DEPARTMENT OF EARTH, ENVIRONMENTAL, AND PLANETARY SCIENCES

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Steven A. Hauck, II, Department Chair
steven.hauck@case.edu

The earth, environmental, and planetary sciences encompass a wide range of inquiries into the physical, chemical, and biological processes that shape the earth and the planets. Application of these inquiries to understanding a planet’s evolution through time is a unique attribute of geological investigations. Knowledge of the past and present reveals the constraints of our environment and serves as a guide for the future.

In recent years, significant advances have been made in the understanding of Earth’s interior, the nature of surface and near-surface processes, the history of the Earth’s climate, the ecology of living and ancient organisms, and the comparative geology of other planets. Geological knowledge is fundamental to resource conservation, land use planning and other environmental concerns.

Department faculty have active research programs to investigate planet formation and evolution, and Earth and environmental history. The department offers degree programs leading to the Bachelor of Arts (BA) and Bachelor of Science (BS) in geological sciences, BA in environmental geology, BA in environmental studies, Master of Science (MS), and Doctor of Philosophy (PhD). The Environmental Studies Program (http://bulletin.case.edu/collegeofartsandsciences/environmentalstudiesprogram/) is described elsewhere in this bulletin.

Department Faculty

Steven A. Hauck, II, PhD
(Washington University in St. Louis)
Professor and Chair
Geodynamics

Ralph P. Harvey, PhD
(University of Pittsburgh)
Professor
Planetary geology

Peter L. McCall, PhD, JD
(Yale University)
Professor; Director, Environmental Studies Program
Benthic ecology; paleoecology

Beverly Z. Saylor, PhD
(Massachusetts Institute of Technology)
Armington Professor
Sedimentary geology

James A. Van Orman, PhD
(Massachusetts Institute of Technology)
Professor
Geochemistry

Peter J. Whiting, PhD
(University of California, Berkeley)
Professor; Associate Dean, College of Arts and Sciences
Geomorphology; surface water hydrology; environmental geology

Adjunct Faculty

Mulugeta Alene Araya, PhD
(University of Turin/University of Genoa)
Adjunct Associate Professor
Structural geology

Jeffrey Balcerski, PhD
(Case Western Reserve University)
Adjunct Assistant Professor

Andrew Dombard, PhD
(Washington University in St. Louis)
Adjunct Associate Professor, University of Illinois-Chicago
Planetary geophysics

Joseph Hannibal, PhD
(Kent State University)
Adjunct Associate Professor; Cleveland Museum of Natural History
Invertebrate paleontology

Zhicheng Jing, PhD
(Yale University)
Adjunct Associate Professor

Anne Willem Omta, PhD
(Vrije Universiteit)
Adjunct Assistant Professor

Michael Ryan, PhD
(Univ of Calgary)
Adjunct Associate Professor

David Saja, PhD
(University of Pennsylvania)
Adjunct Assistant Professor; Cleveland Museum of Natural History
Mineralogy

Emeritus

Gerald Matisoff, PhD
(Johns Hopkins University)
Professor Emeritus
Sedimentary and environmental geochemistry

Samuel M. Savin, PhD
(California Institute of Technology)
Jesse Earl Hyde Professor Emeritus of Geological Sciences and Dean Emeritus, College of Arts and Sciences
Isotope geochemistry

Francis Stehli, PhD
(Columbia University)
Professor Emeritus
Paleontology and stratigraphy
Visiting Faculty

Sharmila Giri, PhD  
(University of Miami)  
Visiting Assistant Professor  
Biogeochemistry

Nick Sutfin, PhD  
(Colorado State University)  
Visiting Assistant Professor  
Fluvial geomorphology

Undergraduate Programs

Majors

Students in Earth, Environmental, and Planetary Sciences obtain a solid background in basic science and mathematics as well as intensive training in the major. In addition, because of the wide variety of ways in which geologic knowledge can be applied, all students are encouraged to take electives in subjects appropriate to their personal objectives, which may range from the engineering applications of geology to the socioeconomic and legal systems bearing on environmental issues. The undergraduate programs stress practical experience and fieldwork as well as classroom study. The environmental geology major combines courses in geological sciences with courses in basic and applied sciences to provide students with an understanding of environmental problems, with employable skills, and with a background for graduate study or professional school.

All students participate in a three-semester Senior Project sequence in which they propose a research project, conduct the research, write a thesis, and present it to the department.

Geological Sciences Major (BA)

Required courses:

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>EEPS 101</td>
<td>The Earth and Planets</td>
<td>3</td>
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<tr>
<td>EEPS 110</td>
<td>Physical Geology</td>
<td>3</td>
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<tr>
<td>EEPS 115</td>
<td>Introduction to Oceanography</td>
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<tr>
<td>EEPS 210</td>
<td>Earth History: Time, Tectonics, Climate, and Life</td>
<td>3</td>
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<tr>
<td>EEPS 301</td>
<td>Stratigraphy and Sedimentation</td>
<td>3</td>
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<tr>
<td>EEPS 315</td>
<td>Structural Geology and Geodynamics</td>
<td>3</td>
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<tr>
<td>EEPS 317</td>
<td>Introduction to Field Methods</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 341</td>
<td>Mineralogy</td>
<td>4</td>
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<tr>
<td>EEPS 344</td>
<td>Igneous and Metamorphic Petrology</td>
<td>4</td>
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<tr>
<td>EEPS 360</td>
<td>Summer Field Camp</td>
<td>6</td>
</tr>
<tr>
<td>EEPS 390</td>
<td>Introduction to Geological Research</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 391</td>
<td>Senior Project</td>
<td>2</td>
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<tr>
<td>EEPS 392</td>
<td>Professional Presentation</td>
<td>2</td>
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Nine hours of approved electives (at least two of these courses must be at the 200 level or higher)

Many of the following (at least two of these courses must be at the 200 level or higher)

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<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
<td>3</td>
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<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
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</tr>
<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
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</table>

Additional Required Courses

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>MATH 125</td>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci</td>
<td>4</td>
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<tr>
<td>or MATH 121</td>
<td>Calculus for Science and Engineering I</td>
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</tr>
<tr>
<td>MATH 126</td>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci II</td>
<td>4</td>
</tr>
<tr>
<td>or MATH 122</td>
<td>Calculus for Science and Engineering II</td>
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</tr>
<tr>
<td>or MATH 124</td>
<td>Calculus II</td>
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<tr>
<td>PHYS 115</td>
<td>Introductory Physics I</td>
<td>4</td>
</tr>
<tr>
<td>or PHYS 121</td>
<td>General Physics I - Mechanics</td>
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<tr>
<td>or PHYS 123</td>
<td>Physics and Frontiers I - Mechanics</td>
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<tr>
<td>PHYS 116</td>
<td>Introductory Physics II</td>
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</tr>
<tr>
<td>or PHYS 122</td>
<td>General Physics II - Electricity and Magnetism</td>
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<tr>
<td>or PHYS 124</td>
<td>Physics and Frontiers II - Electricity and Magnetism</td>
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Total Units 70

EEPS 360 Summer Field Camp provides comprehensive field training in the summer between the junior and senior years (this course necessitates transfer credit, which must be approved by the department).

Geological Sciences Major (BS)

One of the following (EEPS 110 is preferred): 3

<table>
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<td>Geology Laboratory</td>
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<tr>
<td>EEPS 210</td>
<td>Earth History: Time, Tectonics, Climate, and Life</td>
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<td>Introduction to Geological Research</td>
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<tr>
<td>EEPS 391</td>
<td>Senior Project</td>
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<td>EEPS 392</td>
<td>Professional Presentation</td>
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Twenty-one hours of approved electives (at least two of these courses must be at the 200 level or higher)

Many of the following (at least two of these courses must be at the 200 level or higher)

<table>
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<tr>
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<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
<td>3</td>
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<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
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<tr>
<td>ENGR 131</td>
<td>Elementary Computer Programming</td>
<td>3</td>
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<tr>
<td>MATH 121</td>
<td>Calculus for Science and Engineering I</td>
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<tr>
<td>MATH 122</td>
<td>Calculus for Science and Engineering II</td>
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</tr>
<tr>
<td>PHYS 121</td>
<td>General Physics I - Mechanics</td>
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<tr>
<td>PHYS 122</td>
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<tr>
<td>CHEM 301</td>
<td>Principles of Chemistry Laboratory</td>
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One of ENGR 225/225b, CHEM 301, CHEM 335, or PHYS 221 3
Two semesters upper-level MATH or STAT
Two additional semesters math/science/engr

Environmental Geology Major
Required courses:

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<thead>
<tr>
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<tbody>
<tr>
<td>EEPS 110</td>
<td>Physical Geology</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 119</td>
<td>Geology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EEPS 210</td>
<td>Earth History, Time, Tectonics, Climate, and Life</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 220</td>
<td>Environmental Geology</td>
<td>3</td>
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<tr>
<td>EEPS 303</td>
<td>Environmental Law</td>
<td>3</td>
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<tr>
<td>or EEPS 202</td>
<td>Global Environmental Problems</td>
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<tr>
<td>EEPS 305</td>
<td>Geomorphology and Remote Sensing</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 317</td>
<td>Introduction to Field Methods</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 321</td>
<td>Hydrogeology</td>
<td>3</td>
</tr>
<tr>
<td>EEPS 390</td>
<td>Introduction to Geological Research</td>
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<td>Professional Presentation</td>
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Nine hours of approved electives (three additional courses at the 200 level or higher which relate to the science or societal implications of environmental concerns. Must be approved by department advisor.)

Additional Required Courses

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>BIOL 114</td>
<td>Principles of Biology</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
<td>3</td>
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<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
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<tr>
<td>ESTD 101</td>
<td>Introduction to Environmental Thinking</td>
<td>3</td>
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<tr>
<td>STAT 201</td>
<td>Basic Statistics for Social and Life Sciences</td>
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<td>MATH 125</td>
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Total Units 67

In the above majors, the student and his or her advisor will design the remainder of the curriculum based on individual interests, in accordance with departmental and college requirements. Through the Integrated Graduate Studies Program (http://bulletin.case.edu/undergraduates/gradprofessional/accelerationtowardgraduatedegreeestext), students may earn a bachelor’s and a master’s degree in five years. Special programs, such as interdisciplinary majors, also may be arranged.

Minor

Students may complete a minor in geological sciences by taking at least 15 hours of course work.

EEPS 119 Geology Laboratory 1
Up to three of the following courses: 9
EEPS 101 The Earth and Planets 9
EEPS 110 Physical Geology 1
EEPS 115 Introduction to Oceanography 1
EEPS 117 Weather and Climate 1
Upper-level EEPS courses to bring total departmental credits to at least 15 5

Total Units 15

Graduate Programs

Graduate programs leading to the Master of Science and Doctor of Philosophy degrees are offered. Both programs are flexible so as to meet the needs of the individual student. General areas of study include aquatic systems, aquatic and groundwater chemistry, environmental geochemistry, benthic ecology, biostratigraphy and paleontology, environmental and urban geology, geomorphology, limnology, paleoclimatology, petrology, sedimentary geochemistry, sedimentation and stratigraphy, stable isotope studies, meteoritics, planetary materials, geodynamics of planetary interiors, and planetary geology. More specific information is available from the departmental office, the departmental webpage, and the Office of Admission of the School of Graduate Studies.

Facilities

The department’s research facilities include thin sectioning and mineral separation facilities; a variety of high-temperature furnaces, including gas-mixing furnaces; two piston cylinder devices, a 1000-ton Walker-style multi-anvil device, and a 1000-ton D-DIA multi-anvil device; laboratories for chemical analysis of water, including an ion chromatograph, colorimetric spectrometer, atomic absorption spectrophotometer, and sulfur analyzer; alpha and gamma spectroscopic facilities for analysis of environmental nuclides; equipment for studying animal-sediment relations, including a scanning gamma spectrometer; and high-speed computing equipment.

Also housed in the department are laboratories for paleontological and micropaleontological investigations and for work in ecology and sedimentology. A well-field owned by the university is available for groundwater sampling and analysis.

The department also contains a wide range of other equipment, such as reflected and transmitted light microscopes, fluid inclusion microscope, cathodoluminescence microscope, and field equipment for groundwater and geophysical work, including resistivity meter, seismic refraction instrument, ground conductivity meter, magnetometer, and gravimeter and field equipment for soil and sediment sampling.

Courses

EEPS 101. The Earth and Planets. 3 Units.
An examination of the geological processes that have shaped the planets and moons of the inner solar system, focusing on those with relevance to our own planet Earth. Following an introduction to the fundamentals of planetary geology, lectures and exercises will explore how the inner planets (the asteroids, Mercury, Venus, Earth, the Moon, and Mars) exhibit the effects of planetary differentiation, impact cratering, volcanic activity, tectonics, climate, and interactions with life.
EEPS 110. Physical Geology. 3 Units.
Introduction to geologic processes and materials that shape the world we live in. Hydrologic cycle and evolution of landscapes. Earthquakes, volcanoes, plate tectonics, and geologic resources. Students desiring laboratory experience should enroll in EEPS 119 concurrently.

EEPS 115. Introduction to Oceanography. 3 Units.
The sciences of oceanography. Physical, chemical, biologic, and geologic features and processes of the oceans. Differences and similarities between the oceans and large lakes including the Great Lakes. Required: Sunday field trip.

EEPS 117. Weather and Climate. 3 Units.
Introduction to the study of weather and climate. Covers the basics of meteorology, climate zones, the hydrologic cycle, and weather prediction. Lectures address timely topics including greenhouse warming, past global climates, and recent advances in meteorology.

EEPS 119. Geology Laboratory. 1 Unit.
Principles and techniques common to the geological sciences including rock and mineral identification, map interpretation, land form analysis, application of geological information to engineering works, and more. One three-hour laboratory or field trip weekly. Recommended preparation: EEPS 110.

EEPS 201. Formation and Evolution of a Habitable Planet. 3 Units.
This course will provide an introduction to the formation and evolution of Earth with an emphasis on how our habitable planet has originated, developed, and sustained conditions suitable for life from a planetary science perspective. Topics include the Big Bang and formation of elements, formation of minerals and organic molecules, formation of the Solar System and planets, formation and differentiation of Earth’s interior, plate tectonics and internal circulation, interactions between interior, atmosphere, and oceans, climate regulation, co-evolution of life and planet, and habitability of other planets in the Solar System and in the universe.

EEPS 202. Global Environmental Problems. 3 Units.
Global Environmental Problems is a course designed to provide students with an understanding of, and an appreciation for, human-influenced environmental changes that are global in scope. Accordingly, much of the material will focus on the nature and structure of natural global systems, how and where in those systems human influences occur, and will delve deeply into a few particular problems and solutions of current interest, such as population growth, climate change, ozone depletion, and fisheries, from a variety of viewpoints. Offered as ESTD 202 and EEPS 202.

EEPS 210. Earth History: Time, Tectonics, Climate, and Life. 3 Units.
The discovery and measurement of deep time, tectonic cycles, and geochemical cycles. The origin of life, major fossil groups and their evolution over time. Earth systems history: Major tectonic, ecologic, and climatic events in the last 4.5 billion years.

EEPS 215. Climate Crises in Earth History. 3 Units.
The past century has seen three great revolutions in our understanding of how the earth works: a revolution our understanding of geologic time, construction of the tectonic cycle that creates continents and oceans, and most recently, the ability to trace using isotopes global geochemical cycles. One of these, the carbon cycle, is intimately tied to climate change. We now know there have been a handful of climate crises in earth history—at least five—during which the planet experienced large scale changes in a short time, and we live now in the midst of another. We will examine the large-scale workings of the earth system, how the carbon cycle interacts with climate on time scales from millions of years to millennia to decades, and get an accessible overview of what we know about ongoing climate change and its current and future impacts. No prior knowledge of geology is assumed, and the course is suitable for non-majors, though we will encounter a few equations, some graphs, and some very simple computer models.

EEPS 220. Environmental Geology. 3 Units.

EEPS 225. Evolution. 3 Units.
Multidisciplinary study of the course and processes of organic evolution provides a broad understanding of the evolution of structural and functional diversity, the relationships among organisms and their environments, and the phylogenetic relationships among major groups of organisms. Topics include the genetic basis of micro- and macro-evolutionary change, the concept of adaptation, natural selection, population dynamics, theories of species formation, principles of phylogenetic inference, biogeography, evolutionary rates, evolutionary convergence, homology, Darwinian medicine, and conceptual and philosphic issues in evolutionary theory. Offered as ANTH 225, BIOL 225, EEPS 225, HSTY 225, and PHIL 225.

EEPS 260. Introduction to Climate Change: Physics, Forecasts, and Strategies. 3 Units.
This is a one-semester introduction to the physical processes that determine Earth’s past, present, and future climate. The course focuses on quantitatively understanding the human impact on climate, including the historical development of steadily more sophisticated physical models, and ever more complete data. Particular emphasis will be placed on understanding climate change projections, as well as the ethical, political, economic, and communications challenges associated with various strategies going forward. The course is appropriate for all majors. Offered as EEPS 260 and PHYS 260.

EEPS 301. Stratigraphy and Sedimentation. 3 Units.
Formation, distribution, and composition of sediments and sedimentary rocks. Modern depositional environments and their ancient analogues; principles of stratigraphic and biostratigraphic correlation. Two lectures and one laboratory per week. Offered as EEPS 301 and EEPS 401.

EEPS 303. Environmental Law. 3 Units.
Introduction to treatment of environmental issues in legal proceedings. Sources of environmental law, legal procedure, common law remedies (toxic torts and human health, nuisance, contract law), statutes and regulations, endangered species, public lands, toxics regulation, nuclear power, coal. The course employs the case method of reading and recitation of appellate judicial opinions. We read both classic cases in environmental law as well as current controversies. Offered as ESTD 303 and EEPS 303.
EEPS 305. Geomorphology and Remote Sensing. 3 Units.
Recognition and interpretation of land forms and their significance in revealing present and past geologic processes. Introduction to acquisition and analysis of data through aerial photography and satellite imagery. Two lectures and one laboratory weekly. Recommended preparation: EEPS 110 and EEPS 119. Offered as EEPS 305 and EEPS 405.

EEPS 307. Evolutionary Biology and Paleobiology of Invertebrates. 3 Units.
Important events in the evolution of invertebrate life; structure, function, and phylogeny of major invertebrate groups.

EEPS 315. Structural Geology and Geodynamics. 3 Units.
Theoretical analysis of deformation in earth materials, with illustrations of deformational styles in various tectonic settings and the dynamics of the Earth's interior. Recommended preparation: EEPS 110. Offered as EEPS 315 and EEPS 415.

EEPS 317. Introduction to Field Methods. 3 Units.
Practice in field procedures, recognition and testing of hypotheses in the field, field mapping and analysis of sedimentary, igneous, and metamorphic rocks in deformed and tectonically active settings. Weekly meeting plus spring break field trip. Students required to pay partial cost of meals, lodging, and travel. Offered as EEPS 317 and EEPS 417. Prereq: EEPS 119.

EEPS 318. Topics in Field Methods. 3 Units.
Field analysis of geological and environmental problems. Topics and locations will vary. Requires preparatory meetings and week-long field trip, usually during spring break. Students required to pay partial cost of meals, lodging, and travel. Recommended preparation: EEPS 119 or permission of instructor.

EEPS 321. Hydrogeology. 3 Units.
Basic and applied concepts pertaining to the occurrence and movement of groundwater. Definitions, basic equations, applications to a variety of geologic settings, wells. Requires one Saturday field trip to make field measurements, collect and analyze data, and prepare a report. Offered as EEPS 321 and EEPS 421.

EEPS 330. Geophysical Field Methods and Laboratory. 4 Units.
Use of seismic refraction and reflection, gravity, electrical, magnetic, and electromagnetic methods to infer the earth's structure and composition. Application of inverse theory to estimate model parameters. Requires students to make field measurements, analyze data, and prepare a report. Includes several required Saturday field trips. Offered as EEPS 330 and EEPS 430.

EEPS 336. Aquatic Chemistry. 4 Units.
Chemical equilibria occurring in natural waters. Quantitative methods of describing acid-base, metal ion/ligand, precipitation/dissolution, and oxidation/reduction reactions. Geochemical cycling of trace metals and nutrients. Offered as EEPS 336 and EEPS 436.

EEPS 340. Earth and Planetary Interiors. 3 Units.
Quantitative introduction to the composition, structure, dynamics, and evolution of Earth and other planets using principles of geophysics and geochemistry. Planetary formation and differentiation, composition and structure of Earth and planets, heat generation and heat flow, mantle convection and plate tectonics, planetary magnetism and core dynamics, chemical evolution of Earth and planets, extrasolar planets and super Earths. This course will be offered to both undergraduate students and graduates. In addition to the requirements for undergraduate students, graduate students will be asked to work on a small course project relevant to the subject of the course and submit a term paper based on this project by the end of the semester. Offered as EEPS 340 and EEPS 440. Prereq: MATH 122 or MATH 126.

EEPS 341. Mineralogy. 4 Units.
Crystallography, hand specimen mineralogy and petrology, principles of crystal structure and crystal chemistry, elementary thermodynamics and phase diagrams, and an introduction to the petrographic microscope. Three lectures and one three-hour laboratory weekly. Recommended preparation: EEPS 119.

EEPS 344. Igneous and Metamorphic Petrology. 4 Units.
Composition, classification, and genesis of igneous and metamorphic rocks, emphasizing physical and chemical principles governing their origin. Laboratory study of rocks in thin section. Two lectures and two three-hour laboratories weekly. Prereq: EEPS 341.

EEPS 345. Planetary Materials. 1 - 3 Units.
An introduction to the materials that make up the solid matter of the solar system. Student presentations will review our current understanding of accessible primitive materials such as meteorites, cosmic dust, lunar and ancient terrestrial rocks, and their relationship to modern natural materials and solar system processes. Offered as EEPS 345 and EEPS 445.

EEPS 349. Geological Problems. 1 - 3 Units.
Special work arranged according to the qualifications of the student.

EEPS 350. Geochemistry. 3 Units.
Introduction to geochemistry. Properties of the elements, elemental and isotopic fractionation, element transport, geochemical systems, geochronology, mineral reactions, the solid Earth, Earth in the solar system. A quantitative approach to modeling geochemical processes will be emphasized throughout. Offered as EEPS 350 and EEPS 450.

EEPS 352. Biogeochemistry. 3 Units.
This course is intended for upper-level undergraduate and graduate students and will focus on global environmental changes and the intersections between biology, geology, chemistry and environmental sciences. Throughout the semester students will explore the cycling of biologically important elements (carbon, nitrogen, phosphorus) in order to understand their role in shaping ecosystem processes and in the development of life on Earth. In the first half of the class, students will explore the biological/chemical processes that shape the past, present and future Earth System. In the second half of the course, students will investigate inter-related nature of these processes/reactions in regulating global biogeochemical cycles. Topics to be covered in this class include the origin of the Earth, elements and life; the Gaia Hypothesis; Geochemical tools to study Earth processes; biological and chemical processes occurring on Earth's surface; Global Climate/Environmental Change. Recommended Preparation: (CHEM 105 or CHEM 111) and (CHEM 106 or ENGR 145). Offered as EEPS 352 and EEPS 452.
EEPS 360. Summer Field Camp. 6 Units.
Six-week course in geologic field methods and mapping. Not offered at CWRU; must be taken at another college or university. Credits will be transferred.

EEPS 367. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHEL/PHOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467. Prereq: EEPS 225 or equivalent.

EEPS 390. Introduction to Geological Research. 3 Units.
Examination of factors in the selection, design, and conduct of research projects and in the analysis and interpretation of research results. Consideration of ethical issues in scientific research. Development of a written research proposal and oral presentation of proposed research. Consultations with department faculty in development of research proposal. Research initiation. Offered as EEPS 390 and EEPS 490. Counts as SAGES Departmental Seminar.

EEPS 391. Senior Project. 2 Units.
Research project required of all department majors, based on formal project proposals presented to department faculty. Proposals may be submitted prior to the semester in which EEPS 391 is taken. Grading based on project progress presentation that will include a statement of the problem, a literature review, a description of their field/lab work and presentation of their data collected to date. This course is the first of a 2 semester Senior Capstone (EEPS 391, 392) sequence. Recommended preparation: EEPS 390. Counts as SAGES Senior Capstone.

EEPS 392. Professional Presentation. 2 Units.
Preparation and presentation of final written and oral reports on individual Senior Projects. Class meetings focus on group discussion of problem areas in analysis and interpretation of project results, and in styles of writing poster and oral presentation as demonstrated by practice examples. This course is the second in a two-course (EEPS 391, 392) Senior Capstone sequence. Counts as SAGES Senior Capstone. Prereq: EEPS 390 and EEPS 391. Or Coreq: EEPS 390.

EEPS 396. Undergraduate Research in Evolutionary Biology. 3 Units.
Students propose and conduct guided research on an aspect of evolutionary biology. The research will be sponsored and supervised by a member of the CASE faculty or other qualified professional. A written report must be submitted to the Evolutionary Biology Steering Committee before credit is granted. Offered as ANTH 396, BIOL 396, EEPS 396, and PHIL 396.

EEPS 401. Stratigraphy and Sedimentation. 3 Units.
Formation, distribution, and composition of sediments and sedimentary rocks. Modern depositional environments and their ancient analogues; principles of stratigraphic and biostratigraphic correlation. Two lectures and one laboratory per week. Offered as EEPS 301 and EEPS 401.

EEPS 405. Geomorphology and Remote Sensing. 3 Units.
Recognition and interpretation of land forms and their significance in revealing present and past geologic processes. Introduction to acquisition and analysis of data through aerial photography and satellite imagery. Two lectures and one laboratory weekly. Recommended preparation: EEPS 110 and EEPS 119. Offered as EEPS 305 and EEPS 405.

EEPS 415. Structural Geology and Geodynamics. 3 Units.
Theoretical analysis of deformation in earth materials, with illustrations of deformational styles in various tectonic settings and the dynamics of the Earth's interior. Recommended preparation: EEPS 110. Offered as EEPS 315 and EEPS 415.

EEPS 417. Introduction to Field Methods. 3 Units.
Practice in field procedures, recognition and testing of hypotheses in the field, field mapping and analysis of sedimentary, igneous, and metamorphic rocks in deformed and tectonically active settings. Weekly meeting plus spring break field trip. Students required to pay partial cost of meals, lodging, and travel. Offered as EEPS 317 and EEPS 417.

EEPS 421. Hydrogeology. 3 Units.
Basic and applied concepts pertaining to the occurrence and movement of groundwater. Definitions, basic equations, applications to a variety of geologic settings, wells. Requires one Saturday field trip to make field measurements, collect and analyze data, and prepare a report. Offered as EEPS 321 and EEPS 421.

EEPS 430. Geophysical Field Methods and Laboratory. 4 Units.
Use of seismic refraction and reflection, gravity, electrical, magnetic, and electromagnetic methods to infer the earth's structure and composition. Application of inverse theory to estimate model parameters. Requires students to make field measurements, analyze data, and prepare a report. Includes several required Saturday field trips. Offered as EEPS 330 and EEPS 430.

EEPS 436. Aquatic Chemistry. 4 Units.
Chemical equilibria occurring in natural waters. Quantitative methods of describing acid-base, metal ion/ligand, precipitation/dissolution, and oxidation/reduction reactions. Geochemical cycling of trace metals and nutrients. Offered as EEPS 336 and EEPS 436.

EEPS 437. Chemistry of Natural Waters. 3 Units.
Advanced topics in aquatic chemistry. Thermodynamics models for ion/ligand speciation in natural waters; origin and composition of seawater, chemical and mineralogical sequence during evaporation, chemical weathering, groundwater and river water chemistry, chemical cycling and a global mass balances; perturbations on natural systems by man. Predictive capabilities of box models.

EEPS 440. Earth and Planetary Interiors. 3 Units.
Quantitative introduction to the composition, structure, dynamics, and evolution of Earth and other planets using principles of geophysics and geochemistry. Planetary formation and differentiation, composition and structure of Earth and planets, heat generation and heat flow, mantle convection and plate tectonics, planetary magnetism and core dynamics, chemical evolution of Earth and planets, extrasolar planets and super Earths. This course will be offered to both undergraduate students and graduates. In addition to the requirements for undergraduate students, graduate students will be asked to work on a small course project relevant to the subject of the course and submit a term paper based on this project by the end of semester. Offered as EEPS 340 and EEPS 440. Prereq: MATH 122 or MATH 126.

EEPS 445. Planetary Materials. 1 - 3 Units.
An introduction to the materials that make up the solid matter of the solar system. Student presentations will review our current understanding of accessible primitive materials such as meteorites, cosmic dust, lunar and ancient terrestrial rocks, and their relationship to modern natural materials and solar system processes. Offered as EEPS 345 and EEPS 445.
EEPS 450. Geochemistry. 3 Units.
Introduction to geochemistry. Properties of the elements, elemental and isotopic fractionation, element transport, geochemical systems, geochronology, mineral reactions, the solid Earth, Earth in the solar system. A quantitative approach to modeling geochemical processes will be emphasized throughout. Offered as EEPS 350 and EEPS 450.

EEPS 452. Biogeochemistry. 3 Units.
This course is intended for upper-level undergraduate and graduate students and will focus on global environmental changes and the intersections between biology, geology, chemistry and environmental sciences. Throughout the semester students will explore the cycling of biologically important elements (carbon, nitrogen, phosphorus) in order to understand their role in shaping ecosystem processes and in the development of life on Earth. In the first half of the class, students will explore the biological/chemical processes that shape the past, present and future Earth System. In the second half of the course, students will investigate inter-related nature of these processes/reactions in regulating global biogeochemical cycles. Topics to be covered in this class include the origin of the Earth, elements and life; the Gaia Hypothesis; Geochemical tools to study Earth processes; biological and chemical processes occurring on Earth's surface; Global Climate/Environmental Change. Recommended Preparation: (CHEM 105 or CHEM 111) and (CHEM 106 or ENGR 145). Offered as EEPS 352 and EEPS 452.

EEPS 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL/BIOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

EEPS 490. Introduction to Geological Research. 3 Units.
Examination of factors in the selection, design, and conduct of research projects and in the analysis and interpretation of research results. Consideration of ethical issues in scientific research. Development of a written research proposal and oral presentation of proposed research. Consultations with department faculty in development of research proposal. Research initiation. Offered as EEPS 390 and EEPS 490. Counts as SAGES Departmental Seminar.

EEPS 506. Seminar in Geophysics. 1 - 3 Units.
Selected topics in geophysics: advanced research issues, classical papers, current state of the field, advanced techniques. Course content will vary depending on interests of students and faculty.

EEPS 509. Seminar: Graduate Research. 1 Unit.

EEPS 511. Special Readings in Geology. 1 - 6 Units.
Detailed study of a selected topic in geology under the guidance of a faculty member.

EEPS 512. Special Readings in Geology. 1 - 6 Units.
Detailed study of a selected topic in geology under the guidance of a faculty member.

EEPS 601. Special Problems and Research. 1 - 18 Units.
(Credit as arranged.)

EEPS 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)

EEPS 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.