

EARTH AND PLANETARY SCIENCES

earth.northwestern.edu

The Earth and Planetary Sciences study the past, present, and future of the Earth and other planets. Our scientists address fundamental scientific questions important for understanding the Earth and society's connection to it. Courses in the degree program focus on physical, chemical, and biological processes affecting the Earth system spanning vast spatial and temporal scales, from the atomic to the interplanetary and from the origin of the solar system to the modern day.

The Earth major prepares students for a range of future career trajectories including: graduate study, environmental consulting, energy exploration and production, natural resources management, law, and medicine. It is ideal for the undergraduate who is interested in the big picture of science and the world around them.

Earth majors are involved in the full spectrum of departmental activities beyond coursework, including research, seminars, field trips, and social functions. Many do research projects with faculty and graduate students that lead to honors theses and scientific publications.

Programs of Study

- Earth and Planetary Sciences Major (<https://catalogs.northwestern.edu/undergraduate/arts-sciences/earth-planetary-sciences/earth-and-planetary-sciences-major>)
- Earth and Planetary Sciences Minor (<https://catalogs.northwestern.edu/undergraduate/arts-sciences/earth-planetary-sciences/earth-and-planetary-sciences-minor>)
- Earth and Planetary Sciences Second Major for ISP Students (<https://catalogs.northwestern.edu/undergraduate/arts-sciences/earth-planetary-sciences/earth-planetary-sciences-second-major-isp-students>)

EARTH 101-0 Earth Science for the 21st Century (1 Unit) Introduction to earth science through topical issues facing contemporary society. Evolution of the earth, geologic hazards, natural resources, peak oil, climate change, the water cycle, nuclear fuel cycle, geology of US national parks. *Natural Sciences Distro Area*

EARTH 102-6 First-Year Seminar (1 Unit) *WCAS First-Year Seminar*

EARTH 103-0 Geologic Hazards (1 Unit) Examination of the principal sources of natural hazards (earthquakes, volcanoes, tsunamis, hurricanes, tornadoes) in the framework of modern geological theories. *Natural Sciences Distro Area*

EARTH 105-0 Climate Catastrophes in Earth History (1 Unit) Introduction to fundamental components of the earth system that control climate. Exploration of present-day climate change and how climate has changed (sometimes catastrophically) in the geologic past. *Natural Sciences Distro Area*

EARTH 106-0 The Ocean, the Atmosphere & Our Climate (1 Unit) The role of the world's oceans in the earth's climate system. Properties of the oceans and marine life. Interaction of oceans, atmosphere, and land. *Natural Sciences Distro Area*

EARTH 108-0 Geological Impacts on Civilization (1 Unit) Impacts of geological processes and materials upon human civilizations. Geological, archaeological, and historical records. Societal responses to disasters, environmental changes, resource distributions, etc. Ancient and modern examples. *Natural Sciences Distro Area*

EARTH 110-0 Exploration of the Solar System (1 Unit) Origin of the solar system; accretion and differentiation of planets and satellites; missions and discoveries; exoplanets and the search for life in our solar system and beyond. *Natural Sciences Distro Area*

EARTH 114-0 Evolution and the Scientific Method (1 Unit) Review of evolutionary theory and its scientific, philosophical, social, and religious impacts. *Natural Sciences Distro Area*

EARTH 201-0 Earth Systems Revealed (1 Unit) Rocks, minerals, earth surface and interior processes, basic field methods. Required weekend field trip. Recommended Background: At least one credit in math, chemistry, biology or physics. *Natural Sciences Distro Area*

EARTH 202-0 Earth's Interior (1 Unit) The earth as a planet: origin, composition, and evolution of the solar system and the earth; internal structure of the earth; plate tectonics. Recommended Background: At least one credit in math, chemistry, biology or physics. *Natural Sciences Distro Area*

EARTH 203-0 Earth System History (1 Unit) Evolution of the earth system and its record through geological time. Interactions among the atmosphere, hydrosphere, sediments, and life on earth. Recommended Background: At least one credit in math, chemistry, biology or physics. *Natural Sciences Distro Area*

EARTH 204-0 Communication for Geoscientists (1 Unit) Science writing and presentation skills necessary for careers in the earth sciences. Topics include science writing as a language, scientific manuscript components, abstracts, poster presentations, formal talks, and informal presentations. Registration is reserved for Earth & Planetary Sciences majors and minors.

EARTH 300-0 Earth and Planetary Materials (1 Unit) Mineralogy of the earth and planets from atomic to continental scales, focusing on structure, composition, identification, and physical properties of minerals as they pertain to geological and societal applications. Recommended Background: At least one course in each of chemistry, physics, and math. *Natural Sciences Distro Area*

EARTH 301-0 Petrology: Evolution of Crustal and Mantle Rocks (1 Unit) Origin, composition, and classification of igneous, metamorphic, and sedimentary rocks. Application of laboratory characterization and basic thermodynamics to interpreting observed rock textures and mineral assemblages in terms of geological processes. Prerequisite: EARTH 300-0 or consent of instructor. *Natural Sciences Distro Area*

EARTH 302-0 Geological Thermodynamics (1 Unit) Finite strain theory, solid solution thermodynamics, phase transitions, subduction zone processes, seismic velocity structures, mineral equations of state. Prerequisite: EARTH 301-0 or consent of instructor. *Natural Sciences Distro Area*

EARTH 310-0 Aqueous Geochemistry (1 Unit) The geochemistry of rivers, groundwater, lakes, and seawater. Topics include thermodynamics, kinetics, acids and bases, pH and alkalinity, carbonate equilibria, chemical weathering, and numerical modeling. Recommended Background: At least one year of chemistry coursework. *Natural Sciences Distro Area*

EARTH 312-0 Stable Isotope Geochemistry (1 Unit) Fractionation and distribution of stable isotopes (C, H, N, O, S) in the biosphere, hydrosphere, atmosphere, and geosphere. Isotopic biogeochemistry, environmental problems, and global climate change. Recommended Background: EARTH 201-0 and EARTH 203-0, or equivalent.

EARTH 313-0 Radiogenic Isotope Geochemistry (1 Unit) Application of radiogenic isotopes to problems in geochemistry, petrology, hydrology, oceanography, ecology, and environmental science. Includes radioactive decay, nucleosynthesis, cosmochemistry, geochronology, mixing processes, and numerical modeling. Recommended Background: At least one year of chemistry coursework.

EARTH 314-0 Organic Geochemistry (1 Unit) The sources and fates of organic matter in the natural environment; global cycling of organic carbon; applications to the study of modern and ancient environments. Recommended Background: at least one quarter of earth or environmental science, and one quarter of chemistry. Taught with CIV_ENV 314-0; may not receive credit for both courses. *Natural Sciences Distro Area*

EARTH 323-0 Seismology and Earth Structure (1 Unit) Elastic theory, seismic waves, seismometers and seismograms, ray paths, travel times; internal structure of the earth; field seismology. Recommended Background: EARTH 202-0, calculus, ordinary differential equations, and some exposure to complex numbers. No prior earth science experience required. *Natural Sciences Distro Area*

EARTH 324-0 Earthquakes and Tectonics (1 Unit) Earthquakes: location, characteristics, origin, mechanism, and relation to plate motions; seismic hazard. Recommended Background: Calculus, ordinary differential equations, and some exposure to complex numbers. No prior earth science experience required. *Natural Sciences Distro Area*

EARTH 327-0 Geophysical Time Series Analysis (1 Unit) Analysis of seismic and other geophysical data. Sampling, windowing, discrete and fast Fourier transforms, z-transforms, deconvolution, and filtering. Recommended Background: EARTH 202-0 and calculus differential equations; or consent of instructor.

EARTH 330-0 Sedimentary Geology (1 Unit) Sedimentary rocks; stratigraphy; local, regional, and global correlation. Ancient depositional systems; facies analysis in context of tectonic, eustatic, and climatic controls on deposition. Recommended Background: EARTH 201-0 or consent of instructor.

EARTH 331-0 Field Problems in Sedimentary Geology (1 Unit) Field methods in stratigraphy and sedimentology; interpretation of depositional systems, facies models, and sequence stratigraphy based on field observations. Includes 3½-week late-summer field trip to Colorado and Utah. Prerequisite: EARTH 330-0.

EARTH 335-0 Tectonics and Structural Geology (1 Unit) Deformation of rock masses: strain, fracture, slip, stress, and rheologic regimes; rock structures; folds, faults, foliations; seismic parameters in tectonic studies; orogenic belts and their tectonic evolution. Recommended Background: EARTH 201-0, and at least one credit of physics; or consent of instructor.

EARTH 340-0 Atmospheric Physics & Weather (1 Unit) An investigation of atmospheric processes and the physical laws that govern them. Topics covered include atmospheric composition and structure, radiative transfer, thermodynamics, convection, precipitation, and the general circulation of the three-dimensional atmosphere. When possible, course

content will engage with contemporaneous atmospheric conditions, and provide students with a better understanding of their meteorological and climatic environments. Recommended Background: Completion of full year of calculus Math and Physics. *Natural Sciences Distro Area*

EARTH 341-0 Quaternary Climate Change: Ice Ages to the Age of Oil (1 Unit) Methods for reconstructing and dating past environmental changes, causes of natural climate change, and major climate events of the Quaternary through the present. Their relevance for understanding current climate change. Prerequisite: At least one 200-level EARTH course; or consent of instructor. *Natural Sciences Distro Area*

EARTH 342-0 Contemporary Energy and Climate Change (1 Unit) Interdisciplinary course examining global energy use and associated challenges, including the history of energy use, the science of climate change, and technological, economic, and environmental aspects of various energy sources. Registration reserved for seniors majoring in math, science, or engineering, and graduate students in all disciplines. Taught with ISEN 410-0; may not receive credit for both courses. *Natural Sciences Distro Area*

EARTH 343-0 Earth System Modeling (1 Unit) Introduction to the art and science of reducing Earth's complex systems into simple numerical models to build a better understanding of how components interact and evolve. Recommended Background: At least one 200-level course in Earth or Environmental Science, one course in each of calculus and physics. *Natural Sciences Distro Area*

EARTH 350-0 Physics of the Earth (1 Unit) Solid-earth geophysics: the earth's gravity field, the earth's magnetic field, interior of the earth, heat flow, elementary wave propagation, plate tectonics. Prerequisites: second-year standing in ISP; or comparable background in mathematics and physics and consent of both instructor and ISP director.

EARTH 352-0 Global Tectonics (1 Unit) Kinematics of plate tectonics. Geometry, determination, and description of plate motions. Paleomagnetism, marine magnetism, and hot spots. History of ocean basins and mountain-building processes. Recommended Background: EARTH 202-0, and completion of first-year calculus and physics.

EARTH 353-0 Mathematical Inverse Methods in Earth and Environmental Sciences (1 Unit) Theory and application of inverse methods to gravity, magnetotelluric, seismic, and other data. Nonlinear, linearized, underdetermined, and mixed-determined problems and solution methods, including regularized least-squares and neighborhood algorithms. Recommended Background: Linear algebra and differential calculus of multivariable functions.

EARTH 360-0 Instrumentation and Field Methods (1 Unit) Theory and practicum on electronic instrumentation for monitoring and measurement in earth sciences, including data loggers, conceptual design and construction of electronic sensors, signal processing, data management, and network design. Recommended Background: 3 EARTH courses.

EARTH 361-0 Introduction to Scientific Programming in Python (1 Unit) Introduction to coding, scientific computing, and visualization for analyzing data in the physical sciences. Emphasis on Python, but Unix, shell scripting, and Generic Mapping Tools are also introduced. Students undertake a significant final coding project individually or in pairs. *Formal Studies Distro Area*

EARTH 362-0 Data Analysis for Earth and Planetary Sciences (1 Unit) Types and characteristics of earth science data, development and

applications of model types, observational and systematic sources of uncertainties and their characterization, spatial and temporal predictions. Recommended Background: EARTH 201-0 and EARTH 202-0, or equivalent. *Formal Studies Distro Area*

EARTH 370-0 Geobiology (1 Unit) A technical overview of the major topics of geo(micro)biology highlighting the fossil record, biogeochemical cycling, biomineralization, key tools of the field, historical geobiology, and astrobiology. *Natural Sciences Distro Area*

EARTH 371-0 Biogeochemistry (1 Unit) The cycling of biogenic elements (C, N, S, Fe, Mn) in surficial environments. Emphasis on microbial processes and isotopic signatures. Recommended Background: At least one course in biology, chemistry, and earth or environmental science. Taught with CIV_ENV 317-0; may not receive credit for both courses. *Natural Sciences Distro Area*

EARTH 373-0 Microbial Ecology (1 Unit) This course will provide a framework for understanding the role of microbes in natural environments in terms of cell numbers, metabolisms, and interactions with geochemical cycles. We will delve deeply into the interactions between microbial populations, higher organisms, and even our own bodies. The course will finish on a survey of microbial composition and dynamics in key settings across the planet. Recommended Background: Basic understanding of chemistry, biology, and earth science.

EARTH 380-0 Forming a Habitable Planet (1 Unit) Formation and evolution of planets permitting life; global geophysical and geochemical processes critical in our planet's development; prospects for life within our solar system and beyond; exoplanet discovery and characteristics. Recommended Background: At least one course in chemistry, and physics. *Natural Sciences Distro Area*

EARTH 381-0 Planet Formation and Evolution (1 Unit) Survey of planet formation processes including growth from the first solids to the giant planets as well as the internal evolution of planetary bodies. *Natural Sciences Distro Area*

EARTH 382-0 Cosmochemistry (1 Unit) Examine the chemical composition of the universe, the Sun, the planets, and their building blocks. Learn the origin of the elements and their evolution through Solar System history. Use isotopic data to trace cosmic genetic relationships and date important events like the birth of the first solids in the Solar System. Understand the chemical processes that segregate elements into different astrophysical and planetary reservoirs. Observe primitive and evolved meteoritic and planetary materials in the laboratory. Recommended Background: Completion of a full year of chemistry and calculus, and the earth science 200-level courses. *Natural Sciences Distro Area*

EARTH 383-0 Planetary Physics (1 Unit) Quantitative survey of planetary science including dynamics, atmospheres, surfaces, interiors, magnetospheres, rings, and small bodies. *Natural Sciences Distro Area*

EARTH 390-0 Special Topics in Earth and Planetary Science (1 Unit) Topics of current interest to students and faculty. Prerequisites vary. May be repeated for credit with different topic.

EARTH 399-0 Independent Study (1 Unit) Special problems under direct faculty supervision. Comprehensive report required. Consent of instructor required.