.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 395D. Directed Studies. 4 Units.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 395E. Directed Studies. 5 Units.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 395F. Directed Studies. 6 Units.
Prerequisites: consent of the instructor
Offered: Fall, Winter and Spring
Individual laboratory, field or library study conducted under the direction of a faculty member. May be repeated for credit.

GEOL 398. Geological Research Methods and Design. 1 Unit.
Prerequisites: NSCI 306 and consent of instructor
Offered: Spring
Students are advised and guided in research methods and design. Critical reasoning and the scientific method are used to develop and write a research proposal, following departmental guidelines, to undertake a project for GEOL 399 and/or GEOL 597. Graded credit/no credit.

GEOL 399. Undergraduate Geological Research. 3 Units.
Prerequisites: GEOL 398
Offered: Fall
Laboratory and/or field research in geological sciences under the direction of a faculty advisor. Results will be presented as a research paper. Grade is consensus grade of geology faculty.

GEOL 430. Engineering Geology. 5 Units.
Prerequisites: GEOL 301 and 360 with a grade of "C" or better in each course
Offered: Spring
A survey of issues and techniques pertinent to geology as it applies to engineering of structures. Soil and rock mechanics; mass wasting processes; water-related issues; land subsidence; seismic hazards. Field trips are required. Three hours lecture and six hours laboratory, some of which will be conducted in the field. Materials fee required.
GEOL 460. Topics in Applied Geology. 4 Units.
Prerequisites: GEOL 360 or consent of instructor
A selected topic of applied geology such as engineering geology, groundwater, environmental geology, resource management, well-log analysis, and geological hazards. Four hours lecture. May be repeated for credit as topics change.

GEOL 510. Scientific Issues in Surface and Groundwater Management. 4 Units.
Overview of groundwater concepts and issues, including groundwater origins and behavior; response to wells; water chemistry; water quality and contamination; development and management. Emphasis is given to applications and case studies. This course does not satisfy requirements for the B.A. and B.S. degrees in geology. Four hours lecture.

GEOL 520. Readings in Classical Geology. 2 Units.
Prerequisites: consent of instructor
Directed readings of important geologic literature that have shaped our understanding of the earth and its history. May be repeated for credit.

GEOL 530. Microscopy. 5 Units.
Prerequisites: senior standing and consent of instructor
Theory and techniques of modern microscopy. Lectures on theory of optics and imaging for several types of microscopes (Light microscope, fluorescence microscope, confocal microscope, scanning probe microscope, and electron microscope). Laboratory includes hands-on training in the technical aspects of specimen preparation and microscope use. Three hours lecture and six hours laboratory. Materials fee required. (Also offered as BIOL 530. Students may not receive credit for both.).

GEOL 540. Advanced Topics in Geology. 4 Units.
Prerequisites: consent of instructor
An advanced geologic topic, such as geophysics, carbonate petrology, seismic stratigraphy, biostratigraphy, advanced igneous and metamorphic petrology, volcanic processes, geochemistry, paleoecology, Quaternary geology, geostatistics, micropaleontology, vertebrate paleontology, paleobotany, marine geology, and rock mechanics. Overnight field trips may be required. May be repeated for credit as topics change.

GEOL 545A. Laboratory for Advanced Topics in Geology. 1 Unit.
Prerequisites: consent of instructor
Laboratory work to accompany some topics offered in GEOL 540. Three hours laboratory per unit enrolled. Materials fee required. May be repeated for credit as topics change. Overnight field trips may be required.

GEOL 545B. Laboratory for Advanced Topics in Geology. 2 Units.
Prerequisites: consent of instructor
Laboratory work to accompany some topics offered in GEOL 540. Three hours laboratory per unit enrolled. Materials fee required. May be repeated for credit as topics change. Overnight field trips may be required.

GEOL 550. Earth Resources. 5 Units.
Prerequisites: GEOL 322 with a grade of "C" or better
An overview of the geology, distribution, and occurrence of many types of ore deposits, and the methods of their extraction. Topics include metallic resources, industrial minerals, building materials, and energy resources. Weekend field trip(s) may be required. Four hours lecture and three hours laboratory. Materials fee required.

GEOL 551. Neotectonics and Seismic Hazard Analysis. 5 Units.
Prerequisites: GEOL 301 and GEOL 360 with a grade of "C" or better in each course
State-of-the-art methods for studying active faults. Topics include basic seismology, significant historic earthquakes, identifying active faults, estimating fault slip rates, types of evidence for prehistoric earthquakes, models for earthquake recurrence, and evaluating the potential for and likely effects of future earthquakes. Four hours lecture and three hours laboratory. Weekend field trip(s) will be required. Materials fee required. Formerly a topic under GEOL 540.

GEOL 552. Volcanology and Volcanic Hazard Assessment. 5 Units.
Prerequisites: GEOL 325 with a grade of "C" or better
Concepts in modern volcanology and assessment of volcanic hazards. Topics include magma properties; eruptive styles; lava flows; pyroclastic and volcaniclastic deposits; volcanoes and climate; volcanic hazards and their assessment and mitigation; case studies of classic volcanic eruptions. Four hours lecture and three hours laboratory. Weekend field trip(s) will be required. Materials fee required. Formerly a topic under GEOL 540.

GEOL 553. Advanced Structural Geology. 5 Units.
Prerequisites: GEOL 325, 330 and 360 with a grade of "C" or better
Recommended: GEOL 370
Advanced topics in theory and analysis of stress and strain; examination of deformation mechanisms; geometry, kinematics, and mechanisms of orogenic belts. Four hours lecture and three hours laboratory. Materials fee required. Overnight field trips may be required.

GEOL 554. Geochemical Thermodynamics. 4 Units.
Prerequisites: CHEM 216 and MATH 212. Geology majors are recommended to take GEOL 320 and GEOL 322 before taking this course
Application of equilibrium thermodynamics to understand geological, geochemical, and other natural systems. Mathematics of thermodynamics and equations of state, use of thermodynamic datasets and extraction of data from experiments, interpretation of geochemical phase equilibria, introduction to geochemical modeling.

GEOL 555. Site Investigation Methodologies in Engineering Geology. 5 Units.
Prerequisites: GEOL 430 or consent of instructor. Recommended prerequisites: GEOL 301, GEOL 360, GEOL 370
Discussion and practice of methods and strategies to investigate sites for the purpose of engineered or other human designed improvement. Use of aerial photography, mapping, reconnaissance site visits, geophysics, and exploration borings to obtain data at sites; discussion of guidelines and methods to describe rock and soil borings. Discussion of use of geologic site conditions to develop the scope and strategy of site investigation. Discussion of siting of critical facilities. Field trips required. Materials fee required.
GEOL 556. Case Histories in Engineering Geology Practice. 4 Units.
Prerequisites: GEOL 430. Recommended prerequisites: GEOL 301, GEOL 360, GEOL 370
Class focuses on the practice of engineering geology through the analysis of case histories of successful projects and failed projects. Class will cover projects such as dams, tunnels, foundations, and natural hazards through time and show how the field of engineering geology has developed in the United States and internationally.

GEOL 575B. Internship in Geology. 2 Units.
Prerequisites: consent of instructor and department chair
Offered: Fall, Winter and Spring
Work experience off and on campus in geologically related work. Supervised by a member of Geological Sciences faculty. May be repeated for credit with department consent. A total of four units may be applied towards obtaining a bachelor's degree and a total of five units may be applied towards obtaining a master's degree. Graded credit/no credit.

GEOL 575C. Internship in Geology. 3 Units.
Prerequisites: Prerequisite: consent of instructor and department chair
Offered: Fall, Winter and Spring
Work experience off and on campus in geologically related work. Supervised by a member of Geological Sciences faculty. May be repeated for credit with department consent. A total of four units may be applied towards obtaining a bachelor's degree and a total of five units may be applied towards obtaining a master's degree. Graded credit/no credit.

GEOL 575D. Internship in Geology. 4 Units.
Prerequisites: consent of instructor and department chair
Offered: Fall, Winter and Spring
Work experience off and on campus in geologically related work. Supervised by a member of Geological Sciences faculty. May be repeated for credit with department consent. A total of four units may be applied towards obtaining a bachelor's degree and a total of five units may be applied towards obtaining a master's degree. Graded credit/no credit.

GEOL 590. Senior Seminar. 2 Units.
Prerequisite/Corequisite: GEOL 399 with a grade of "C" or better
Offered: Spring
Assessment of student learning through a standardized test and through written and oral presentation of a research project, which may have been initiated as part of another course. This course should be taken in the spring quarter immediately prior to graduation.

GEOL 591. Digital Mapping and GIS for Scientists. 4 Units.
Prerequisites: GEOG 202. Recommended: GEOL 301
Emphasis on real-time field-data collection in direct digital form, and manipulation of these data using GIS. Scientific application to geologic and/or environmental problems will be stressed. Two hours lecture and six hours laboratory. Previously offered as Geol 620; students may not receive credit for both courses. Materials fee required.

GEOL 595A. Independent Study. 1 Unit.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 595B. Independent Study. 2 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 595C. Independent Study. 3 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 595D. Independent Study. 4 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 595E. Independent Study. 5 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 595F. Independent Study. 6 Units.
Prerequisites: consent of instructor
Offered: Fall, Winter and Spring
Laboratory, field or library research conducted under the direction of a faculty member. A total of four units in GEOL 595 may be applied towards the major in geology.

GEOL 597B. Senior Honors Research. 2 Units.
Prerequisites: GEOL 399 with a grade of "C" or better
Offered: Fall, Winter and Spring
Original research in the geological sciences Work will be conducted in consultation with a faculty advisor, and will culminate in a written paper and an oral presentation. Grade is consensus grade of the geology faculty.

GEOL 597C. Senior Honors Research. 3 Units.
Prerequisites: GEOL 399 with a grade of "C" or better
Offered: Fall, Winter and Spring
Original research in the geological sciences Work will be conducted in consultation with a faculty advisor, and will culminate in a written paper and an oral presentation. Grade is consensus grade of the geology faculty.

GEOL 597D. Senior Honors Research. 4 Units.
Prerequisites: GEOL 399 with a grade of "C" or better
Offered: Fall, Winter and Spring
Original research in the geological sciences Work will be conducted in consultation with a faculty advisor, and will culminate in a written paper and an oral presentation. Grade is consensus grade of the geology faculty.
GEOL 610. Environmental Geosciences. 5 Units.
Application of earth science principles to environmental issues. Topics include applications of fundamentals of physical geology to geohazards, engineering geology, surface and groundwater, erosion, and environmental geochemistry. Atmospheric and climate topics will include global change issues. Labs will feature hands-on-experience with earth materials, maps, analytical techniques and environmental problem solving. Four hours lecture and three hours laboratory. Prerequisites: GEOL 103, or GEOL 101 or equivalent.

GEOL 621. Graduate Geological Mapping. 4 Units.
Prerequisites: GEOL 301, GEOL 325, GEOL 330, GEOL 340, and GEOL 360 or equivalents, classified standing, and consent of instructor. Application of geologic techniques and principles to selected field problems. Includes geologic mapping, data collection, analysis, and presentation, and report writing. Overnight field work may be required. One hour lecture and nine hours laboratory.

GEOL 630. Environmental Geochemistry. 4 Units.
Prerequisites: GEOL 610. Contemporary problems in environmental geochemistry, such as fate and transport of inorganic and organic pollutants in the terrestrial environment covering both equilibrium and kinetic descriptions of the processes.

GEOL 635. Low-temperature Geochemistry. 4 Units.
Prerequisites: GEOL 610. Low-temperature geochemistry including sedimentary systems, weathering, and aqueous geochemistry. Includes discussion of thermodynamics of aqueous reactions, elemental speciation, activity diagrams, the carbonate system, water-rock reactions and stable isotopes. Two hours lecture and six hours laboratory.

GEOL 690. Graduate Seminar in Environmental Sciences. 2 Units.
Selected topics and reviews of current investigations in the fields of environmental geology.

GEOL 691B. Graduate Independent Study. 2 Units.
Prerequisites: classified standing in master's program and consent of instructor. Independent study of an advanced topic in geology or environmental science.

GEOL 691C. Graduate Independent Study. 3 Units.
Prerequisites: classified standing in master's program and consent of instructor. Independent study of an advanced topic in geology or environmental science.

GEOL 691D. Graduate Independent Study. 4 Units.
Prerequisites: classified standing in master's program and consent of instructor. Independent study of an advanced topic in geology or environmental science.

GEOL 695D. Supervised Graduate Study in Geology. 4 Units.
Prerequisites: classified standing in master's program and consent of advisor. Original individual research in environmental geology; to be conducted under the direct supervision of a faculty member of the student's committee, and if desired in collaboration with other members of the students masters committee.

GEOL 695E. Supervised Graduate Study in Geology. 5 Units.
Prerequisites: classified standing in master's program and consent of advisor. Original individual research in environmental geology; to be conducted under the direct supervision of a faculty member of the students committee, and if desired in collaboration with other members of the students masters committee.

GEOL 696A. Graduate Project. 1 Unit.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.

GEOL 696B. Graduate Project. 2 Units.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.

GEOL 696C. Graduate Project. 3 Units.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.

GEOL 696D. Graduate Project. 4 Units.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.

GEOL 696E. Graduate Project. 5 Units.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.

GEOL 696F. Graduate Project. 6 Units.
Prerequisites: classified standing and consent of instructor. Original individual research in geology, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. May be repeated for credit for a maximum of 12 units. Graded credit/no credit.
GEOL 697. Advanced Internship. 4 Units.
Prerequisites: CHEM 575 or GEOL 575 and consent of advisor. Supervised work or study in private or public organizations. May be repeated for credit with consent of Environmental Science Graduate Committee.

GEOL 698A. Continuous Enrollment for Graduate Candidacy Standing. 1 Unit.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 698B. Continuous Enrollment for Graduate Candidacy Standing. 2 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 698C. Continuous Enrollment for Graduate Candidacy Standing. 3 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 698D. Continuous Enrollment for Graduate Candidacy Standing. 4 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 698E. Continuous Enrollment for Graduate Candidacy Standing. 5 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 698F. Continuous Enrollment for Graduate Candidacy Standing. 6 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.
GEOL 698Z. Continuous Enrollment for Graduate Candidacy Standing. 0 Units.
Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies. Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

GEOL 699. Graduate Thesis. 4 Units.
Prerequisites: CHEM 695 or GEOL 695
Independent graduate research conducted under guidance of the major advisor culminating in a written thesis option of the degree requirements.

GEOL 999. Comprehensive Examination. 0 Units.
Prerequisites: advancement to candidacy, approval of department, completion of course work in the masters program, and good academic standing.
Assessment of the students ability to integrate the knowledge of the area, show critical and independent thinking and demonstrate mastery of the subject matter.