Earth and Planetary Science

College of Letters and Science (http://ls.berkeley.edu)

Department Office: 307 McCone Hall #4767, (510) 642-3993

Chair: Bruce Buffett, PhD

Department Website: Earth and Planetary Science (http://eps.berkeley.edu)

Overview

The Department of Earth and Planetary Science (formerly Geology and Geophysics) offers a program of instruction that focuses on the origin, evolution, structure and dynamics of the Earth and other planetary bodies. This is an emerging discipline built from such fields as geology, geophysics, geochemistry, oceanography, and the atmospheric, environmental and planetary sciences. We offer classes that provide core training in specialized topics, as well as integrative courses that provide a broad overview. Beginning with an introduction to planet Earth, the undergraduate major has six specializations giving students many options for courses. Extensive opportunities are provided for field work, laboratory analysis and theoretical investigations. Our upper division and graduate courses are relatively small in size, allowing close interactions between students and faculty. Our undergraduate program provides strong technical training for those who wish to pursue professional careers in the Earth, environmental and planetary sciences, but it also provides training in critical thinking and communication that serves well those who choose other paths, such teaching, law, resource management and other sciences. The graduate program is driven largely by collaborations in research with faculty who are leaders in their field.

Major

The Department of Earth and Planetary Science offers six specializations —Atmospheric Science, Environmental Earth Science, Geology, Geophysics, Marine Science, and Planetary Science—which lead to a Bachelors degree. Students in the earlier majors should consult with the department about their program. Lower division prerequisite courses must be taken on a letter-graded basis (except when a course is offered only on a P/NP basis) and must be completed with a grade of C- or higher in each course. The department will allow one D grade in a lower division class as long as the student maintains at least a C average in the major.

Atmospheric Science

This course of study explores the fundamental natural processes controlling atmospheric composition, circulation dynamics, and climate. Understanding how these processes have changed in the past and may change in the future are among the greatest intellectual and technological challenges of our time. Topics covered will include the physics of climate variability and climate change, changes in stratospheric ozone, coupling of atmospheric chemistry and climate, changes in the oxidation capacity of the troposphere, smog, and the impacts of atmosphere-biosphere exchange on atmospheric composition.

Degree Requirements

- **Lower Division**: Math 1A-1B-53-54, Physics 7A-7B-7C, Chem 1A, EPS 50
- **Upper Division**: EPS 102, 150, C180, 181, 182 plus 9 additional upper division units (see department for a list of electives)

Environmental Earth Science

The Environmental Earth Science major is designed to provide students with a broad background in the earth sciences with an emphasis on environmental sciences. Interrelationships between physical, biological, and chemical processes at the Earth's surface will be emphasized. The major focuses more broadly on the natural sciences by using earth science mainly as a base for expanding outward depending upon students' interests by incorporating courses in biology, hydrology, hazardous waste management, ecology and natural resources. The program is designed to provide background for graduate study in environmental science, preparation for work within governmental agencies such as the Environmental Protection Agency, Bureau of Land Management, United States Geological Survey or consulting firms, or broader involvement in land use planning, business, policy, law or management.

Degree Requirements

- **Lower Division**: Math 1A-1B (or 16A-16B), Physics 7A-7B (or 8A-8B), Chem 1A, Biology 1B, EPS 50
- **Upper Division**: EPS 102, 117, 150, ERG 102 plus 12 additional upper division units (see department for a list of electives)

Geology

Geology is the science of the Earth—of its minerals and processes, of its origin and evolution. It is a broad science concerned with a vast range of physical phenomena in both space and time, and requires a broad scientific background. Trained geologists can address a wide range of concerns, including energy supply, mineral resources, and environmental protection. This major provides strong background in the processes shaping the Earth; it emphasizes quantitative understanding and a strong foundation in the physical sciences.

Degree Requirements

- **Lower Division**: Math 1A-1B, Physics 7A-7B, Chem 1A, EPS 50
- **Upper Division**: EPS 100A, 100B, 101, 102, 118, 150 plus 10 additional upper division units (see department for a list of electives)

Geophysics

The Geophysics major is designed to provide students with theoretical, field and laboratory experience in studying geodynamic processes and the structure of the Earth and other planets. It is designed for students with good physics and mathematics ability. It provides a solid background in physical science and mathematics with an emphasis on the physics of the Earth.

Degree Requirements

- **Lower Division**: Math 1A-1B-53-54, Physics 7A-7B-7C, Chem 1A, EPS 50
- **Upper Division**: EPS 102, 104 or Math 121A, 130, 150 plus 11 additional upper division units (see department for a list of electives)

Marine Science

The ocean plays a central role in physical, biological, chemical, and geological processes on Earth. The field of marine science thus requires an understanding of the interactions between the biosphere, hydrosphere, lithosphere, and atmosphere. Some examples of the current research

directions of societal concern in the marine sciences include: the role of the ocean in climate change; the ocean's role in climate phenomena such as El Niño and La Niña, and their effect on modern marine ecosystems; the history of El Niño and other climatic/oceanographic events recorded in marine sediments and corals; coastal pollution and its affect of coastal marine ecosystems; coastal erosion (natural and human-caused).

Degree Requirements

- **Lower Division**: Math 1A-1B (or 16A-16B), Physics 7A-7B (or 8A-8B), Chem 1A, Biology 1B, EPS 50, C82
- **Upper Division**: EPS 102, 150 and four courses from the following: EPS 100A, 100B, 103/203, 109, 115, C146, IB 106, IB 106A plus 8 additional upper division units (see department for a list of electives)

Planetary Science

Planetary science encompasses the study of the physical and chemical nature of planetary bodies, both in the Solar System and in extrasolar systems. The formation of planets, the forces that sculpted their orbits, the processes that shaped their interiors, surfaces, and atmospheres and the development of life all fall under its rubric. Understanding these complex phenomena requires knowledge of astronomy and astrophysics, earth science, meteorology, atmospheric science, space science, plasma physics, chemistry, and biology. The Planetary Science major has been developed to study the remarkable interface among these disciplines.

Degree Requirements

- **Lower Division**: Math 1A-1B-53-54, Physics 7A-7B-7C, Chem 1A, EPS 50
- **Upper Division**: EPS 102, 150, C162 plus 14 additional upper division units (see department for a list of electives).

Honors Program

Students in the honors program must fulfill the following additional requirements: (1) maintain a GPA of at least 3.3 in all courses in the major, and an overall GPA of at least 3.3 in the University; and (2) carry out an individual research or study project, involving at least three units of H195. The project is chosen in consultation with a departmental adviser, and written report is judged by the student's research supervisor and a departmental adviser. Application for the Honors Program should be made through the student's adviser no later than the end of the student's junior year.

Minor Requirements

Lower Division

Earth and Planetary Science 50 or equivalent

Upper Division

Five upper division courses chosen from the major list and approved by the major adviser. In consultation and with prior approval of the major adviser, students will have the opportunity to choose a coherent program which parallels the department's major specializations or a combined earth and planetary emphasis. Course selections will be guided by the same parameters as those in each of the majors. At least three of the five upper division courses must be completed at Berkeley. No more than one of the five required courses for your minor may be included in your major program. All courses must be taken for a letter grade and a minimum 2.0 GPA is required in the upper division courses applied to the minor. Students interested in the minor should contact the Student Affairs Officer in 305 McCone Hall.

Graduate Programs

The department offers PhD degrees in Earth and Planetary Science. The central objective of the graduate program is to encourage creative thinking and develop the capacity for independent and original research. A strong undergraduate background in the sciences other than geology is especially helpful, and a significant number of our graduate students have their training in physics, chemistry, mathematics, engineering or astronomy. Graduate students are formally accepted into the Earth and Planetary Science program, and they normally work directly toward a PhD. A master's degree is not a prerequisite for a PhD.

Master's Degree

Admission to the Master of Arts degree is available only to graduates of our bachelor's degree program in Earth and Planetary Science. We do not accept applications from other majors or universities. Requirements for the degree consist of 24 semester units of upper division and graduate courses (at least 12 must be graduate, non-research units), followed by a comprehensive oral examination.

PhD Degree

Candidates for the PhD degree must pass the oral qualifying examination by the end of the second year and complete a thesis to the satisfaction of the appointed thesis committee. Students must have two research propositions to present at the qualifying examination, each developed under the supervision of a different professor on substantially different topics.

Research Facilities

Center for Isotope Geochemistry , directed by Professor Donald DePaolo, is a joint research center of both UC Berkeley and Lawrence Berkeley National Laboratory. CIG provides state-of-the-art analyses for measuring concentrations and isotopic compositions of elements in rocks, minerals, fluids and gases in the Earth's crust, oceans, and atmosphere. CIG has seven mass spectrometers that provide high precision isotopic and isotope dilution analyses of Rb, Sr, Nd, Sm, Ca, K, Re, Os, Fe, U, Th, Pb, Ba, La, Ce; clean laboratories; and clean mineral separation and rock preparation laboratories. Materials analyzed are rock, ocean and ground waters, and naturally occurring noble gases.

The Center for Atmospheric Sciences is a new multidisciplinary academic group at Berkeley. It focuses on the processes that maintain and alter the atmosphere's chemical composition and circulation. It also examines the climatic effects of changes in these processes. A special emphasis is the interaction between the geosphere-biosphere and climate, with the atmosphere as the synthesizer of changes at its boundaries, and the communicator of these changes to the other spheres. Center members and associates are from the Department of Earth and Planetary Science, Department of Chemistry, Department of Environmental Science, Policy and Management, Department of Mechanical Engineering, Space Sciences Laboratory, Lawrence Berkeley National Laboratory, among others. Research approaches are multi-faceted, and include: global three-dimensional circulation models, satellite observations, high-precision instrumentation for atmospheric chemistry, aircraft measurements of stratospheric-tropospheric exchange, measurements and simulations of atmosphere-biosphere exchange of

trace gases. This diversity permits the Center to pose and attack new questions about past and future climate change.

Berkeley Geomorphology Group prospers because of the diversity of strong research programs across the campus and because of a commitment to undergraduate teaching and graduate training. The core faculty consist of Kurt Cuffey (Geography), William Dietrich, Jim Kirchner, and Michael Manga (Earth and Planetary Science). Their research programs tackle a wide range of topics including glacier mechanics, paleoclimate analysis, hydrology, environmental geochemistry, landscape evolution, hillslope erosion mechanics, fluvial processes, restoration geomorphology, and biologic extinctions and evolutionary processes. These faculty and their students interact and collaborate with many other related groups on campus.

Active Tectonics Group uses an interdisciplinary approach to investigate active tectonic processes and the rheology of the Earth's lithosphere. This approach integrates geodetic, seismologic, geomorphic, and geologic observations with theoretical models to improve scientific understanding of fault zone processes and crustal deformation. Of particular value in this endeavor are space geodetic observations employing the Global Positioning System and Synthetic Aperture Radar Interferometry to precisely measure deformation near active faults, volcanoes, and landslides. Members of the group, led by Roland Bürgmann, often interact closely with colleagues in the Berkeley Seismological Laboratory and the Geomorphology Group.

The Berkeley Geochronology Center is a non-profit research institution dedicated to establishing the evolution of the Earth, its various inhabitants, and its interactions with the rest of our Solar System, throughout the 4.6 billion years of our Planet's existence. BGC scientists determine the ages of rocks and other materials to date important events in geological and biological history. Through understanding such information in geologic context, BGC research provides key insights into such processes as plate tectonics, volcanism, mountain building, mass extinctions, climate change, interactions between the Earth and Solar System, and the evolution of life, including humankind.

The Berkeley Seismological Laboratory (http://seismo.berkeley.edu) **:** The University operates several networks of geophysical instruments in northern California to study earthquakes and tectonic processes at the regional scale: a network of 26 broadband seismometers regionally distributed and linked by continuous telemetry to UC Berkeley forms the core of the monitoring program. In addition, a network of permanent GPS stations and a network of borehole seismometers are maintained and operated by the lab, as well as an on-line archive for earthquake related data in northern California. Research includes the study of earthquake wave propagation through complex structures, the nature of earthquake sources, eigenvibrations of the earth and global tomography.

Center for Computational Geoscience (http://esd.lbl.gov/research/facilities/ccg) **:** Within the Earth Sciences Division at the Lawrence Berkeley National Laboratory is a facility for modern seismological research which relies heavily upon intensive computational analysis (e.g., acoustic imaging, 3D wave propagation, high resolution inverse earthquake analyses) or large database manipulations. The center is used in a number of Ph.D. and postdoctoral research studies.

The Engineering Geoscience Group teaches and researches Applied Geophysics. It is an integral part of the Geological Engineering Group within the Department of Civil and Environmental Engineering at the University of California at Berkeley. The group formed originally in 1962, to study and encourage the use of geophysical methods in mineral and petroleum exploration programs. Recently, attention has shifted to the more general topic of subsurface mapping and imaging. While research in resource exploration topics is still actively pursued, the group's activities now include work on methodology and instrument development for a variety of near surface applications related to the resolution of geotechnical and environmental problems. In this area, the group works jointly with the Department of Civil and Environmental Engineering on site remediation, near surface hydrology and soil stability projects. Incidentally, geophysical technology developed for use in shallow subsurface regions can also be used as an aid to archeological searches. The technology is also expected to play a key role in resolving contemporary problems associated with the detection and removal of buried explosive ordinance.

Center for Integrative Planetary Science (CIPS) (http://cips.berkeley.edu) is a new organized research unit at the University of California, Berkeley. Our task is to unite scientists and students from many disciplines on a rapidly emerging scientific landscape characterized by striking developments. These discoveries, and others during the past decade, have revealed a remarkable set of connections among many separate traditional sciences: geophysics, astrophysics, meteorology, oceanography, organic chemistry, biology, and planetary science. These disciplines are well represented at Berkeley, where strong research programs with long records of accomplishment have existed for some time in diverse campus departments, the Space Science Laboratory, and the Lawrence Livermore National Laboratory. CIPS takes advantage of these strengths with the integrated study of the physical origin and geochemical evolution of planets and planetary systems. Much of the compelling research about our solar system and other planetary systems will require knowledge across traditional disciplinary boundaries. From the condensation of planets within protoplanetary discs to the geochemical history of planets and moons, future researchers will require frontier knowledge of all related disciplines.

EPS 3 The Water Planet 2 Units
Department: Earth and Planetary Science
Course level: Undergraduate
Terms course may be offered: Fall, spring and summer
Grading: Letter grade.
Hours and format: 2 hours of Lecture per week for 15 weeks. 3.5 hours of Lecture per week for 8 weeks.
An overview of the processes that control water supply to natural ecosystems and human civilization. Hydrologic cycle, floods, droughts, groundwater. Patterns of water use, threats to water quality, effects of global climate change on future water supplies. Water issues facing California.
Formerly known as Geology 3.

EPS 8 Geologic Record of Climate Change 3 Units
Department: Earth and Planetary Science
Course level: Undergraduate
Terms course may be offered: Fall, spring and summer
Grading: Letter grade.
Hours and format: 3 hours of Lecture per week for 15 weeks. 8 hours of Lecture per week for 6 weeks.
This course will review the geologic record of climate change emphasizing how such knowledge can constrain present day thinking about (and predictive models of) future climate change. We will cover the entire spectrum of climate variations, from the formation of the Earth's early atmosophere 4.6 billion years ago to the ice ages to the development of instrumental records.
Formerly known as Geology 8.

EPS C12/ASTRON C12/L & S C70T The Planets 3 Units
Department: Earth and Planetary Science; Astronomy; Letters and Science
Course level: Undergraduate
Terms course may be offered: Fall, spring and summer
Grading: Letter grade.
Hours and format: 3 hours of Lecture per week for 15 weeks. 7.5 hours of Lecture per week for 6 weeks.
A tour of the mysteries and inner workings of our solar system. What are planets made of? Why do they orbit the sun the way they do? How do planets form, and what are they made of? Why do some bizarre moons have oceans, volcanoes, and ice floes? What makes the Earth hospitable for life? Is the Earth a common type of planet or some cosmic quirk? This course will introduce basic physics, chemistry, and math to understand planets, moons, rings, comets, asteroids, atmospheres, and oceans. Understanding other worlds will help us save our own planet and help us understand our place in the universe.

EPS W12/ASTRON W12 The Planets 3 Units
Department: Earth and Planetary Science; Astronomy
Course level: Undergraduate
Term course may be offered: Summer
Grading: Letter grade.
Hours and format: 6 hours of Web-based lecture per week for 8 weeks. This is an online course.
A tour of the mysteries and inner workings of our solar system. What are planets made of? Why do they orbit the sun the way they do? How do planets form, and what are they made of? Why do some bizarre moons have oceans, volcanoes, and ice floes? What makes the Earth hospitable for life? Is the Earth a common type of planet or some cosmic quirk? This course will introduce basic physics, chemistry, and math to understand planets, moons, rings, comets, asteroids, atmospheres, and oceans. Understanding other worlds will help us save our own planet and help us understand our place in the universe. This course is web-based.
Instructors: Marcy, Militzer

EPS 20 Earthquakes in Your Backyard 3 Units
Department: Earth and Planetary Science