

GEOLOGICAL SCIENCES

College of Natural Sciences and Mathematics

Department Chair: Robert D. Francis

Department Office: Hall of Science (HSCI) 322
Telephone/FAX: (562) 985-4809 / (562) 985-8638
Website: <http://geology.cnsm.ad.csulb.edu/index-shtml>

Faculty: Matthew Becker, Richard J. Behl, Stanley C. Finney, Robert D. Francis, Roswitha B. Grannell, Gregory J. Holk, Thomas Kely, Nathan Onderdonk, Lora Stevens

Administrative Support Coordinator: Margaret Costello

Advisors:

Undergraduate: Thomas Kely
Credential: James Kiesel, Tim Williamson
Graduate: Gregory J. Holk

Students desiring information should contact the Department Office for referral to one of the faculty advisors.

Career Possibilities

Geologist • Geophysicist • Hydrologist • Mineralogist • Paleontologist • Seismologist • Geophysical Prospector • Laboratory Assistant • Soils Engineer • Stratigrapher • Crystallographer • Geodesist • Environmental Analyst • Oceanographer • Teacher • Petrologist • Ecologist • Geochemist (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.) Various entry-level trainee positions in business and industry are available for graduates regardless of academic discipline.

Introduction

The Geological Sciences includes the study of the solid earth, the hydrosphere, and the atmosphere. All Earth Science and Geology majors must contact the Undergraduate Advisor prior to the first semester in residence.

The Geological Sciences Department participates in the Southern California Marine Institute for our marine geology, oceanography, seismic studies. See the Ocean Studies Institute section of this *Catalog* for additional information.

Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the Jensen Student Access to Sciences and Mathematics Center (HSCI 164) or department office for additional information.

Concurrent and/or Summer Enrollment at Another College

Students who wish to take course work at a community or another college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate Department for prior approval to earn credit for specific courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be complied with; see 'Concurrent Enrollment' and 'Transfer of Undergraduate Credit' in this *Catalog*. Courses not receiving prior approval will not be accepted for credit by the Department.

Undergraduate Programs

Bachelor of Science in Geology (120-126 units)

The bachelor of science degree program is intended to provide a thorough background in the geological sciences for those planning to pursue careers in industry or to do graduate study. The program explores the fundamental geological processes, cultivates skills in integrative three-dimensional geological thinking, provides laboratory and field experience, and stimulates interest in the many subdisciplines of the geological sciences.

Within the broad field of geology, students may elect to follow any one of five emphases: General Geology, Petroleum Geology, Stratigraphy/Sedimentology, Geochemistry/Mineralogy-Petrology, and Structural Geology/Tectonics. Each student should contact the undergraduate advisor for assistance in planning the degree program.

Geology majors must receive a grade of "C" or better in all courses required for the major. A minimum of 120-126 units is required for the bachelor of science degree in the various emphases in geology. Emphases other than General Geology are based on the General Geology emphasis, but have structured electives and other variations from that plan. Transfer students should attempt to fulfill, prior to transferring, the appropriate lower division curricular requirements as outlined in later sections. Particular attention should be paid to fulfilling the lower division math, chemistry, physics, and biology requirements.

Lower Division:

Take all of the following

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

- GEOL 240 Historical Geology (4)
Prerequisite: GEOL 106 or both GEOL 102, 104.
- GEOL 250 Introduction to Field Petrology and Geological Field Techniques (3)
Prerequisites: GEOL 102 with 104 or 105; or GEOL 106; all with grades of "C" or better. Corequisite: GEOL 240.
- GEOL 273 Computer Statistical Methods in Geology (4)
Prerequisites: GEOL 240, MATH 117 or 122. An elementary background in computers is recommended.
- BIOL 200 General Biology (4)
Prerequisite: G.E. Foundation requirements.
- CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination. (Credit in Chem 101 does not substitute for a passing score on the Chemistry Placement Examination) and a "C" or better in MATH 113 or 117 or 119A or 122. One year of high school chemistry is strongly recommended. (Recommended for students who intend to pursue careers in science or engineering).
- CHEM 111B General Chemistry (5)
Prerequisite: CHEM 111A with a grade of "C" or better.
- MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and 113, or a grade of "C" or better in MATH 117.
- MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.
- PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.
- PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following

- GEOL 322 Crystallography, Mineralogy and Optical Methods (5)
Prerequisites: GEOL 250; CHEM 101 or 111A.
- GEOL 341 Paleontology and Biostratigraphy (4)
Prerequisites: GEOL 240 and BIOL 200.
- GEOL 350 Spring Field Geology (2)
Prerequisites: GEOL 250 and 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.
- GEOL 428 Igneous and Metamorphic Petrology and Petrography (4)
Prerequisites: GEOL 322; CHEM 111A, B.
- GEOL 433 Structural Geology (4)
Prerequisites: GEOL 250, 322; PHYS 151.
- GEOL 443 Stratigraphy/Sedimentology (4)
Prerequisites: GEOL 240, 322.
- GEOL 450 Summer Field Geology (4)
Prerequisites: GEOL 350, 428, 433, and 443.
- GEOL 460 Introduction to Geophysics (3)
Prerequisites: PHYS 151, 152; MATH 123; and GEOL 273.
- GEOL 461 Introduction to Geochemistry (3)
Prerequisites: CHEM 111A,B and MATH 123.

Additional required courses for the various emphases are listed below.

- General Geology (120 units):
Six units electives (normally at upper division) approved in advance by the undergraduate advisor.
- Petroleum Geology (123 units):
MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or 222.

- GEOL 420 Geowriting (3)
Prerequisites: Upper division or graduate standing in the College of Natural Sciences and Mathematics; ENGL 100 or equivalent; a course in geology; consent of instructor.
- GEOL 471 Petroleum Geology & Well Log Analysis (4)
Prerequisites: GEOL 240, 443.

- Stratigraphy/Sedimentology (122 units):
GEOL 364 Intro to Geological Oceanography (2)
Prerequisites: GEOL 102 or 160; and CHEM 111A or MATH 122, or consent of instructor.
GEOL 420 Geowriting (3)
Prerequisites: Upper division or graduate standing in the College of Natural Sciences and Mathematics; ENGL 100 or equivalent; a course in geology; consent of instructor.
GEOL 424 Sedimentary Petrology (4)
Prerequisites: GEOL 322 and 443.
- Geochemistry/Mineralogy-Petrology (126 units):
MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or 222.
CHEM 371A Physical Chemistry: Thermodynamics and Kinetics (3)
Prerequisites: CHEM 251, MATH 123, PHYS 152 (all with a grade of "C" or better), MATH 224 (may be taken concurrently).
CHEM 371B Physical Chemistry: Quantum Mechanics and Spectroscopy (3)
Prerequisites: CHEM 251, MATH 123, PHYS 152 (all with a grade of "C" or better), and MATH 224 (may be taken concurrently).
- Structural Geology/Tectonics (122 units):
GEOL 430 Seminar in Structural Geology and Tectonics (3)
Prerequisite: GEOL 433.
GEOL 462 Physics and Chemistry of the Earth's Interior (3)
Prerequisites: GEOL 240, 428; PHYS 152.
MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or 222.
MATH 370A Applied Mathematics I (3)
Prerequisites: MATH 123. Not open to Freshmen.

Minor in Geology

The Minor in Geology is available to any non-Geology major.

Twenty units in geology courses that must include:

Lower Division:

Take all of the following

- GEOL 102 General Geology (3)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.
- GEOL 104 Geology Laboratory (1)
Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.
- GEOL 240 Historical Geology (4)
Prerequisite: GEOL 106 or both GEOL 102, 104.

Upper Division:

Take at least 9 additional units of geology approved in advance by the Undergraduate Advisor.

Bachelor of Science in Earth Science (122-129 units)

The Earth Science program prepares students to understand the natural environment, earth resources, land and ocean use, pollution, geology of the sea floor, and other areas of critical importance to present and future world problems. Career-oriented interdisciplinary emphases are offered in Geohydrology/Environmental Geology, Engineering Geology, Exploration Geophysics, and Marine Geology/Oceanography.

Earth Science majors must receive a grade of "C" or better in all courses required for the major. As outlined below, a minimum of 122 units is required for the various emphases in Earth Science.

Lower Division:

Take all of the following

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 240 Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, 104.

GEOL 250 Introduction to Field Petrology and Geological Field Techniques (3)

Prerequisites: GEOL 102 with 104 or 105; or GEOL 106; all with grades of "C" or better. Corequisite: GEOL 240.

GEOL 273 Computer Statistical Methods in Geology (4)

Prerequisites: GEOL 240, MATH 117 or 122. An elementary background in computers is recommended.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination. (Credit in Chem 101 does not substitute for a passing score on the Chemistry Placement Examination) and a "C" or better in MATH 113 or 117 or 119A or 122. One year of high school chemistry is strongly recommended. (Recommended for students who intend to pursue careers in science or engineering).

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and 113, or a grade of "C" or better in MATH 117.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)

Prerequisite: A grade of "C" or better in MATH 123 or 222.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Additional required courses for the various emphases are listed below.

Upper Division:

Take all of the following

GEOL 322 Crystallography, Mineralogy and Optical Methods (5)

Prerequisites: GEOL 250; CHEM 101 or 111A.

GEOL 350 Spring Field Geology (2)

Prerequisites: GEOL 250 and 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.

GEOL 428 Igneous and Metamorphic Petrology and Petrography (4)

Prerequisites: GEOL 322; CHEM 111A, B.

GEOL 433 Structural Geology (4)

Prerequisites: GEOL 250, 322; PHYS 151.

GEOL 443 Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, 322.

GEOL 460 Introduction to Geophysics (3)

Prerequisites: PHYS 151, 152; MATH 123; and GEOL 273.

Additional required courses for the various emphases are listed below.

1. Geohydrology/Environmental Geology (122 units):

C E 205 Analytical Mechanics I (Statics) (3)

Prerequisite: PHYS 151. Prerequisite/Corequisite: MATH 123.

C E 335 Fluid Mechanics (3)

Prerequisites: MATH 224 and C E 205.

C E 336 Fluid Mechanics Laboratory (1)

Prerequisite: ENGL 100 or equivalent. Prerequisite or corequisite: C E 335.

CHEM 111B General Chemistry (5)

Prerequisite: CHEM 111A with a grade of "C" or better.

ES P 300I Environmental Law and Policy (3)

Prerequisites: GE Foundation requirements; ECON 100 and 101, or ECON 300; POSC 100; and upper division standing.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, 428, 433, and 443.

GEOL 461 Introduction to Geochemistry (3)

Prerequisites: CHEM 111A,B and MATH 123.

GEOL 477 Hydrogeology (3)

Prerequisites: GEOL 102, 104; CHEM 111B; PHYS 152; MATH 123.

MICR 200 General Microbiology for Health

Professionals (4)

Prerequisites: CHEM 111A or 140 with a grade of "C" or better and GE Foundation requirements.

2. Engineering Geology (129 units):

C E 205 Analytical Mechanics I (Statics) (3)

Prerequisite: PHYS 151. Prerequisite/Corequisite: MATH 123.

C E 345 Geotechnical Engineering I (3)

Corequisites: MAE 373; GEOL 370. Prerequisite: Consent of Department Undergraduate Advisor.

C E 346 Geotechnical Engineering Laboratory (1)

Prerequisite: ENGL 100 or equivalent. Corequisite: CE 345.

C E 445 Geotechnical Engineering II (3)

Prerequisites: CE 345, 346.

CHEM 111B General Chemistry (5)

Prerequisite: CHEM 111A with a grade of "C" or better.

GEOL 444 Engineering Geology (4)

Prerequisites: GEOL 250, 273, 322; MATH 122, 123; CHEM 111A,B; PHYS 151, 152.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, 428, 433, and 443.

GEOL 477 Hydrogeology (3)

Prerequisites: GEOL 102, 104; CHEM 111B; PHYS 152; MATH 123.

MAE 373 Mechanics of Deformable Bodies (3)

Prerequisite: CE 205.

3. Exploration Geophysics (126 units):

BIOL 200 General Biology (4)

Prerequisite: G.E. Foundation requirements.

GEOL 462 Physics & Chemistry of Earth's Interior (3)

Prerequisites: GEOL 240, 428; PHYS 152.

MATH 247 Introduction to Linear Algebra (3)

Prerequisite: MATH 123 or 222.

MATH 370A Applied Mathematics I (3)

Prerequisites: MATH 123. Not open to Freshmen.

PHYS 310 Analytic Mechanics I (3)

Prerequisite: PHYS 151. Corequisite: MATH 364A or 370A.

PHYS 340A Electricity and Magnetism I (3)
Prerequisites: PHYS 152, 310. Prerequisite/Corequisite:
MATH 370A or 364A.

Take 8 units in consultation with undergraduate advisor

4. Marine Geology/Oceanography (122 units):

BIOL 200 General Biology (4)

Prerequisite: G.E. Foundation requirements.

CHEM 111B General Chemistry (5)

Prerequisite: CHEM 111A with a grade of "C" or better.

GEOL 341 Paleontology and Biostratigraphy (4)

Prerequisites: GEOL 240 and BIOL 200.

GEOL 364 Intro to Geological Oceanography (2)

Prerequisites: GEOL 102 or 160; and CHEM 111A or MATH 122, or consent of instructor.

GEOL 461 Introduction to Geochemistry (3)

Prerequisites: CHEM 111A,B and MATH 123.

GEOL 465 Physical and Chemical Oceanography (3)

Prerequisites: CHEM 111B; PHYS 100B, and upper division standing in the College of Natural Sciences and Mathematics or Engineering.

GEOL 466 Oceanography Lab and Ocean Studies (1)

Prerequisite/Corequisite: GEOL 465.

GEOL 496 Investigations in Geology and Other Earth Sciences (1-4)

Prerequisites: Senior standing in geology, earth science or related fields, completion of an upper division course in geology or earth science in the area of the topics chosen and approval of the topic chosen by the Geological Sciences faculty.

Geoscience Concentration

The Geosciences Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Geosciences. Prospective students should consult the Single Subject Science Education Advisor in the Department of Science Education early to plan their program.

Requirements

Lower Division:

Take all of the following

ASTR 100 Astronomy (3)

Corequisites: One course from General Education Category B.2 and ASTR 100L.

BIOL 211 Introduction to Evolution and Diversity (4)

Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)

Prerequisites: Completion of BIOL 211 and CHEM 111A with grades of "C" or better.

BIOL 213 Introduction to Ecology and Physiology (4)

Prerequisites: BIOL 211, 212, CHEM 111B all with a grade of "C" or better.

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination. (Credit in Chem 101 does not substitute for a passing score on the Chemistry Placement Examination) and a "C" or better in MATH 113 or 117 or 119A or 122. One year of high school chemistry is strongly recommended. (Recommended for students who intend to pursue careers in science or engineering).

CHEM 111B General Chemistry (5)

Prerequisite: CHEM 111A with a grade of "C" or better.

MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and 113, or a grade of "C" or better in MATH 117.

MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

GEOL 160 Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

GEOL 273 Computer & Statistical Methods in Geology (4)

Prerequisites: GEOL 240, MATH 117 or 122. An elementary background in computers is recommended.

NOTE: BIOL 111, 111L, 212, 212L, 213, 213L are required if courses were taken prior to catalog year 2010-11.

Upper Division:

Take all of the following

GEOL 341 Paleontology and Biostratigraphy (4)

Prerequisites: GEOL 240 and BIOL 200.

GEOL 428 Igneous and Metamorphic Petrology and Petrography (4)

Prerequisites: GEOL 322; CHEM 111A, B.

GEOL 433 Structural Geology (4)

Prerequisites: GEOL 250, 322; PHYS 151.

GEOL 443 Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, 322.

GEOL 450 Summer Field Geology (4)

Prerequisites: GEOL 350, 428, 433, and 443.

SCED 403 Integrated Science (3)

Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

Single Subject Teaching Credential in Geosciences

In addition to meeting the subject matter competence requirement for the Teaching Credential, prospective Geosciences teachers are also required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Students may begin the professional preparation courses as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website (www.ced.csulb.edu/single-subject) for a description of the professional preparation requirements, courses, and application procedures.

The Geosciences Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

GRADUATE PROGRAMS

Master of Science in Geology

The Department of Geological Sciences offers a comprehensive program of courses coupled with appropriate thesis projects leading to the Master of Science in Geology. Within geology, students specialize in any of a number of sub-disciplines including engineering geology, environmental geochemistry, geology, hydrogeology, marine geology, mineralogy and petrology, paleontology, petroleum geology, sedimentology, stratigraphy, structural and field geology, and volcanology. In addition, a formal emphasis in geophysics is available. Students may include in their studies courses offered by other departments at CSULB.

Emphasis in Geophysics

The emphasis in geophysics is available for students wishing to specialize in the application of geophysical principles to the solution of problems in engineering geology, geohydrology, structural geology, tectonics, petroleum geology, and mineral exploration. Students are expected to have completed the equivalent of course work required for the B.S. in Earth Science, Geophysics emphasis, and additionally to complete M.S. requirements with a program of geophysical course work approved in advance by both the graduate advisor and a geophysics advisor. Appropriate B.S. programs which provide training suitable for completion of the M.S. in Geology, Geophysics Emphasis, include Civil and Electrical Engineering, Physics, Mathematics, and Geology in addition to Geophysics, although some deficiencies will exist in these alternate programs. Confer with the graduate advisor about this program.

Offshore Resources

The Department has access to an ocean-going research vessel, support staff, and dockside facilities of the Southern California Marine Institute (SCMI), a consortium of several California State University campuses, University of Southern California, and Occidental College.

Admission to the Program

The basic requirement for admission to the graduate program is possession of a bachelor's degree or equivalent in geology, or a closely related field. The final curriculum requirements for the Master of Science Degree are set by the Thesis Committee at Advancement to Candidacy, but the following undergraduate courses are considered an essential foundation for the program: (1) two courses in calculus, (2) two courses in general chemistry, (3) two courses in calculus-based physics, (4) a course in physical geology, (5) a course in historical geology, (6) mineralogy, (7) sedimentology/stratigraphy, (8) structural geology, (9) a course in field methods or a field camp. Students who are missing some of this course work may be admitted to the program but will be expected to remove deficiencies or present acceptable alternatives prior to Advancement to Candidacy. Students who are missing the general science and math requirements are recommended to complete an undergraduate degree in Geological Sciences or a closely related field before applying to the Graduate Program.

In addition to the above course work requirements, students are required to take the General test of the

Graduate Record Examination and to submit three letters of recommendation prior to entry.

Prospective graduate students in the geological sciences, including CSULB graduates, must formally apply for admission to CSULB as described previously in this Catalog and must also apply directly to the Department of Geological Sciences. All applicants must submit the following documents directly to the Department no later than April 1 for the fall semester or November 1 for the spring semester to receive full consideration for admission and financial support:

1. Department Application Form, available from the Department Office and on the Department's website;
2. Official transcripts of all college level academic work including that done at CSULB, in addition to those transcripts required for general graduate admission to CSULB;
3. Three letters of recommendation from persons familiar with the applicant's academic performance and research potential. Instructions, including forms to be used for these letters, are included in the Department application form, available from the Department's website;
4. Official reports of scores on the General test of the Graduate Record Examination.

A limited number of teaching and research assistantships are available to fund graduate studies in the Department of Geological Sciences. Applicants wishing to secure research assistantships are encouraged to make direct contact with faculty in their area of research interest.

Johnson-Conrey Graduate Fellowship

The Johnson-Conrey Graduate Fellowship is awarded to the most highly qualified incoming Geological Sciences graduate students each year. The Fellowship, which provides \$15,000 per year for two years, is competitive, and is awarded by the Department based on students' Application materials. Up to two Fellowships are awarded each year.

Initiation of Graduate Study

Students are responsible for all University and Department regulations governing master's degrees as outlined in this *Catalog*. The regulations governing the degree are those in effect at the time of advancement to candidacy. Until that time, students are governed by the most current *Catalog*. The advising of incoming graduate students is carried out by the graduate advisor, who explains the requirements of the program and carries out initial academic advising. It is required that the student arrange for this initial advising before or during his/her first semester.

All entering students must take GEOL 500 (Introductory Graduate Seminar) during their first Fall semester. This course consists of faculty-given seminars that introduce to new students the faculty and their research. One purpose of this is to encourage the student to find a thesis topic and thesis advisor by the end of the second semester. This is done with the help of the graduate advisor once the student has chosen a sub-discipline or option in which to specialize.

Students are required to maintain a GPA of 3.0 or higher at all times. If at any time a student's GPA drops below 3.0, that student will immediately be placed on probation for a maximum of two semesters. If the student does not bring the GPA back up to 3.0 during the probationary period, he/she will not be allowed to continue as a graduate student in this Department. In order for a student to regain status in the

Department after failing to maintain this academic standard, he/she must formally reapply for Department admission.

Advancement to Candidacy

A student must have been advanced to candidacy before initiating formal thesis research necessary to complete the M.S. degree. Students are expected to be advanced by the end of their fourth semester. Students may petition the Department for an extension of the four semester time limit on a semester by semester basis. Students should be aware, however, that they are at risk of not receiving credit toward their graduate programs for research started or courses taken prior to advancement. Students must have fulfilled the Graduation Writing Assessment Requirement (GWAR) and have advanced to candidacy before they apply for graduation. Requests to graduate must be received during the preceding May for Spring/Summer graduation or preceding December for Fall graduation. Filings after the deadlines are not accepted.

Before advancement can proceed, a thesis topic, committee, and graduate program consisting of at least 30 units (see below) must be established by the student and the prospective thesis committee chair. In addition, the following requirements must be met:

1. Prior completion of all deficiencies and incompletes. This includes courses required in the undergraduate major for the emphasis in which the student is pursuing graduate research, as well as additional courses specified by the thesis advisor.
2. Completion of six units of graduate level courses with a 3.0 or higher grade point average and attainment of a 3.0 or higher grade point average in all upper division and graduate work attempted, as well as in courses to be listed in the student's graduate academic program (see below).
3. A passing grade in GEOL 500.
4. Satisfying the Graduation Writing Assessment Requirement (GWAR).
5. Successful completion of an oral qualifying examination given by the student's thesis committee, and acceptance of a written proposal for the thesis research. The student's thesis topic will be the subject of the examination.

Once the above requirements are met, advancement to candidacy proceeds with approval of the committee, graduate advisor, Department Chair and Associate Dean in the College of Natural Sciences and Mathematics. After the student has been advanced, no course work in addition to that specified in the graduate program may be required of the student. In order for a student to change thesis chair/director, topic, committee members, or courses in the graduate program, approvals must be obtained. Under some circumstances this may mean that additional courses are required.

Requirements of Graduate Academic Program

The graduate academic program consists of at least 30 units of courses and is finalized when the student advances to candidacy. Although courses that will eventually become part of the student's academic program may be taken before advancement, it is strongly recommended that students make up any undergraduate deficiencies first, and

then advance as early as possible. The program proposed by the thesis committee chair and the student must be approved by the thesis committee, Graduate Advisor, Department Chair, and Associate Dean. Six units of GEOL 698 (Thesis) must be taken as part of the program. Directed Research, GEOL 697, may account for up to three units, but normally cannot be taken before the student completes 12 units of the graduate program with a grade point average of 3.0 or higher.

A minimum of 18 units of 500 or 600 level courses, including Thesis, must be completed; the remaining units (12 or less) may be 300, 400, 500, or 600 level courses, although courses at 300 level in the Department may not be used in the program. Units may be taken at other universities if suitable courses are not offered at CSULB. Appropriate courses from related areas in science, mathematics, or engineering may be substituted within limits with consent of the Department.

Thesis Defense

All M.S. students are required to submit a thesis that conforms to the University and Department guidelines. The thesis should document the systematic study of a significant geological problem; evidence originality and critical, independent thinking; and conform to appropriate and accepted organization, format, and writing style. Each student should discuss thesis format with his/her thesis committee chair.

All M.S. students are also required to present the results of their research orally. With prior approval, this presentation can take one of many possible formats, including a departmental seminar, a presentation at a regional or national meeting, or a formal thesis defense. The student must schedule his/her presentation at least two weeks in advance, and with the approval of the thesis committee. The date of the presentation must precede the semester's thesis submission deadline for which the student plans to graduate.

Single Subject Teaching Credential in Geosciences

For information, refer to the undergraduate section in this department.

Courses (GEOL)

LOWER DIVISION

102. General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Broad based introductory study of geology. Broad based introductory study of geology. Structure, composition, distribution, and modification of earth materials and elementary geologic history of the Earth.

Concurrent enrollment in GEOL 104 or 105 recommended. (Lecture, demonstration 3 hrs.)

104. Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

Laboratory study of earth materials.

(Laboratory 3 hrs.)

105. Geology Field Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent, and concurrent or prior enrollment in GEOL 102.

Field trips to areas of geologic significance and field study of earth materials.

May be repeated to a maximum of 3 units with consent of instructor. (Field trips, 6 days per unit.) Course fee may be required for bus trips.

106. Earth Science for Teachers (4)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics, including algebra, geometry, and intermediate algebra or the equivalent.

Introduction to earth science including geology, oceanography, meteorology, solar system and astronomy. Scientific method addressed. Methods of teaching science to K-8 pupils.

Letter grade only (A-F). (Lecture, demonstration 3 hours., laboratory 3 hrs., field trips.)

110. Natural Disasters (3)

Prerequisites/Corequisites: Courses that fulfill the GE A.1 and B.2 requirements. Corequisite: GEOL 110L is recommended.

Introductory study of Earth's natural processes that severely impact humans. Includes study of processes causing natural disasters such as earthquakes, volcanic eruptions, landslides, floods, tornadoes, hurricanes, tsunamis, and asteroid impacts.

(Lecture 3 hrs.)

110L. Natural Disasters Laboratory (1)

Prerequisites/Corequisites: Courses that fulfill the GE A.1 and B.2 requirements. Corequisite: GEOL 110.

Laboratory analysis of geological data and field observations of geologic features associated with natural disasters.

Course fee may be required. (Laboratory 3 hrs, field trips).

160. Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Origin and extent of oceans, nature of ocean floor, and cause and effect of currents, tides, and waves; and life in the ocean.

(Lecture, discussion 3 hrs.)

160L. Introduction to Oceanography Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra (MAPB 7) or the equivalent; and previous credit or concurrent registration in GEOL 160.

Field and laboratory study of marine environment. Analysis of maps, plus shore and on-water trips for experience in use of oceanographic instruments. Analysis and interpretation of results.

(Laboratory-field 3 hrs.) Course fee may be required.

190. Environmental Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Interrelationships between humans and hazards: landslides, floods, erosion, subsidence, volcanism, earthquakes, and seismic sea waves. Origin of resources and impacts of resource development: water, soils, and energy. Waste and waste disposal.

(Lecture 3 hrs.)

191. Air and Water Pollution (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Survey course dealing with the causes and nature of pollution in

the air, groundwater, fresh water lakes and streams, and the ocean. Effects of air and water pollution on the environment.

(Lecture 3 hrs.)

240. Historical Geology (4)

Prerequisite: GEOL 106 or both GEOL 102, 104.

History of earth and evolution of animals and plants.

(Lecture 3 hrs., laboratory 3 hrs., field trips.)

250. Introduction to Field Petrology and Geological Field Techniques (3)

Prerequisites: GEOL 102 with 104 or 105; or GEOL 106; all with grades of "C" or better. Corequisite: GEOL 240.

Identification and description of igneous, sedimentary, and metamorphic rocks in the field. Development of fundamental geological field techniques: recording, collection, and interpretation of geological field data. Creation and interpretation of geological maps, writing technical reports, and construction of geological illustrations.

Letter grade only (A-F). (Lecture 1 hour, weekend field trips.)

273. Computer and Statistical Methods in Geology (4)

Prerequisites: GEOL 240, MATH 117 or 122. An elementary background in computers is recommended.

Introduction to statistical theory, computer programming, and the use of computer-based statistical and graphical packages as applied to problem-solving in the geological sciences.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs., field trips.) Course fee may be required.

280. Water Resources and Society (3)

Prerequisites: GEOL 102, 104. A grade of "C" or better in MATH 117, or four years of high school mathematics.

Hydrologic, geologic, and other factors controlling groundwater and surface water occurrence, movement, quality, and contamination. Environmental effects of groundwater and surface water contamination.

(Lecture 3 hours; field trips)

UPPER DIVISION

300I. Earth Systems and Global Change (3)

Prerequisites: GE Foundation requirement, upper division standing, and CHEM 100 or CHEM 111A or GEOL 102 or GEOL 106 with a grade of "C" or better.

Interaction of Earth's systems (biosphere, lithosphere, hydrosphere, cryosphere, and atmosphere) and links between life, oceans, climate, and the solid earth. This approach is used to understand important issues confronting society regarding climatic and environmental change.

Letter grade only (A-F). (Lecture 3 hrs.)

303. Coastal Systems and Human Impacts (3)

Prerequisites: GE Foundation requirement, one or more Exploration courses, and upper-division standing; BIOL 200; GEOL 102 or 160.

Natural processes impacting human activities in coastal zone and human influence on natural processes. Includes global warming, sea level rise, El Nino, port development, ocean outfalls and water quality, fisheries, and coastal erosion.

May not apply units towards elective requirements of Geology and Earth Science majors. Letter grade only (A-F). Not open for credit to students with credit in BIOL 303. (Lecture 3 hrs.)

322. Crystallography, Mineralogy and Optical Methods (5)

Prerequisites: GEOL 250; CHEM 101 or 111A.

Morphological and structural crystallography, crystal structure, chemistry, classification, origin, occurrence, and association of minerals reviewed. Analysis and identification of minerals by megascopic, qualitative, chemical, and instrumental means. Optical properties of minerals reviewed including nature of light. Petrographic microscope used.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 6 hrs., field trip)

339. Introduction to Geomorphology (3)

Prerequisites: GEOL 102 with 104 or 105; or GEOL 106; or GEOG 140.

Study of landforms and processes producing and modifying them. Emphasis on mechanics of geomorphic processes and relationships between properties of earth materials and forces applied to them by gravity, wind, ice, water, waves, and humans. Conceptual basis of geomorphology addressed.

Designed for Geology, Geography, Biology, Anthropology, and Civil Engineering majors. Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., field trips).

341. Paleontology and Biostratigraphy (4)

Prerequisites: GEOL 240 and BIOL 200.

Morphologic, systematic, and ecologic aspects of invertebrate fossils; methods and techniques in collection, preparation, illustration, and description of fossils; uses of fossils in stratigraphic work; principles of biostratigraphy.

(Lecture 3 hrs., laboratory 3 hrs., fieldtrips) Course fee may be required.

350. Spring Field Geology (2)

Prerequisites: GEOL 250 and 443 with grades of "C" or better. Prerequisite/Corequisite: GEOL 433.

Development of proficiency in geological mapping skills. Construction of stratigraphic columns and structural cross sections.

Letter grade only (A-F). (Field trips, 5 days per unit)

364. Introduction to Geological Oceanography (2)

Prerequisites: GEOL 102 or 160; and CHEM 111A or MATH 122, or consent of instructor.

Topography and structure of ocean floor. Waves, currents, and tides as agents of sedimentation. Geological processes effect on the sea floor environment. Tectonic and sedimentary history of ocean basins and continental margins. Shipboard techniques in marine geology.

(Lecture 2 hrs.; sea trips.)

370. Geology for Engineers (2)

Prerequisites: MAE 172, CE 130.

Earth processes and materials which influence the design, construction and operation of engineering works, construction materials. Not open for credit to geology majors.

(Lecture 2 hrs., field trips.)

410./510. Biogeochemical Cycles (3)

Prerequisites: GEOL 102, 300I or 461; BIOL 200 or 211A,B or BIOL 211, 211L, 212, 212L, 213, and 213L; MATH 122; CHEM 111A, B; or GEOL 191. (Undergraduates enroll in GEOL 410; graduates enroll in GEOL 510.)

Study of carbon, nitrogen, phosphorus, iron, and sulfur cycles among the bio-, hydro-, and geospheres with an emphasis on transfer rates, mass balance, and residence times. Evaluation of processes and interactions among key ecosystems (wetlands, rivers, ocean, lakes, estuaries).

Letter grade only (A-F). (Lecture 3 hrs.)

420. Geowriting (3)

Prerequisites: Upper division or graduate standing in the College of Natural Sciences and Mathematics; ENGL 100 or equivalent; a course in geology; consent of instructor.

Writing for scientific audience; writing scientific content at an advanced level emphasized. Journal article and abstracts reviewed. Includes handling descriptive scientific data, distinction between data and interpretation, logic and argument, clarity of style, and writing for specific audiences. Extensive writing. Enrollment limited.

Letter grade only (A-F). (Lecture 3 hrs.)

424./524. Sedimentary Petrology (4)

Prerequisites: GEOL 322 and 443. (Undergraduates enroll in GEOL 424; graduates enroll in GEOL 524.)

Microscopic and macroscopic study of the origin and diagenesis of sedimentary rocks. Identification of grain types, textures, structures, and cements emphasizing provenance, paleotectonics, paleoenvironmental reconstructions, and post-depositional alteration.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

428. Igneous and Metamorphic Petrology and Petrography (4)

Prerequisites: GEOL 322; CHEM 111A, B.

Magmatic and metamorphic rock bodies and systems characteristics, including mineralogical and chemical aspects. Fabrics' origin, evolution of igneous and metamorphic rocks, modeling of magma genesis. Microscopic, hand specimen and x-ray analysis of rocks, including fabric and mineral content.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs., and field trips)

430./530. Seminar in Structural Geology and Tectonics (3)

Prerequisite: GEOL 433. (Undergraduates enroll in GEOL 430; graduates enroll in GEOL 530.)

Review of analysis, interpretation and origin of geologic structures, mechanics of rock deformation and of large scale crustal deformation.

(Lecture 2 hrs., laboratory 3 hrs.; field trips.)

431./531. Tectonic Geomorphology (4)

Prerequisite: GEOL 433. (Undergraduates enroll in GEOL 431; graduates enroll in GEOL 531.)

Observation and analysis of Earth surface processes, and development of landforms and landscape. Interaction between surficial processes and tectonic, biologic, hydrologic, climatic, and atmospheric processes. Tectonic generated landforms, earthquake hazards evaluated, and geomorphic assessment. Assessing problems including landforms and environmental hazards.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs., field trips.)

433. Structural Geology (4)

Prerequisites: GEOL 250, 322; PHYS 151.

Theories/principles of structural geology, orogenesis, and tectonics. Planar/linear structures in naturally deformed rocks. Description, classification, interpretation, and kinematic and dynamic analysis of faults/folds. Field measurement, analysis and mapping of structures. Deformation, strength, fracture, and rheological properties of rocks.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs., required field trips)

443. Stratigraphy/Sedimentology (4)

Prerequisites: GEOL 240, 322.

Introduction to sedimentology and stratigraphy, flow mechanics and sedimentary structures, laboratory and field methods for the description and classification of sedimentary rocks, depositional systems, sequence stratigraphy, subsurface stratigraphic methods, sedimentation and tectonics, and preparation of sedimentologic field reports.

Not open for credit to students with credit in GEOL 343. Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs., required field trips)

444./544. Engineering Geology (4)

Prerequisites: GEOL 250, 273, 322; MATH 122, 123; CHEM 111A,B; PHYS 151, 152. (Undergraduates enroll in GEOL 444; graduates enroll in GEOL 544.)

In depth study of the fundamentals of engineering geology and related hazards. Evaluation of aggregate, cement and grouts. Soil and rock engineering characteristics.

Letter grade only (A-F). (Lecture 3 hrs, laboratory 3 hrs.; field trips.)

450. Summer Field Geology (4)

Prerequisites: GEOL 350, 428, 433, and 443.

Four weeks of geological field mapping at a selected area. Preparation of geological reports of the field problems.

Course fee may be required. (Lecture as needed, daily field work)

454./554. Environmental Geochemistry (3)

Prerequisites: CHEM 111B and consent of instructor.

Geochemical cycles. Human interference with cycles. Trace elements, health and agriculture. Clay mineral reactions. Groundwater chemistry. Reading and discussion of research articles; projects in environmental geochemistry.

Letter grade only (A-F). (Lecture 3 hrs., field trips.)

460. Introduction to Geophysics (3)

Prerequisites: PHYS 151, 152; MATH 123; and GEOL 273.

Introduction to geophysics; principles and processes; methods of investigation.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs., field trips.)

461. Introduction to Geochemistry (3)

Prerequisites: CHEM 111A,B and MATH 123.

Abundance and migration of elements in the earth; chemical processes in evolution of earth and its crust including geochemistry of organic compounds.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

462. Physics and Chemistry of the Earth's Interior (3)

Prerequisites: GEOL 240, 428; PHYS 152.

Structure and composition of the Earth's interior. Origin and evolution of the Earth. Review of geophysical data, petrologic analyses, and other types of evidence for Earth structure and compositional models.

Letter grade only (A-F). (Lecture 3 hrs.)

465./565. Physical and Chemical Oceanography (3)

Prerequisites: CHEM 111B; PHYS 100B, and upper division standing in the College of Natural Sciences and Mathematics or Engineering. (Undergraduates enroll in GEOL 465; graduates enroll in GEOL 565.)

Physics and chemistry of the oceans, carbon cycle; minor and trace elements in sea water, nutrients, water masses and currents; physical concepts and interpretative theories related to ocean circulation.

(Lecture 3 hrs.)

466. Oceanography Laboratory and Ocean Studies (1)

Prerequisite/Corequisite: GEOL 465.

Analysis and interpretation of oceanographic data, acquisition of data at sea on field trip, and post-cruise analysis and presentation of results.

Not open for credit to students with credit in GEOL 462. (Laboratory 3 hrs., sea trips.)

471. Petroleum Geology and Well Log Analysis (4)

Prerequisites: GEOL 240, 443.

Geological application in exploration and production of petroleum, including uses of surface and subsurface techniques. Basic well logging techniques employed, including data collection, reduction, interpretation, and integration among various logging methods as well as with surface geology and geophysical data.

(Lecture 2 hrs., laboratory 6 hrs., field trips.)

474./574. Physical Hydrology (3)

Prerequisites: GEOL 102, MATH 122; PHYS 151. (Undergraduates enroll in GEOL 474; graduates enroll in GEOL 574.)

Quantitative study of the terrestrial water cycle; prediction and measurement of precipitation, surface water, soil water, and groundwater.

Letter grade only (A-F). (Lecture 2 hrs, lab/field trips 3 hrs)

477./577. Hydrogeology (4)

Prerequisites: GEOL 102, 104; CHEM 111B; PHYS 152; MATH 123. (Undergraduates enroll in GEOL 477; graduates enroll in GEOL 577.)

Groundwater flow, occurrence, development, chemistry, and contamination. Elementary groundwater flow theory. Well hydraulics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

486./586. Engineering Geophysics (3)

Prerequisite/Corequisite: GEOL 460. (Undergraduates enroll in GEOL 486; graduates enroll in GEOL 586.)

Applying geophysical techniques to geology and hydrogeology problems. Geophysical techniques, and identification and utilization of specialized techniques. Case histories in site evaluations, subsiding areas, basement topography mapping, seawater problems, water table mapping, groundwater contamination, and subsurface cavities detection.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.; field trips.) Course fee may be required.

489. Current Topics in Geological Sciences (3)

Prerequisite: Consent of instructor.

Topics of current interest in the geological sciences selected for intensive development.

May be repeated to a maximum of 6 units. Field trips may be required. (Lecture 2 hrs., laboratory 3 hrs.)

B. Urban Geology

490. Current Topics in Geological Sciences (1-3)

Prerequisite: Consent of instructor.

Topics of current interest in the geological sciences selected for intensive development.

May be repeated to a maximum of 6 units. Field trips may be required.

496. Investigations in Geology and Other Earth Sciences (1-4)

Prerequisites: Senior standing in geology, earth science or related fields, completion of an upper division course in geology or earth science in the area of the topics chosen and approval of the topic chosen by the Geological Sciences faculty.

Supervised research in geology or the other earth sciences. Field trips may be required.

GRADUATE LEVEL

500. Introductory Graduate Seminar (1)

Prerequisite: Graduate standing.

Introduction to graduate policies and faculty research in Geological Sciences. Abstracts on faculty presentation required of all students.

Course cannot be counted for program requirements for the M.S degree in Geology. Credit/No Credit grading only. May be repeated to a maximum of 3 units. (Seminar 1 hr.)

510./410. Biogeochemical Cycles (3)

Prerequisites: GEOL 102, 300I or 461; BIOL 200 or BIOL 211A,B or BIOL 211, 211L, 212, 212L, 213, and 213L; MATH 122; CHEM 111A, B; or GEOL 191. (Undergraduates enroll in GEOL 410; graduates enroll in GEOL 510.)

Study of carbon, nitrogen, phosphorus, iron, and sulfur cycles among the bio-, hydro-, and geospheres with an emphasis on transfer rates, mass balance, and residence times. Evaluation of processes and interactions among key ecosystems (wetlands, rivers, ocean, lakes, estuaries).

Letter grade only (A-F). (Lecture 3 hrs.)

524./424. Sedimentary Petrology (4)

Prerequisites: GEOL 322 and 443. (Undergraduates enroll in GEOL 424; graduates enroll in GEOL 524.)

Microscopic and macroscopic study of the origin and diagenesis of sedimentary rocks. Identification of grain types, textures,

structures, and cements emphasizing provenance, paleotectonics, paleoenvironmental reconstructions, and post-depositional alteration.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

530./430. Seminar in Structural Geology and Tectonics (3)

Prerequisite: GEOL 433. (Undergraduates enroll in GEOL 430; graduates enroll in GEOL 530.)

Review of analysis, interpretation and origin of geologic structures, mechanics of rock deformation and of large scale crustal deformation.

(Lecture 2 hrs., laboratory 3 hrs.; field trips.)

531./431. Tectonic Geomorphology (4)

Prerequisite: GEOL 433. (Undergraduates enroll in GEOL 431; graduates enroll in GEOL 531.)

Observation and analysis of Earth surface processes, and development of landforms and landscape. Interaction between surficial processes and tectonic, biologic, hydrologic, climatic, and atmospheric processes. Tectonic generated landforms, earthquake hazards evaluated, and geomorphic assessment. Assessing problems including landforms and environmental hazards.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs., field trips.)

537. California Geology (3)

Prerequisites: GEOL 433, 450.

Examination of recent theories concerning evolution of California's geological provinces; geological, geochemical, and geophysical evidence for these theories.

Letter grade only (A-F). (Lecture 3 hrs., field trips.)

544./444. Engineering Geology (4)

Prerequisites: GEOL 250, 273, 322; MATH 122, 123; CHEM 111A-B; PHYS 151, 152. (Undergraduates enroll in GEOL 444; graduates enroll in GEOL 544.)

In depth study of the fundamentals of engineering geology and related hazards. Evaluation of aggregate, cement and grouts. Soil and rock engineering characteristics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.; field trips.)

554./454. Environmental Geochemistry (3)

Prerequisites: CHEM 111B and consent of instructor.

Geochemical cycles. Human interference with cycles. Trace elements, health and agriculture. Clay mineral reactions. Groundwater chemistry. Reading and discussion of research articles; projects in environmental geochemistry.

Letter grade only (A-F). (Lecture 3 hrs., field trips)

565./465. Physical and Chemical Oceanography (3)

Prerequisites: CHEM 111B; PHYS 152 or 100B, and upper division standing in the College of Natural Sciences and Mathematics or Engineering. (Undergraduates enroll in GEOL 465; graduates enroll in GEOL 565.)

Physics and chemistry of the oceans, carbon cycle; minor and trace elements in sea water, nutrients, water masses and currents; physical concepts and interpretative theories related to ocean circulation.

(Lecture 3 hrs.)

570. Special Topics in Geology (3)

Prerequisite: Consent of instructor.

Investigation of selected topics in geology. May be repeated to a maximum of 9 units toward any single degree with different topics. Seminars with field trips as appropriate.

Letter grade only (A-F). (Seminar, 3 hrs.) May be repeated to a maximum of 9 units with different topics in different semesters.

571. Contaminant Hydrogeology (3)

Prerequisites: GEOL 102, 104, 477/577; CHEM 111B; PHYS 152; MATH 123.

Study and prediction of groundwater pollution transport, reaction, and remediation.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.)

574./474. Physical Hydrology (3)

Prerequisites: GEOL 102, MATH 122; PHYS 151. (Undergraduates enroll in GEOL 474; graduates enroll in GEOL 574.)

Quantitative study of the terrestrial water cycle; prediction and measurement of precipitation, surface water, soil water, and ground water.

Letter grade only (A-F). (Lecture 2 hrs, lab/field trips 3 hrs)

575. Advanced Topics in Sedimentology (3)

Prerequisite: Consent of instructor.

Investigation of topics in sedimentology such as depositional facies analysis, basin evolution, coastal processes, fluvial processes, advanced stratigraphic analysis, and tectonics and sedimentation.

Content varies from year to year. May be repeated to a maximum of 9 units toward any single degree with different topics in different semesters. Letter grade (A-F). Seminars with field trips as appropriate. (Seminar 3 hrs.)

577./477. Hydrogeology (4)

Prerequisites: GEOL 102, 104; CHEM 111B; PHYS 152; MATH 123. (Undergraduates enroll in GEOL 477; graduates enroll in GEOL 577.)

Groundwater flow, occurrence, development, chemistry, and contamination. Elementary groundwater flow theory. Well hydraulics.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

579. Applied Groundwater Monitoring (4)

Prerequisites: GEOL 102, 104, 477/577; PHYS 152; MATH 123. MATH 370A recommended.

Numerical modeling of groundwater flow and mass transport. Emphasis is on creation of numerical models from conceptual models of geology derived from geologic mapping and sampling.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 3 hrs.)

586./486. Engineering Geophysics (3)

Prerequisite/Corequisite: GEOL 460. (Undergraduates enroll in GEOL 486; graduates enroll in GEOL 586.)

Applying geophysical techniques to geology and hydrogeology problems. Geophysical techniques, and identification and utilization of specialized techniques. Case histories in site evaluations, subsiding areas, basement topography mapping, seawater problems, water table mapping, groundwater contamination, and subsurface cavities detection.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 3 hrs.; field trips.) Course fee may be required.

695. Directed Reading (1-3)

Survey of information in published or unpublished geological literature or databases on a designated topic, under the direction of a faculty member. Written reports prepared from these readings.

May be repeated to a maximum of 4 units toward any single degree with different topics in different semesters. Limited to 3 units per semester. Letter grade only (A-F).

697. Directed Research (1-3)

Prerequisite: Consent of instructor.

Research on a specific subject in geology. Topic for study to be approved and directed by a faculty member in geological sciences.

Letter grade only (A-F).

698. Thesis (1-6)

Prerequisites: Advanced to candidacy for M.S. in Geology, consent of Graduate Committee and graduate advisor.

Either laboratory or field investigations, or both, for a total of six semester units to culminate in an approved thesis.

Letter grade only (A-F).