Earth Sciences

OFFICE: Galbraith Hall, room 188,
Revelle College

Professors

Jeffrey L. Bada, *Marine Chemistry*
Wolfgang H. Berger, *Oceanography*
Catherine G. Constable, *Geophysics*
James W. Hawkins, *Geology*
Myrl C. Hendershott, *Oceanography*
Nicholas D. Holland, *Marine Biology*
Jeremy B. Jackson, *Paleontology*
Miriam Kastner, *Earth Sciences*
Devendra Lal, *Nuclear Geophysics*
J. Douglas Macdougall, *Earth Sciences*
T. Guy Masters, *Geophysics (Program Director)*
Jean-Bernard H. Minster, *Geophysics*
David T. Sandwell, *Marine Geophysics*
John G. Sclater, *Marine Geophysics*
Richard C.J. Somerville, *Meteorology*
Lisa Tauxe, *Geophysics*
Mark Thiemens, *Chemistry*
Martin Wahlen, *Geochemistry*
Edward L. Winterer, *Geology (Emeritus)*

Professor-in-Residence

Steven C. Constable, *Geophysics*

Associate Professors

Kevin M. Brown, *Geology*
Paterno R. Castillo, *Geology*
Christopher D. Charles, *Oceanography*
Jeffrey P. Severinghaus, *Geoscience*

Assistant Professor

David R. Hilton, *Geochemistry*

Research Scientist/Senior Lecturer

Alistair J. Harding, *Research Geophysics*

Associate Research Scientist/Lecturer

Jeffrey S. Gee, *Geophysics*

The *UCSD Interdisciplinary Earth Sciences Undergraduate Program* offers an earth sciences major leading to a B.S. degree, with emphasis on the quantitative aspects of the field. As a guiding concept, the focus of the earth sciences curriculum is the physical and chemical evolution of the earth system and the energetics and dynamics of this evolution. The program takes advantage of the unique opportunities offered by UCSD, in particular through the Scripps Institution of Oceano-graphy and the California Space Institute. The major can be complemented by various minors ranging from mathematics, physics or chemistry, to biology, environmental science, or public policy, and political science. Chemistry and physics majors may also specialize in earth sciences by taking a series of courses offered through this program (see the "Chemistry" and "Physics" sections of the catalog for details). In addition, the program offers a broad choice of courses, including general-education courses in the earth sciences and related topics from which to select a minor in the earth sciences.

The Undergraduate Earth Science Program was initiated in the fall of 1992 and is intended to be a transition program to a proposed Department of Earth Sciences, to be implemented at UCSD at a future time. Most earth science faculty are members of the Scripps Institution of Oceanography, and students, especially earth science majors, are encouraged to consult with these instructors about incorporating appropriate Scripps Institution of Oceanography courses into their programs.

Majors in Earth Sciences

Three tracks with slightly different course requirements are presently offered through the UCSD Interdisciplinary Earth Sciences Undergraduate Program. These are the General ERTH major, and the *ERTH/Chemistry* and *ERTH/Physics* majors.

Lower-division requirements are the same for all majors and are designed to provide the foundations in mathematics, physics, chemistry, and biology that are essential in modern quantitative earth sciences disciplines. In addition, two upper-division courses introducing the basic concepts of geology and geochemistry, ERTH 101 and ERTH 102, should be taken during the sophomore year to provide the appropriate background for other upper-division courses.

A grade-point average of 2.0 or higher in the upper-division major program is required for graduation. Students must receive a grade of C– or better in any course to be counted toward fulfillment of the major requirements. In exceptional cases, students with a grade-point average in the major of 2.5 or greater may petition to have one grade of D accepted. All courses (lower- and upper-division) required for the major must be taken for a letter grade.

Special Studies Courses

Special studies in the earth sciences are offered as the courses ERTH 198 and ERTH 199. These courses are subject to consent of the instructor and approval by the Earth Sciences faculty adviser. They are open to students who have accrued at least ninety quarter-units and have a GPA of at least 3.0. No more than two quarters of earth sciences special studies may be counted toward any earth sciences major.

Lower-Division Requirements (common for all earth science majors)

The following courses must be taken for a letter grade:

1. Mathematics 20A, 20B, 21C, 21D or equivalent
2. Physics 2A, 2B, 2C
3. Chemistry 6A, 6B, 6C, 6BL
4. Biology 3 (BILD 3)

Note: Physics 2CL is a required prerequisite for various upper-division chemistry electives.

5. Earth Sciences courses which should be taken in the sophomore year:

   ERTH 101. Introduction to Earth and Environmental Science
   ERTH 102. Introduction to Geochemistry

   A possible schedule yields:

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Chem. 6BL	Math. 21C
	Math. 20B	
SOPHOMORE YEAR		
Phys. 2A	Phys. 2B	Phys. 2C
Math. 21D	ERTH 102	BILD 3
ERTH 101		

ERTH/Chemistry Major

This specialization focuses on the Earth as a chemical system, and on its evolution. Emphasis is placed on the fundamental observations that allow geoscientists to understand better the past history of the planet, the energetics of its evolution, and the major "cycles" (e.g., water, carbon)

that characterize and control planetary-scale changes on a broad range of time scales. The major is appropriate for students interested in modern geochemistry, in "global change" studies, and in global and local environmental problems, including biochemical and anthropogenic effects.

Upper-Division Requirements

In addition to ERTH 101 and ERTH 102 (see lower-division requirements), the following courses must be taken for a letter grade:

1. Earth Sciences requirements:

   ERTH 103. Introduction to Geophysics
   ERTH 120. Mineralogy
   ERTH 162A. Introduction to Field Geology
   ERTH 162L. Structural Analysis for Field Geology

2. Chemistry requirements:

   Chemistry 120A. Inorganic Chemistry
   Chemistry 131. Physical Chemistry or
   Chemistry 127
   Chemistry 140A. Organic Chemistry

3. Chemistry restricted electives. (Total of sixteen units required), at least eight units from:

   Chemistry 140B-C. Organic Chemistry
   Chemistry 143A-B. Organic Chemistry Lab
   Chemistry 132-133. Physical Chemistry
   *Chemistry 105A-B. Physical Chemistry Lab
   Chemistry 106. Instrumental Analysis Lab

   up to eight units from:
   Chemistry 120B-C. Inorganic Chemistry
   Chemistry 122. Biochemical Evolution
   Chemistry 149A-B. Environmental
   Geochemistry
   Chemistry 170. Cosmochemistry
   Chemistry 171. Nuclear Chemistry
   Chemistry 173. Atmospheric Chemistry

4. Earth Sciences restricted electives: at least sixteen units selected from among the following courses must be passed with a 2.0 grade-point average and grades of C– or better:

   ERTH 104. Geobiology
   ERTH 130. Geodynamics of Terrestrial Planets
   ERTH 142. Atmospheric Chemistry
   ERTH 143. Marine Paleoecology
   ERTH 144. Isotope Geochemistry
   ERTH 152. Petrology and Petrography
   ERTH 155. Igneous and Metamorphic Processes
   ERTH 160. Introduction to Tectonics
   SIO 226. Introduction to Marine Geophysics
   SIO 240. Marine Geology
   SIO 247. Rock Magnetism and
   Paleomagnetism
   SIO 260. Marine Chemistry

Students may wish to incorporate a small portion of the major program into their lower-division course load, for example, Chemistry 120A, Chemistry 140A.

* Requires prerequisite other than earth science requirements.

A possible schedule yields:

FALL	WINTER	SPRING
JUNIOR YEAR		
Chem. 140A	Chem. Elect.	ERTH 103
Chem. 120A	Chem. Elect.	ERTH Elect.
ERTH Elect.	ERTH 120	—
SENIOR YEAR		
Chem. Elect.	Chem. Elect.	ERTH Elect.
ERTH Elect.	ERTH 162A	Chem. Elect.
Chem. 131	ERTH 162L	—

ERTH/Physics Major

This specialization focuses on the mechanical, dynamical, and thermodynamical aspects of the Earth. Emphasis is placed on a solid background of fundamental physics, from mechanics and electromagnetism to continuum- and quantum mechanics, and on the necessary mathematical skills. The major introduces basic techniques used to investigate the internal structure of the Earth, from seismology to the study of potential fields, and space geodesy. Elementary geodynamics, including the physics of simple convective systems, introductory rock mechanics, and plate kinematics are among topics introduced. At the same time, a "hands on" exposure to field problems and techniques will be accessible through a Natural Resources and Field Geophysics sequence.

Upper-Division Requirements

In addition to ERTH 101 and ERTH 102 (see lower-division requirement), the following courses must be taken for a letter grade:

1. Earth Sciences requirements:

   ERTH 103. Introduction to Geophysics

2. Physics requirements:

   Physics 100A-B-C. Electromagnetism
   Physics 110A-B. Mechanics

3. Physics restricted electives: minimum of four units selected from:

   Physics 121. Experimental Techniques
   Physics 140A-B. Statistical and Thermal Physics
   Physics 105. Computational Physics
   MAE 131A. Solid Mechanics I
   MAE 180A. Space Science and Engineering

4. Mathematics restricted electives: minimum of eight units selected from:
   Mathematics 110. Partial Differential
   Equations or equivalent
   Mathematics 102. Linear Algebra or equivalent
   Mathematics 120A-B. Complex Analysis or
   equivalent
   Mathematics 183. Statistical Methods or
   equivalent

5. Earth Sciences restricted electives: at least sixteen units selected from among the following courses must be passed with a 2.0 grade-point average and grades of C– or better:

   ERTH 104. Geobiology
   ERTH 120. Mineralogy
   ERTH 130. Geodynamics of Terrestrial Planets
   ERTH 143. Marine Paleoecology
   ERTH 155. Igneous and Metamorphic Processes
   ERTH 160. Introduction to Tectonics
   ERTH 162A. Introduction to Field Geology
   ERTH 162L. Structural Analysis for Field
   Geology
   ERTH 180. Geophysics of Natural Resources
   ERTH 182. Field Geophysics
   SIO 223. Geophysical Data Analysis
   SIO 224. Physics of the Earth Interior
   SIO 226. Introduction to Marine Geophysics
   SIO 227. Advanced Seismology
   SIO 247. Rock Magnetism & Paleomagnetism

Students may wish to incorporate a small portion of the major program into their lower-division course load, for example, Physics 105, Mathematics 110, or equivalent. Students intending to do graduate work in geophysics are encouraged to take the Physics 4 sequence rather than the Physics 2 sequence. Students are also strongly encouraged to participate in a field geology course.

An example schedule is outlined below.

FALL	WINTER	SPRING
JUNIOR YEAR		
Phys. 100A	Phys. 100B	Phys. 100C
Phys. 110A	Phys. 110B	Math. Elect.
—	—	ERTH 103
SENIOR YEAR		
—	Phys. Elect.	ERTH Elect.
Math. Elect.	—	—
ERTH Elect.	ERTH Elect.	ERTH Elect.

ERTH/General

The general ERTH major is designed to allow students maximum flexibility in tailoring the curriculum to their interests, within the constraints of obtaining the necessary background in physical, biological, and earth sciences. Compared to the ERTH/Chemistry and ERTH/Physics tracks, it requires more earth science and fewer non-earth science courses.

Upper-Division Requirements

In addition to ERTH 101 and ERTH 102 (see lower-division requirements), the following courses must be taken for a letter grade:

1. Earth Sciences requirements:

   ERTH 103. Introduction to Geophysics
   ERTH 104. Geobiology
   ERTH 120. Mineralogy
   ERTH 152. Petrology and Petrography
   ERTH 160. Introduction to Tectonics
   ERTH 162A. Introduction to Field Geology
   ERTH 162L. Structural Analysis for Field Geology
   ERTH 180. Geophysics of Natural Resources
   ERTH 182. Field Geophysics

2. Chemistry requirements:

   Chemistry 131. Physical Chemistry or Chemistry 127

3. Upper-division restricted electives: at least eight units from earth sciences and at least twelve units from non-earth science courses.

   ERTH 130. Geodynamics of Terrestrial Planets
   ERTH 142. Atmospheric Chemistry
   ERTH 144. Isotope Geochemistry
   ERTH 150. Environmental Perils
   ERTH 155. Igneous and Metamorphic Processes

   SIO 223. Geophysical Data Analysis
   SIO 224. Physics of the Earth Interior
   SIO 226. Introduction to Marine Geophysics
   SIO 227A. Advanced Seismology
   SIO 234. Introduction to Geodynamics
   SIO 240. Marine Geology
   SIO 242. Controversies in Geomorphology
   SIO 245A. Interpretation of the Sedimentary Record
   SIO 247. Rock Magnetism & Paleomagnetism
   SIO 249. Hydrogeological Modeling
   SIO 253. Igneous and Metamorphic Petrology
   SIO 260. Marine Chemistry

   MAE 131A. Solid Mechanics
   MAE 180A. Space Science and Engineering

   BIBC 100. Structural Biochemistry
   BIEB 120. General Ecology
   BIBC 130. Marine Biochemistry
   BIEB 130. Introductory Marine Ecology
   BIEB 150. Introductory Marine Ecology Evolution

   Chemistry 105A-B. Physical Chemistry Lab
   Chemistry 120A-B-C. Inorganic Chemistry
   Chemistry 122. Biochemical Evolution
   Chemistry 132-133. Physical Chemistry
   Chemistry 140A-B-C. Organic Chemistry
   Chemistry 143A-B. Organic Chemistry Lab
   Chemistry 149A-B. Environmental Geochemistry
   Chemistry 170. Cosmochemistry
   Chemistry 171. Nuclear and Radiochemistry
   Chemistry 173. Atmospheric Chemistry

   Mathematics 102. Linear Algebra
   Mathematics 110. Partial Differential Equations or equivalent
   Mathematics 120A-B. Complex Analysis
   Mathematics 183. Statistical Methods

   Physics 100A-B-C. Electromagnetism
   Physics 105. Computational Physics
   Physics 110A-B. Mechanics
   Physics 121. Experimental Techniques
   Physics 140A-B. Statistical and Thermal Physics

   A possible schedule yields :

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Chem. 6BL	Math. 21C
	Math. 20B	
SOPHOMORE YEAR		
Phys. 2A	Phys. 2B	Phys. 2C
Math. 21D	ERTH 102	BILD 3
ERTH 101		
JUNIOR YEAR		
Chem. 131	ERTH 120	ERTH 103
ERTH 104	Elect.	ERTH 152
ERTH 160	Elect.	
SENIOR YEAR		
Elect.	ERTH 162A	ERTH 180
Elect.	ERTH 162L	ERTH 182
Elect.		

Earth Sciences Minor

A minor in earth sciences consists of twenty-eight units of earth science courses, at least twenty of which must be upper-division, focused on geology, geochemistry, or geophysics. Courses required by a student's major may not be applied toward a minor and neither can ERTH 198 nor ERTH 199. Courses for the minor may be taken on a Pass/Not Pass basis if the student's college permits.

Honors Program

The Earth Sciences Program offers an Honors Program for a limited number of students who have demonstrated excellence in the major. Students are eligible for admission to the program when they have:

1. Completed ninety units of courses including twelve units of earth science courses.
2. Achieved a GPA of 3.3 overall and 3.5 in earth science courses.
3. Submitted to the Earth Science Steering Committee, and had approved, an honors thesis research proposal.

Successful completion of the Honors Program requires:

1. Maintenance of a GPA of 3.3 overall and 3.5 in earth science courses.
2. Completion, with a B grade or higher, of a minimum of eight units of ERTH 196 related to the honors thesis research, distributed over at least two quarters. These units must be in addition to the ordinary major requirements. However, students who subsequently fail to complete the Honors Program may apply up to four of these 196 units to their major.
3. Acceptance of a written honors thesis report by a committee of not fewer than three faculty members.
4. Satisfactory presentation of an oral report on the thesis research, preferably at a public undergraduate research conference on campus, or at an earth science conference. Alternatively, the oral report may be given at a seminar involving honors students and at least three faculty members.

Students who successfully complete the Honors Program will graduate with "high distinction."

Students who are interested in the Honors Program should contact the undergraduate coordinator in Galbraith Hall, room 188, Revelle College.

Study Abroad

Study abroad through the **Education Abroad Program** or **Opportunities Abroad Program** can enhance a student's major, particularly as an opportunity for diverse field experiences. However, careful planning is important to meet all major requirements. Please contact the Earth Sciences Office as early as possible if you are planning to study abroad.

Careers in Education

Students interested in a teaching career should be aware that the earth sciences major, because of its broad course requirements in the sciences, fulfills many of the subject requirements for obtaining a California Teaching Credential through UCSD's Teacher Education Program (TEP). The projected high demand over the next decade for well-trained teachers, particularly in the sciences, makes this an attractive option for many students. Students who wish to take advantage of this opportunity may wish to complete a minor in education. Please contact the TEP office directly for further details.

Contiguous Bachelor's/ Master's Degree Program

The integrated program leading to a bachelor of science and a master of science degree in Earth Sciences is offered to undergraduate students who are enrolled in the Earth Sciences major, and to qualified students who are completing a specialization or minor in Earth Sciences. It is open only to UCSD undergraduates, and entails participation in research in an area of the earth sciences to be determined jointly by the student and a committee of faculty members from the Earth Sciences Program. Applications will only be accepted during the final quarter of the applicant's junior year, or the first or second quarter of the senior year. A minimum undergraduate GPA of 3.0 overall and 3.3 in upper-division Earth Sciences courses is required for admission. Applications must include a written statement of purpose, a summary of the research proposal, and a letter of support from the potential M.S. thesis adviser. Students must complete requirements for the B.S. degree before they are enrolled in the M.S. program, and are expected to meet the requirements for the M.S. degree within three consecutive academic quarters after obtaining the B.S. Students may be dropped from the program if breaks in enrollment occur. The Earth Sciences Program does not have financial aid available for students enrolled in the program. Please contact the Earth Sciences Office in Galbraith Hall, room 188, Revelle College for information.

Earth Sciences Graduate Program

Other graduate degrees in the earth sciences are offered through the graduate department of the Scripps Institution of Oceanography. See listings under "Scripps Institution of Oceanography" for detailed information.

COURSES

NOTE: The program will endeavor to offer the courses outlined below. However, unforeseen circumstances (particularly changes in ship schedules) sometimes mandate a change of scheduled offerings, especially the quarter offered (F,W,S). Students are strongly advised to check the Schedule of Classes or to contact the Earth Sciences Program Office (Galbraith Hall, room 188, Revelle College, (858) 534-8157) to obtain up-to-date information.

LOWER-DIVISION

ERTH 10. The Earth (4)
A basic introduction to geology for students with little previous science background. The course stresses understanding of the concepts of the structure of the Earth and the processes which have formed it and continue to modify it. The course emphasizes material which every educated citizen should know for appreciation and enjoyment of the world around us, for understanding geological events as reported in the news, and for participating in making intelligent decisions regarding the future of our environment. Three-hour lecture plus optional local field trips. (W)

ERTH 12. History of the Earth and Evolution (4)
Evolution of the Earth from its origin in the early solar system to formation of continents and ocean basins, and how the planet became habitable. It examines the geologic record of evolution, extinction, plate tectonics, and climate changes through time. Three-hour lecture. *Prerequisite: none*. (S)

ERTH 20. The Atmosphere (4)
Descriptive introduction to meteorology and climate studies. Topics include global and continental wind and precipitation patterns, weather forecasting, present climate and past climate changes (including droughts, El Ni–o events), man-made modification of climate, including CO_2 and other "greenhouse" gases effects, ozone destruction, "little ice ages," acid rain. Three-hour lecture. *Prerequisites: some high school physics and chemistry background recommended.* (W)

ERTH 30. The Oceans (4)
Presents modern ideas and descriptions of the physical, chemical, biological, and geological aspects of oceanography, and considers the interactions between these aspects. Intended for students interested in the oceans, but who do not necessarily intend to become professional scientists. Three-hour lecture, one-hour discussion. *Prerequisite: some background in high school chemistry recommended.* (F)

ERTH 40. Earth Sciences and the Environment (4)
A survey of Earth and environmental sciences as they deal with human impact on the global environment and the availability of resources. Topics chosen may vary somewhat from year to year, but focus on the evidence for, and the dynamics of, global change from human activity. Resource limitations, climate modification, water cycle, ecological principles, and basic political and economic factors are discussed in the framework of global habitat modification, including large-scale extinction.

ERTH 96. Frontiers in the Earth Sciences (2)
An introduction to current research in the earth sciences. Background in science not required, but may be useful for some topics. Areas covered vary from year to year. (S)

UPPER-DIVISION

ERTH 101. Introduction to Earth and Environmental Science (5)
This course is an introduction to how our planet works, focusing on the formation and evolution of the solid earth, and the processes affecting both its surface and interior. Laboratories and field trips complement and extend the lecture material. *Prerequisites: one year each of college-level math, physics, and chemistry, or consent of instructor.* (F)

ERTH 102. Introduction to Geochemistry (4)
A broad introduction to the chemical composition and evolution of the Earth and the solar system. This course explores applications of chemical methods to elucidate the origin and geologic history of the Earth and the planets, the evolution of the oceans and atmosphere, and the impact of humankind on the environment. *Prerequisites: ERTH 101, Chemistry 6A-B-C or equivalent, first-year, mathematics, and physics, or consent of instructor.* (W)

ERTH 103. Introduction to Geophysics (4)
An introduction to the structure and composition of the solid earth. Topics include seismology, the gravity and magnetic fields, high-pressure geophysics, and concepts in geodynamics. Emphasis is on global geophysics, i.e., on the structure and evolution of the planet. *Prerequisites: Math. 20A-B, 21C-D and Physics 2 sequence or equivalent, ERTH 101, or consent of instructor. ERTH 160 recommended.* (S)

ERTH 104. Geobiology (5)
Introduction to the major biological transitions in earth history from the origins of metabolism and cells to the evolution of complex societies. The nature and limitations of the fossil record, patterns of adaptation and diversity, and the tempo and mode of biological and environmental change. Laboratories and field trips complement and extend the lecture material.

Prerequisites: ERTH 101, BILD 3 or equivalent, or consent of instructor. (F)

ERTH 120. Introduction to Mineralogy (4)
This course focuses on the symmetry, crystal structure, chemical, and physical properties of minerals with special emphasis on the common rock-forming minerals, and highlights the applications of mineralogical and X-ray crystallographic techniques to a spectrum of important problems in the earth sciences. The laboratory will introduce the students to the polarizing microscope and X-ray powder diffraction methods for the study of rock-forming minerals. *Prerequisites: ERTH 101, ERTH 102 (may be taken concurrently with ERTH 102).* (W)

ERTH 130. Geodynamics of Terrestrial Planets (4)
Planetary differentiation through geodynamical processes is the fundamental agent controlling the evolution of the planet on geological time scales. Similarities and differences between the Earth, Venus, Mars, and other terrestrial planets and satellites teach us about the processes which shape a planet's formation and evolution. The course includes a computer-oriented lab. *Prerequisites: Math. 20A-B, 21C-D and Physics 2 sequence, or consent of instructors.* Offered in alternate years (offered fall 2001). (F)

ERTH 142. Atmospheric Chemistry and the Biochemical Cycles of Atmospheric Trace Gases (4)
Evolution of the Earth's atmosphere, from the earliest days of the planet to the present, and into the future. The atmospheres of other terrestrial planets are discussed to provide a planetary perspective. Discussions will include effects of "greenhouse" gases such as H_2O, CO_2, and CH_4 in climate modification, and other influences of civilization's byproducts on atmospheric chemistry, e.g., the destruction of the ozone layer. The biogeochemical cycles of the radioactively important trace gases will be examined. *Prerequisites: Chemistry 6 sequence or equivalent*. Offered in alternate years (offered spring 2002). SIO staff. (S)

ERTH 143. Marine Paleoecology (4)
Paleoecology of marine plankton, nekton, and benthos. Patterns and changes in marine communities and ecosystems over geological time in relation to changes in the physical, chemical, and geological environment and biotic interactions. The preservation filter and inference of ecological processes from fossils and biogeochemical proxies. Biotic interchanges, incumbency, escalation and trends, mass extinctions, and recovery. Lectures, seminar discussion, laboratory, and field trips. *Prerequisites: Bachelor's degree in science or consent of instructor; open to undergraduates with completion of ERTH 104 and either BIEB 130 or BIEB 140 or equivalent.* (W)

ERTH 144. Isotope Geochemistry (4)
Isotopic ratios of various elements serve as natural tracers, as chronometers, and as geothermometers. Thus isotope measurements have become an indispensable tool for earth scientists. This course introduces students to the theory of radioactivity, geochronology, and stable isotope fractionation and shows how these principles are used to investigate important geochemical problems. *Prerequisites: ERTH 101, ERTH 102, ERTH 120.* Offered in alternate years (offered spring 2003). (S)

ERTH 150. Environmental Perils (4)
An advanced field-oriented course for engineering and science students stressing the geologic basis for environmental perils such as earthquakes, erosion flooding, and waste disposal. Two one-hour lectures and a two-hour lab/field trip each week. One Saturday field trip. *Prerequisites: Math 20A-B, 21C-D, sequence and Physics 2A-B-C sequence or equivalent.* (S)

ERTH 152. Petrology and Petrography (4)
Mineralogic, chemical, textural, and structural properties of igneous, metamorphic, and sedimentary rocks; their origin and relations to evolution of the Earth's crust and mantle. Includes rocks of both the continents and ocean basins. The laboratory emphasizes both hand specimens and microscopic studies of rocks in thin sections. *Prerequisites: ERTH 101, ERTH 102, and ERTH 120 or their equivalents.* (S)

ERTH 155. Igneous and Metamorphic Processes (4)
This course provides an overview of the Earth from a geochemical and petrogenetic point of view. Topics include the formation and chemical differentiation of material in the solar system, the formation and differentiation of the Earth into core, mantle, crust and atmosphere/hydrosphere, the generation of magma in a variety of plate tectonic settings, and isotope and trace element geochemistry of igneous and metamorphic rocks. Literature readings will be assigned for most topics and discussion is expected of everyone. *Prerequisite: ERTH 152, or consent of instructors.* (F)

ERTH 160. Introduction to Tectonics (4)
The theory of plate tectonics attempts to explain how forces within the earth give rise to continents, ocean basins, mountain ranges, earthquake belts and most volcanoes. In this course we will learn how plate tectonics works. *Prerequisites: ERTH 101 or consent of instructor.* (F)

ERTH 162A. Introduction to Field Geology (4)
Mapping and interpretation of geologic units and structures in the field. Field observations at the surface are related to theory and extrapolated to three dimensions. Field work is done on weekends in local areas; field data are discussed and evaluated through applicable geologic principles in the laboratory. *Prerequisites: ERTH 101, ERTH 120 or consent of instructor. To be taken concurrently with ERTH 162L.* (W)

ERTH 162L. Structural Analysis for Field Geology (4)
Principles of stratigraphy and structural geology applicable to field geologic studies. Discussion and laboratory exercises. *Prerequisites: ERTH 101, ERTH 120, or consent of instructor. To be taken concurrently with ERTH 162A.* (W)

ERTH 180. Geophysics of Natural Resources (4)
Introduction to seismic, gravity, magnetic, and electrical methods used in exploration geophysics on scales of hundreds of kilometers to tens of meters. These are the principal means of discovering energy and mineral resources such as oil, gas, and ore deposits. Emphasis is on the underlying physical principles of the methods, instrumentation, and data interpretation, including an introduction to geophysical inverse theory. *Prerequisites: Math. 20A-B, 21C-D and Physics 2 sequence or equivalent, or consent of instructor. ERTH 182 must be taken concurrently.* (S)

ERTH 182. Field Geophysics (4)
Introduction to design and execution of simple geophysical field experiments, including seismic, gravimetric, geoelectrical, and geodetic techniques. The focus is on a simple geological problem that can be solved by geophysical experiments. Computer-aided data analysis and interpretation. *Prerequisites: ERTH 180 (must be taken concurrently) or consent of instructor.* (S)

ERTH 190. Special Topics in Earth Sciences (2-4)
A seminar course designed to treat emerging or topical subjects in the earth sciences. Involved reading from the literature and student participation in discussion. Topics vary from year to year.

ERTH 194. Research Seminar in Washington, D.C. (4)
Course attached to six-unit internship taken by students participating in the UCDC program. Involves weekly seminar meetings with faculty and teaching assistant and substantial research paper. *Prerequisites: departmental approval. Participating in UCDC Program.*

ERTH 196. Honors Thesis Research (4)
Independent reading or research on a problem. By special arrangement with a faculty member. (Letter grade only.)

ERTH 198. Directed Group Study (2–4)
This course covers a variety of directed group studies in areas not covered by formal ERTH courses (P/NP grades only.) *Prerequisite: consent of instructor.*

ERTH 199. Independent Study for Undergraduates (4)
Independent reading or research on a problem. By special arrangement with a faculty member. (P/NP grades only.)

ERTH 211. Research Seminar (2)
A three quarter required sequence for BS/MS Earth Sciences students to prepare students for thesis writing. (F,W,S)