

EARTH SCIENCE

The options available in the undergraduate program in earth science are geosciences and geophysics and lead to the Bachelor of Science degree in earth science. Both options provide a strong basis for understanding the functioning of the Earth system. Students who are uncertain as to which option best suits their needs should contact a departmental advisor or faculty mentor. In each option, the undergraduate program emphasizes coursework in theoretical, laboratory and field-oriented aspects of earth science. The nearby Rocky Mountains provide a natural laboratory for many of these courses.

Students interested in earth science may also wish to consider the Baker Residential Academic Program (see the Undergraduate Residential Programs (<https://catalog.colorado.edu/undergraduate/colleges-schools/academic-enrichment-programs/undergraduate-residential-programs/>) section). Students who do not wish to pursue a career in earth science, or who would like to combine a basic knowledge of earth science with that of some other field, should consider a minor in earth science. Students who intend to pursue graduate study in earth science are encouraged to consider developing an honors thesis as part of their undergraduate studies.

The two options available in the undergraduate major offer different focus areas of instruction. Both options offer excellent preparation for students interested in pursuing professional careers, or graduate study, in earth sciences.

Each option emphasizes knowledge in:

- The ways in which Earth responds to internal and external forces; the physical, chemical and biological evolution of Earth; and the nature of the materials of which the Earth is made.
- The role of physics, chemistry, mathematics and biology in understanding geological processes.
- The history of discoveries and ideas that have contributed to our current knowledge of Earth and the planetary system.

Course codes for this program are EARTH.

Earth Science Honors Program

Opportunity is provided for qualified earth science majors to participate in the earth science honors program and graduate with honors (cum laude, magna cum laude or summa cum laude) in earth science. Students interested in the honors program should contact the departmental honors advisor during their junior year.

Professional Licensure

The State of Colorado does not require individuals working in Geology or the Geological Sciences to obtain Professional Geology Licensure, however many states require professional geologists to pass the ASBOG Fundamentals of Geology (FG) and/or Practice of Geology (PG) examinations. Information regarding ASBOG examination specifications can be found at the ASBOG (<https://www.asbog.org/>) website.

Students planning to seek professional licensure or certification for employment in a state other than Colorado, are strongly recommended to contact the appropriate licensing entity in the state in which they are, or plan to be, located in order to seek information and guidance regarding licensure or certification requirements and how the education received at

CU Boulder may assist the student in their efforts to gain licensure in that state.

Bachelor's Degree

- Earth Science - Bachelor of Science (BS) (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/earth-science/earth-science-bachelor-science-bs/>)

Minor

- Earth Science - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/earth-science/earth-science-minor/>)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Abbott, Lon D. (https://experts.colorado.edu/display/fisid_145044/)
Teaching Professor of Distinction; PhD, University of California, Santa Cruz

Anderson, Robert S. (https://experts.colorado.edu/display/fisid_130117/)
Distinguished Professor; PhD, University of Washington

Anderson, Suzanne Prestrud (https://experts.colorado.edu/display/fisid_131099/)
Professor; PhD, University of California, Berkeley

Arthurs, Leilani A. (https://experts.colorado.edu/display/fisid_145087/)
Associate Professor; PhD, University of Notre Dame

Chin, Karen (https://experts.colorado.edu/display/fisid_122666/)
Professor; PhD, University of California, Santa Barbara

Clark, Alisha (https://experts.colorado.edu/display/fisid_164457/)
Assistant Professor; PhD, University of California-Davis

Crow, Carolyn Alicia (https://experts.colorado.edu/display/fisid_163334/)
Assistant Professor; PhD, University of California-Los Angeles

Eberle, Jaelyn J. (https://experts.colorado.edu/display/fisid_126544/)
Professor; PhD, University of Wyoming

Farmer, G. Lang (https://experts.colorado.edu/display/fisid_100498/)
Professor; PhD, University of California, Los Angeles

Flowers, Rebecca M. (https://experts.colorado.edu/display/fisid_144054/)
Professor; PhD, Massachusetts Institute of Technology

Ge, Shemin (https://experts.colorado.edu/display/fisid_101387/)
Distinguished Professor, Chair; PhD, Johns Hopkins University

Hynek, Brian Michael (https://experts.colorado.edu/display/fisid_130622/)
Professor; PhD, Washington University

Jones, Craig H. (https://experts.colorado.edu/display/fisid_105590/)
Professor; PhD, Massachusetts Institute of Technology

Kopf, Sebastian H. (https://experts.colorado.edu/display/fisid_155295/)
Assistant Professor; PhD, California Institute of Technology

Mahan, Kevin H. (https://experts.colorado.edu/display/fisid_143975/)
Professor; PhD, University of Massachusetts at Amherst

Marchitto, Thomas (https://experts.colorado.edu/display/fisid_128241/)
Professor, Associate Chair; PhD, Massachusetts Institute of Technology

Markle, Bradley R. (https://experts.colorado.edu/individual/fisid_167413/)
Assistant Professor; PhD, University of Washington

Mueller, Karl Jules (https://experts.colorado.edu/display/fisid_107629/)
Professor; PhD, University of Wyoming

Overeem, Irina (https://experts.colorado.edu/display/fisid_125258/)
Associate Professor; PhD, Delft University of Technology (Netherlands)

Rahman, Shaily (https://experts.colorado.edu/display/fisid_168587/)
Assistant Professor; PhD, SUNY at Stony Brook

Schulte-Pelkum, Vera (https://experts.colorado.edu/display/fisid_126623/)
Associate Research Professor, Lecturer; PhD, University of California-San Diego

Sepulveda Arellano, Julio Cesar (https://experts.colorado.edu/display/fisid_154923/)
Associate Professor; PhD, University of Bremen (Germany)

Sheehan, Anne (https://experts.colorado.edu/display/fisid_103645/)
Chair, Professor; PhD, Massachusetts Institute of Technology

Simpson, Carl (https://experts.colorado.edu/display/fisid_159652/)
Assistant Professor; PhD, University of Chicago

Tilton, Eric (https://experts.colorado.edu/display/fisid_126548/)
Professor, Associate Chair; PhD, University of California, Santa Cruz

Snell, Kathryn Elaine (https://experts.colorado.edu/display/fisid_155298/)
Associate Professor; PhD, University of California, Santa Cruz

Stempien, Jennifer (https://experts.colorado.edu/individual/fisid_143751/)
Associate Teaching Professor; PhD, Virginia Polytechnic Institute and State University

Templeton, Alexis S. (https://experts.colorado.edu/display/fisid_141202/)
Professor; PhD, Stanford University

Tiampo, Kristy F. (https://experts.colorado.edu/display/fisid_155908/)
Professor; PhD, University of Colorado Boulder

Trower, Lizzy (https://experts.colorado.edu/display/fisid_159463/)
Assistant Professor; PhD, Stanford University

Tucker, Gregory E. (https://experts.colorado.edu/display/fisid_130605/)
Professor; PhD, Pennsylvania State University

Wing, Boswell A. (https://experts.colorado.edu/display/fisid_158302/)
Associate Professor; PhD, Johns Hopkins University

Courses

ERTH 1010 (3) Exploring Earth

Introductory geology for majors and non-majors. Studies Earth, its materials, its characteristics, its dynamic processes, and how it relates to people. Separate lab (ERTH 1030) is recommended. Formerly GEOL 1010. Degree credit not granted for this class and ERTH 1012.

Additional Information: GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science

ERTH 1012 (3) Exploring Earth for Scientists

Studies Earth, its materials, its characteristics, its dynamic processes, and how it relates to people. This course is an introductory geology course suitable for geology and other STEM majors. Like ERTH 1010, but taught at a higher intellectual level with a greater amount of quantitative analysis. Separate lab (ERTH 1030) is recommended. Formerly GEOL 1012.

Equivalent - Duplicate Degree Credit Not Granted: ERTH 1012

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 1020 (3) Dodos, Dinos, and Deinococcus: The History of a Habitable Planet

Examines how the solid, fluid, and living Earth interact, how changes in the oceans, atmosphere and life reflect that interaction over the immensity of geologic time, and how the rock record is analyzed to reconstruct the co-evolution of Earth and life. Formerly GEOL 1020.

Additional Information: GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science

ERTH 1030 (1) Introduction to Earth Science Laboratory 1

Features field trips to local points of geologic interest. Studies rocks and topographic and geologic maps. Meets the MAPS requirement for natural science lab, if taken with ERTH 1010 or ERTH 1012. Formerly GEOL 1030. **Recommended:** Requisite Concurrent registration in any 1000-level Earth Science course is beneficial but not required.

Additional Information: GT Pathways: GT-SC1 - Natural Physcal Sci:Lec Crse w/ Req Lab

Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab
MAPS Course: Natural Science Lab or Lab/Lec

ERTH 1040 (3) Geology of Colorado

Reviews the geologic evolution and history of Colorado. It first develops the basic concepts needed to interpret the geology and then systematically shows how the state evolved through geologic time. Designed for those who enjoy understanding the beauty and splendor of the state. Formerly GEOL 1040.

Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science

ERTH 1060 (3) Global Change: An Earth Science Perspective

Focuses on evidence for planetary warming, climate change, glacier and ice-sheet melting and sea level rise both now and in the recent past. Attempts to develop understanding of the interactions within the coupled Earth system that regulate such changes. Utilizes examples from the geological and instrumental records, and evaluates the global warming forecast. Formerly GEOL 1060.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

ERTH 1150 (3) Water, Energy and Environment: An Introduction to Earth Resources

Explores how geological processes and human populations together affect the quantity, quality and availability of Earth resources. Includes examination of the water cycle and how humans use and modify water; fossil-fuel and mineral resources, and renewable energy options. Sustainable versus non-sustainable use and population growth is considered. Formerly GEOL 1150.

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

ERTH 1160 (3) Environmental Geoscience: Where Science Meets Society

This is an introductory-level course designed primarily for freshmen non-science majors. The course targets four main questions at the intersection of geoscience and society. (1) What is science and how is it useful to me? (2) How do Earth processes, particularly natural disasters, impact people? (3) How does the Earth, particularly its natural resources, allow people to live the way we do? (4) How do people impact the environment? The course is designed to not only support students in learning about how science and society intersect in the realm of environmental geoscience, it is also designed to support students' development of academic-success and career-ready skills including goal setting, time management, communication, collaboration and teamwork, and more. Formerly GEOL 1160.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 1170 (3) Our Deadly Planet

This course investigates those events so dramatic and catastrophic that they have left evidence in the geologic record that suggest they significantly impacted life on the planet. These include, but are not limited to, violent volcanic eruptions, mega-earthquakes and associated tsunamis, landslides and sector collapse on volcanoes, megafloods, rapid climatic change, superstorms, and impacts from asteroids and comets. The intent is to use examples from recent events and processes to frame and interpret evidence for these types of events observed in the rock record. Formerly GEOL 1170.

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

ERTH 1180 (3) Our Microbial Planet

Examines how microorganisms shape the world around us, both throughout the Earth's history and today. Major topics include the origin and evolution of life, the interplay between microbes and the environment, roles of microbes in global change, and applications of microbiology in biotechnology and energy.

Equivalent - Duplicate Degree Credit Not Granted: EBIO 1180

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

ERTH 2001 (4) Planet Earth

Explores the dynamics of planet Earth with particular emphasis on the factors that make the planet habitable. Includes examination of heat balance, hydrology, geomorphology, biogeochemistry and climate history through both lecture and lab-based activities. Required for the Earth Science major, introduces students to the major concepts in contemporary Earth system science. Formerly GEOL 2001.

Requisites: Requires prerequisite course of EARTH 1010 or EARTH 1012 or EARTH 1020 or EARTH 1040 or EARTH 1060 or EARTH 1150 or EARTH 1170 or EARTH 1180 or EARTH 2100 or ENV 1000 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 2005 (4) Introduction to Earth Materials

Provides introduction to the classification, composition and properties of the materials that compose the Earth, how these materials are studied, and how they are used to interpret Earth history and processes. Required for the Earth Science major. Formerly GEOL 2005.

Requisites: Requires prerequisite courses of (ERTH 1010 or EARTH 1012 or EARTH 1020 or EARTH 1040 or EARTH 1060 or EARTH 1150 or EARTH 1170 or EARTH 1180 or EARTH 2100) and CHEM 1113 and CHEM 1114 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 2040 (3) The Search for Life in the Universe

Introduces the scientific basis for the possible existence of life elsewhere in the universe. Includes origin and evolution of life on Earth and the search for evidence of life in our solar system, including Mars and Jupiter's moon Europa. Discusses the conditions necessary for life and whether they might arise on planets around other stars.

Equivalent - Duplicate Degree Credit Not Granted: ASTR 2040

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 2100 (3) Environmental Geology

Introduces the influences of geologic processes on human lives and the changes human actions cause in geologic systems. Uses examples and case studies from Colorado and the West. Formerly GEOL 2100.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 2110 (4) Physical Science of the Earth System

Covers basic concepts of physics and chemistry, taught in the context of Earth and space science. Small class size and emphasis on student investigations, lab and field work, and active learning make this course particularly appropriate for future K-6 teachers. Students should have completed two high school science courses (college prep level) in order to take this class. Formerly GEOL 2110.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Core Curr: Natural Science Lab

ERTH 2700 (2) Introduction to Field Geology

Introduces basic field techniques necessary to collect geologic data and samples, and necessary to map geologic units. Formerly GEOL 2700.

Requisites: Requires prerequisite courses of EARTH 1030 and EARTH 2005 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3005 (3) Mesozoic Monsters: Dinosaurs, Pterosaurs, and Sea Lizards

Origin and evolution of the reptiles that lived during the Mesozoic Era, including dinosaurs, pterosaurs, mosasaurs, and plesiosaurs. Course will focus on evolution, paleobiology, paleoecology, and extinction of these extraordinary animals, and a history of their discoveries. The course also introduces students to the scientific method and how hypotheses in paleontology are formulated and tested. Formerly GEOL 3005.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3010 (3) Introduction to Mineralogy

Covers origin, occurrence, identification, classification, and uses of minerals with emphasis on applications of mineralogy to economic geology and petrology. Two lectures and one lab per week. Formerly GEOL 3010.

Requisites: Requires prerequisite courses of CHEM 1113 and CHEM 1114 and ERTH 2005 and MATH 1300 or APPM 1350 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3020 (4) Petrology

Studies field relations, petrography, petrology, chemistry, and origins of igneous and metamorphic rocks by means of lectures, reading, and lab and field experience. Labs include instruction in the fundamentals of optical petrography and the study of rocks in thin section. Formerly GEOL 3020.

Requisites: Requires prerequisite course of ERTH 2005 or ERTH 3010 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3023 (4) Statistics and Geographic Data

Learn how to use computational and statistical tools to solve problems in the geographic domain and apply introductory statistical concepts to real world problems through lab exercises. Using spatial data you will be trained in powerful specialized descriptive and predictive analysis technique. You will explore how to manipulate and visualize data and make inference using state-of-the art statistics software, applied to various social and Earth Science problems.

Equivalent - Duplicate Degree Credit Not Granted: GEOG 3023

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Quantitative Reasoning Math

ERTH 3030 (3) Introduction to Hydrogeology

Introduces groundwater flow concepts, hydrologic cycle, physical and chemical properties, flow net, hydraulic potential, geologic controls on heterogeneity and anisotropy, aquifers and aquitards in a geologic system, saturated and unsaturated flow, flow to a well, pumping tests, and role of groundwater in geologic processes. Formerly GEOL 3030.

Requisites: Requires prerequisite courses of any 1000-level ERTH lecture course (ERTH 1010, 1012, 1020, 1040, 1060, 1150, 1170, or 1180), ERTH 2001, and (MATH 1300 or APPM 1350) (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3040 (3) Global Change: The Recent Geological Record

Geological records in lakes, oceans, deserts, and around glaciers indicate the significant changes in the global systems that have taken place over the last few hundred or thousand years. Explores the timing and nature of these changes. Department enforced prerequisites: any two-course sequence of natural science core courses. Formerly GEOL 3040.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3050 (3) GIS for Geologists

Provides an introduction to Geographic Information Systems (GIS) techniques focused on geological applications. Covers GIS analyzing, mapping and GPS use. Basic computer skills are a plus before entering the class. Formerly GEOL 3050.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3060 (3) Geology of U.S. National Parks

Reviews the geologic history and evolution of the U.S. national parks. Surveys the regional geology of the U.S., and then the details of each park based on its geologic occurrence and geographic setting. The course is designed for non-majors who enjoy understanding the origins and the beauty of our national parks. Formerly GEOL 3060.

Requisites: Requires prerequisite course of ERTH 1010 or ERTH 1012 (min grade C-).

ERTH 3070 (3) Introduction to Oceanography

Explores Earth's dynamic oceans. Discusses the disciplines of oceanography including marine geology, chemistry, biology and physical oceanography with emphasis on global change. Specific topics may include: tectonics, currents, biogeochemical cycles, ecology and global warming.

Equivalent - Duplicate Degree Credit Not Granted: ATOC 3070

Recommended: Prerequisite any 1000-level ATOC or ERTH course or ATOC major.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3090 (3) Developing Scientific Writing Skills

Focuses on the development of scientific writing skills. Enhances student ability to write professionally, revise text and review the work of others. Writing assignments integrate the subject matter of different topics in earth science. Department enforced prerequisites: a lower division writing course. Formerly GEOL 3090.

Requisites: Two of the following: ERTH 2001 or ERTH 2005 or ERTH 2700 or ERTH 3010 or ERTH 3030 or ERTH 3120 or ERTH 3320 or ERTH 3430 or ERTH 3820 (minimum grade C-).

Additional Information: Arts Sci Core Curr: Written Communication
Arts Sci Gen Ed: Written Communication-Upper

ERTH 3120 (4) Structural Geology

Introduces the basic principles and processes involved in deformation of natural rocks and minerals and the techniques used to analyze a variety of common geological structures (e.g., fractures, folds, fault zones). Formerly GEOL 3120.

Requisites: Requires prerequisite courses of ERTH 2001 and ERTH 2005 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3181 (4) Microbial Planet Laboratory

Provides beginner friendly lab & research experience working on a microbiology project. The course teaches how to conduct original scientific research from hypothesis to experimentation, evaluation and reporting. Students study non-pathogenic microorganisms they isolate themselves from nature as part of the course. Hands-on topics covered in class include how to isolate & culture new microbes; how to observe, describe and classify them; and how to examine their metabolic capabilities such as the production of antibiotics.

Equivalent - Duplicate Degree Credit Not Granted: MCDB 3181

Requisites: Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (all minimum grade C-).

Recommended: Prerequisite ERTH 1180 or MCDB 1150 or EBIO 1210.

ERTH 3300 (3) Extraterrestrial Life

Discusses the scientific basis for the possible existence of extraterrestrial life. Includes origin and evolution of life on Earth; the possibility of life elsewhere in the solar system, including Mars; and the possibility of life on planets around other stars. Department enforced prerequisite: one-year sequence in a natural science.

Equivalent - Duplicate Degree Credit Not Granted: ASTR 3300

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3320 (3) Introduction to Geochemistry

Students build upon principles introduced in general chemistry in order to predict and interpret chemical dynamics in Natural environmental systems. We explore the formation and chemical differentiation of the early Earth, how chemical weathering and mineral dissolution and precipitation modifies the Earth's surface, and how redox biogeochemistry shapes aquatic environments. Formerly GEOL 3320.

Requisites: Requires prerequisite courses of CHEM 1113, CHEM 1114, EARTH 2001, and (MATH 1300 or APPM 1350). All minimum grade C-.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3330 (3) Principles of Geophysics

Provides an introduction to fundamental geophysics including seismology, geomagnetism, gravity, and electromagnetic methods with applications to plate tectonics and exploration of the subsurface. Formerly GEOL 3320 and GEOL 4130.

Requisites: Requires prerequisite courses of MATH 1300 or APPM 1350 and PHYS 1110 or PHYS 1115 and EARTH 2001 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3400 (4) Evolution of Continental Ecosystems

Enquiry into the evolution of important ecosystems of the past and present. Biological and geological data for reconstructing ecosystems discussed in detail and applied to creating scenarios of past ecosystems. Emphasizes vertebrates and their structure. Formerly GEOL 3400.

ERTH 3410 (3) Paleobiology

Surveys morphology, ecology and evolution of ancient animal and plant life and their interactions on Earth. Fossils used to solve geological and biological problems. Formerly GEOL 3410.

Requisites: Requires prerequisites of one of the following: EARTH 1010, EARTH 1012, EARTH 1020, EARTH 1040, EARTH 2001, EARTH 2005, EBIO 1100, EBIO 1210, EBIO 1220, or EBIO 1250 (min grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3430 (4) Sedimentology and Stratigraphy

Introduces the study of sedimentary rocks emphasizing their origin, characteristics, and interpretation; and the principles and techniques for establishing the temporal order and spatial distribution of sedimentary layers. Formerly GEOL 3430.

Requisites: Requires prerequisite courses of EARTH 2001 and EARTH 2005 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3500 (3) Earth Resources and the Environment

Examines Earth's most important natural resources and their impact on society and the environment. Addresses the geology, occurrence, production, and use of petroleum, coal, mineral, and water resources. Future world energy supply and demand, conservation, and the transition from fossil fuels to non-polluting renewable resources are discussed. Formerly GEOL 3500.

Requisites: Requires prerequisite course of EARTH 1010 or EARTH 1040 or EARTH 1060 (minimum grade C-).

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence

ERTH 3520 (3) Energy and Climate Change: An Interdisciplinary Approach

Ever think about what keeps the lights on, and what it costs the planet? This course explores the resources we depend on, how we use them, and the impacts they have on climate, policy, and the economy. Since fossil fuels are still the biggest player, we'll take a close look at their role in climate change and the carbon cycle. We'll connect science to real-world challenges, like making ethical choices and protecting the environment, and you'll understand why energy knowledge matters in your own future career. The class is designed to be flexible and supportive, so that it is both manageable and rewarding.

Equivalent - Duplicate Degree Credit Not Granted: ENVS 3520

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3540 (3) Introduction to Petroleum Geology

Discusses the origin and distribution of conventional and unconventional petroleum resources, source rocks, types of traps and seals, reservoir rock properties, exploration methods (seismic data analysis and interpretation, formation evaluation, subsurface mapping), reservoir characterization and modeling, reserves calculations. Formerly GEOL 3540.

Requisites: Requires prerequisite courses of EARTH 2001 and EARTH 2005 (minimum grade C-).

Recommended: Corequisite EARTH 3430.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3600 (3) Introduction to Python Programming for Earth Scientists

Introduces students to scientific computing and computer programming using the Python language. Emphasis is on scientific applications such as data input and analysis, plotting, and simulation. Examples are drawn from earth and environmental sciences. Course covers variables, operations, data types, conditionals, loops, data structures, array calculations, and libraries for data analysis and plotting. Coursework is primarily based on weekly programming assignments. Formerly GEOL 3600.

Requisites: Requires prerequisite course of EARTH 2001 (minimum grade C-).

Recommended: Prerequisite Introductory course in EARTH, ENVS, GEOG, ATOC, or EVEN.

ERTH 3630 (3) Great Geological Controversies

Significant Historical and Contemporary Controversial Issues in the Geological Sciences (E.G. AGE OF THE Earth, Ice Ages, Continental Drift, Health Hazards Related to Rocks and Minerals) Are Critically Examined By Means of Reading, Classroom Discussion and Argument, and Written Assignments. Formerly GEOL 3630.

ERTH 3700 (2) Geology of the Front Range

Field-oriented approach to tracing the geologic development of the Colorado Front Range, from the Precambrian to recent times. Field observations provide a framework for discussions of current ideas concerning the geologic evolution of the Front Range. Formerly GEOL 3700.

Recommended: Prerequisite 1000-level EARTH course.

ERTH 3720 (3) Evolution of Life: The Geological Record

Discusses the evolution of life on Earth, beginning with the earliest origins and surveying the major steps that led to the rise of higher plants and animals. Covers modern ideas on the causes of periodic mass extinctions in both the marine and terrestrial realms. Emphasizes geologic evidence for the pathways of evolution, using examples from the ordinary to the bizarre. Formerly GEOL 3720.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 3820 (4) The Fluid Earth

Examines the myriad forms of fluid behavior found on Earth, from the atmosphere to the inner core. Explores how basic principles of fluid physics may be used to understand a broad range of earth processes, including mantle convection, atmosphere and ocean dynamics, stream flow, lava spreading, and glacier motion, among others. Covers fundamental fluid concepts such as viscosity, pressure, convection, friction, and free-surface flow. Formerly GEOL 3820.

Requisites: Requires prerequisites of EARTH 2001 and (MATH 1300 or (APPM 1340 and APPM 1345) or APPM 1350) (all minimum grade of C-).

Recommended: Prerequisites Any 1000-level EARTH class and PHYS 1110.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 3910 (4) Earth and Planetary Inference

Introduces modern ways to interpret earth science observations in the context of conceptual models. We will learn how earth and planetary scientists synthesize geological, geochemical, and geophysical measurements and theoretical knowledge to make new discoveries and predictions. The tools that will be introduced in the course range from order-of-magnitude estimation techniques to a gentle intro to inverse thinking. Formerly GEOL 3910.

ERTH 3950 (3) Natural Catastrophes and Geologic Hazards

Surveys historic and prehistoric natural disasters, their cause and potential for recurrence. Meteorite impact, earthquakes, volcanic eruptions, tsunamis, landslides, floods, magnetic reversals and major extinction events. Formerly GEOL 3950.

Recommended: Prerequisite one year of science.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4001 (1) Earth Science Majors Research Seminar

Reading and discussion seminar to enhance students' critical evaluation of research design, assumptions, and presentation of results in the geosciences. Readings will focus on the events involved in the geologic evolution of the American West and its timing. Papers read will employ a variety of geologic and geophysical techniques. Geared towards students completing independent research and interested in pursuing a research-focused career. Development of career/graduate school plan and application materials is covered. Formerly GEOL 4001.

Repeatable: Repeatable for up to 4.00 total credit hours.

Requisites: Requires Prerequisites of EARTH 2005 or EARTH 2001 (all minimum grade C-). Restricted to Earth Science majors only.

Recommended: Prerequisite or corequisite EARTH 2700.

ERTH 4020 (3) Marine Geology

Studies the Geology and Geophysics of the Ocean Basins and Marginal Seas, Including Discussions of Plate Tectonics and History of the Ocean Basins, the Formation of Ocean Crust, the Development of Active and Passive Continental Margins, and Interpretation of the Distribution of Ocean Sediments. Formerly GEOL 4020.

ERTH 4021 (4) Petrology: Evolution of Crustal and Mantle Rocks

Origin, physical, and chemical properties of igneous and metamorphic rocks. This course develops a thermodynamic framework for the interpretation of geologic processes from observed mineral assemblages and rock textures. Laboratory component emphasizes the study of rocks in thin section and hand samples to understand earth processes in the mantle and crust.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5021

Requisites: Requires prerequisite courses of CHEM 1113 and CHEM 1114 and EARTH 2005 and (MATH 1300 or APPM 1350) (all minimum grade C-).

Recommended: Prerequisites EARTH 2001 and EARTH 2700.

Grading Basis: Letter Grade

ERTH 4023 (3) Statistics for Earth Science

Introduction to Parametric and Distribution-Free Statistics Emphasizing Applications to Earth Science Problems. Formerly GEOL 4023.

ERTH 4030 (3) Coastal Processes

Course Will Cover the Physical Processes That Work to Shape the Sedimentary Deposits Located in Various Coastal Environments: Estuaries, Deltas, Fjords, Barrier Islands, Beaches and Lagoons, Glacier Coastal Settings, Paraglacial Coasts, Tidal Flats, and Mangroves. Formerly GEOL 4030.

ERTH 4050 (3) Earthquakes

Covers causes and effects of earthquakes, earthquake prediction, seismic waves, record interpretation, parameters of seismic foci, and seismotectonics of the world.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5050

Requisites: Requires prerequisite of MATH 1300 or APPM 1350 (min grade C-).

Recommended: Prerequisite one year of natural science.

ERTH 4093 (4) Remote Sensing of the Environment

Covers acquisition and interpretation of environmental data by remote sensing. Discusses theory and sensors as well as manual and computerized interpretation methods. Stresses infrared and microwave portions of the spectrum.

Equivalent - Duplicate Degree Credit Not Granted: GEOG 5093 and GEOG 4093 and EARTH 5093

Requisites: Requires prerequisite course of APPM 1340 1345 or APPM 1350 or ECON 1088 or 3818 or MATH 1081 or 1300 or 1310 or 2510 or ANTH 4000 or BCOR 1020 or GEOG 3023 or EARTH 3023 or PSCI 2075 or PSYC 2111 or SOCY 2061 or 4061 or STAT 4000 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4110 (4) Field Geology

Methods of Geologic Mapping Including Plane Table Surveying and Introduction to Photogrammetry. Formerly GEOL 4110.

ERTH 4120 (3) Advanced Structural Geology and Tectonics

Provides valuable exposure to theory and applications related to deformation (rheology) of solid Earth materials as well as the structural and geophysical characteristics of the world's major orogenic belts.

The processes that will be covered span a wide range of Earth's depths, from compaction in sedimentary rocks and flow of ice/salt near Earth's surface to cataclastic mechanisms in fault rocks to plastic flow of deep crust and mantle rock. The course will involve lectures, some in-class and take home problem sets, some local field exercises and field data analysis, classic and modern paper discussions, and a research term project (written and oral presentation).

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5120

Requisites: Requires prerequisite course of EARTH 3120 (minimum grade C-).

Grading Basis: Letter Grade

ERTH 4150 (2) Planetary Field Geology

Provides an overview of the geology, age and origins of the solid (rocky) planets, dwarf planets and moons of our solar system and the processes that form them from comparative studies from comparative geology. Includes modules on volcanism, rifting, aeolian processes, fluvial erosion, impacts, climate change and paleontology. Formerly GEOL 4150.

Requisites: Requires prerequisite course of EARTH 2700 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4185 (3) Geomicrobiology

Examines how microbial and chemical processes interact on the Earth's surface today and have shaped the planet throughout its history.

Emphasis will be placed on how the life styles and chemical ingenuity of microorganisms drive key biogeochemical processes including weathering and transformations of carbon, oxygen, sulfur, iron and nitrogen. Towards this goal, major geologic and evolutionary events will be examined through the lens of microbial diversity, metabolic energetics, microbe-mineral interactions, and molecular biomarkers.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5185, ENVS 4185, and MCDB 4185

Requisites: Requires prerequisite courses (CHEM 1113 or CHEM 1400 or CHEN 1201 or CHEN 1211) and (CHEM 1114 or CHEM 1401 or CHEM 1221) (minimum grade C-).

Recommended: Prerequisites EARTH 1180 or MCDB 1150 or EARTH 3320 or EBIO 3400 or ENVS 4160 or EVEN 4484.

Grading Basis: Letter Grade

ERTH 4215 (3) Geochronology and Thermochronology

Constraining the timing of events and rates of processes is fundamental to earth science research. The field of geochronology and thermochronology is rapidly evolving. Cutting-edge aspects of geochronologic methods and emerging techniques will be especially emphasized. Lectures will emphasize the principles and assumptions of each technique. Seminar discussions will focus on recent papers that demonstrate state-of-the-art applications to diverse problems.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5215

Requisites: Requires prerequisite courses of EARTH 2001 and EARTH 2005 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4241 (4) Earth Surface Processes

Earth's surface is constantly reshaped by water, ice, wind, and life. This class investigates the earth's landscapes and the processes that modify them, both gradually by slow weathering and erosion, and abruptly through the action of floods, landslides, and other geologic events. We cover surface processes in hillslope, glacial, riverine, desert, and coastal environments. Upon completion of the course, students will have mastered knowledge about diverse surface processes and landforms and applied core geomorphic principles to a variety of landscapes. Students will also learn that understanding surface processes is important for managing natural hazards (e.g., landslides and floods). This course will draw from many disciplines, including geology, geography, physics, chemistry, and biology. The laboratory portion of the course will include quantitative problem solving and field trips to collect and analyze geomorphic data.

Equivalent - Duplicate Degree Credit Not Granted: GEOG 4241

Requisites: Requires prerequisite courses of GEOG 1011 or EARTH 2001 and a calculus course (MATH 1300 or APPM 1350 or (APPM 1340 and APPM 1345)), all minimum grade C-.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4270 (3) Marine Chemistry and Geochemistry

Examines the chemical, biological, geological and physical processes affecting (and affected by) the chemistry of the oceans. Topics include: chemical cycling in seawater; the marine carbon cycle and its long-term control on atmospheric CO₂; the large-scale interdependence of nutrient distributions and biological productivity, chemical tracers of ocean circulation; the chemistry of marine sediments, including early diagenesis.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5270

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors). Requires prerequisite courses of CHEM 1113, CHEM 1114, CHEM 1133, CHEM 1134, and EARTH 2001 (minimum grade C-).

Recommended: Prerequisites introductory chemistry, introductory geology, introductory oceanography.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4330 (3) Cosmochemistry

Investigates chemical and isotopic data to understand the composition of the solar system: emphasis on the physical conditions in various objects, time scales for change, chemical and nuclear processes leading to change, observational constraints, and various models that attempt to describe the chemical state and history of cosmological objects in general and the early solar system in particular.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5330 and ASTR 4330 and ASTR 5330

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors). Requires prerequisite courses of (CHEM 1113 or CHEM 1400 or CHEN 1211) and (PHYS 1110 or PHYS 1115); all minimum grade C-.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4341 (3) The Cryosphere: Earth's Icy Environments

Serves as an advanced introductory course in to the cryosphere for science majors. The course covers the nature of ice and the icy component of the Earth System, and how changing ice affects society. The course will not cover sea ice. Formerly offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5341

Requisites: Requires prerequisite course of EARTH 2001 or PHYS 1110 or PHYS 1115 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4380 (3) Fundamentals of Stable Isotope Geochemistry

This course teaches students the fundamental principles of stable isotope fractionation during physical and biological processes, and the application of these behaviors to a wide range of important geologic questions. The course will use classic case studies from the geologic record to illustrate these principles.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5380

Requisites: Requires prerequisite courses of (MATH 1300 or APPM 1350) and CHEM 1113 (all minimum grade C-).

ERTH 4440 (3) Morphology and Genesis of Soils

Effects of Climate, Vegetation, Parent Material, Topographic Position, and Time on Development, Classification, and Chemistry of Soils and Paleosols. Geomorphic and Quaternary History Used to Interpret Soils. Lab Is Field Trips to Study Soils in Plains to Mountains Transect. Formerly GEOL 4440.

ERTH 4444 (3) Data Visualization for Earth and Environmental Scientists

Data fluency and visualization are highly desirable skills both inside and outside of academia. This class focuses on the power, theory, best practices, and common pitfalls of programmatic data visualization with hands-on in-class programming sessions and fun weekly data wrangling and visualization exercises using data from across the earth, environmental, and biological sciences. We'll be using Quarto/RMarkdown notebooks and tidyverse-style R programming for data wrangling; ggplot2 and its powerful grammar-of-graphics approach for data visualization; and Git & GitHub for code management, collaborative coding, and instructor/peer feedback.

Equivalent - Duplicate Degree Credit Not Granted: EBIO 4444 and EBIO 5444 and EARTH 5444

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).

Recommended: While some experience with a programming language (R, python, matlab, C++, fortran, or any other) is beneficial, students with no prior programming experience are welcome to take this course.

Grading Basis: Letter Grade

ERTH 4474 (4) Vertebrate Paleontology

Discusses the history and evolution of the vertebrates, including the phylogenetic relationships and evolutionary patterns of the major groups. Lab focuses on comparative vertebrate osteology and fossil representation of major groups.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5474 and MUSM 5474

Requisites: Requires prerequisites EARTH 1020 and EARTH 3410 (minimum grade C-). Restricted to students with 57-180 credits (Juniors or Seniors).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4540 (4) Petroleum Geology

Covers theoretical and applied aspects of petroleum geology and geochemistry. Discusses organic geochemistry, time-temperature models, migration, trapping mechanisms, log analysis, application of facies models in the subsurface, and reservoir geology.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5540

Recommended: Prerequisites course work in structure, stratigraphy, sedimentology, deposits, environment, physics, and chemistry.

ERTH 4611 (3) Organic Geochemistry

Explores the biomarker concept as a tool to elucidate microbial, biogeochemical, and climatic processes in natural systems through three fundamental goals: a) characterization and classification of organic molecules in complex, natural mixtures; b) biosynthesis, transport, transformation, preservation and destruction of organic matter in nature; c) application of lipid biomarkers and their stable isotope composition to study biological, biogeochemical, and climatic processes in modern and ancient systems.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5611

Requisites: Requires prerequisite courses of CHEM 1113, CHEM 1114, CHEM 1133, and EARTH 2001 (all minimum grade C-).

Recommended: Prerequisite EARTH 3320 or EARTH 4270.

Grading Basis: Letter Grade

ERTH 4640 (3) Glaciology

Explores ice physics, snow, glaciers, floating ice, ice in the ground and in the solar system. Emphasizes glaciers and ice sheets, including reconstruction of past glaciations and impacts of ice and snow on society.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5640

Requisites: Requires prerequisite of MATH 1300 or APPM 1350 (minimum grade C-).

ERTH 4670 (3) Isotope Geology

Introduces principles of stable and radiogenic isotope systematics in inorganic and organic geochemistry. Emphasizes application of isotope data to problems in igneous, metamorphic and sedimentary petrology, geobiochemistry, and petroleum genesis.

Equivalent - Duplicate Degree Credit Not Granted: EARTH 5670

Requisites: Requires prerequisite course of MATH 1300 or APPM 1350 (minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4700 (1-4) Special Earth Science Topics

Studies in selected Earth Science subjects of special current interest (for undergraduates). Formerly GEOL 4700.

Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4711 (2) Igneous and Metamorphic Field Geology

Applies field techniques to interpretation of igneous and metamorphic rocks. Field exercises and lectures focus on collecting data required to map igneous and metamorphic rock units. Formerly GEOL 4711.

Requisites: Requires prerequisite courses of (ERTH 2001 or EARTH 2700) and EARTH 2005 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4712 (2) Structural Field Geology

Explores methods of field study of structure of rocks, including observations, data collection and interpretation to understand geometry of deformation and causative processes and kinematics. Field projects are mapped using different scales, air photos, topographic maps and compass and tape. Formerly GEOL 4712.

Requisites: Requires prerequisite courses of EARTH 2700 and EARTH 3120 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4714 (2) Field Geophysics

Applies geophysical field techniques and data interpretation to studying geological and engineering problems. Fieldwork includes seismic, gravity, magnetic, and electrical measurements. Formerly GEOL 4714.

Requisites: Requires prerequisite courses of EARTH 2001 or EARTH 2700 and EARTH 3330 and MATH 1300 and PHYS 1110 or PHYS 1115 (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4715 (2) Field Techniques in Hydrogeology

Introduces various field techniques and data analysis methods in hydrogeologic studies for students in geology, environmental studies, geography, and civil engineering. Exercises include mapping ground water levels, conducting slug and pumping tests, measuring stream flows, interpreting aquifer parameters from geophysical measurements, and using field data for water budget analysis. Formerly GEOL 4715.

Requisites: Requires prerequisite courses of EARTH 3030 and (ERTH 2001 or EARTH 2700) (all minimum grade C-).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4716 (2) Environmental Field Geochemistry

This is a critical thinking course that makes use of field and laboratory environments. Students learn methods and develop hands-on expertise needed to identify, characterize and interpret the reactions that govern the quality of water in natural systems, through activities in local watersheds. Formerly GEOL 4716.

Requisites: Requires prerequisite courses of (ERTH 2001 or ERTH 2700) and ERTH 3320 and (CHEM 1011 and CHEM 1031) or (CHEM 1113 and CHEM 1133). All minimum grade C-.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 4717 (2) Field Seminar in Geology and Tectonics

Studies geologic features in and around Colorado to gain an overview of the geologic and tectonic evolution of the western U.S.. Formerly GEOL 4717.

Requisites: Requires prerequisite courses of (ERTH 2001 or ERTH 2700) and (ERTH 3120 or ERTH 3320 or ERTH 3430 or ERTH 4241). All minimum grade C-.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 4718 (2) Paleoenvironmental Field Techniques

Provides experience in field techniques used to reconstruct paleoenvironments, including sediment coring and cataloging. Emphasis on glacial, lacustrine, bog, soil, and cave environments. Formerly GEOL 4718.

Recommended: Prerequisites one 1000-level ERTH course or other environmental science and ERTH 2700.

ERTH 4719 (2) Field Analysis and Tectonics of Crystalline Rocks

Introduces basic and advanced mapping tools and concepts for structural and tectonic analysis of solid-state and magmatic deformation, metamorphism, and fluid flow in igneous and metamorphic rocks. Includes some digital mapping concepts using smartpad and smartphone applications, and computer-based analysis of structure data. Includes multi-day mapping projects in the Front Range, and in western Colorado, southern Wyoming, or northern New Mexico. Also includes introductions to Precambrian tectonic history of western North America and mineral resources of Colorado.

Equivalent - Duplicate Degree Credit Not Granted: ERTH 5719

Repeatable: Repeatable for up to 4.00 total credit hours.

Requisites: Requires prerequisite courses of ERTH 2700 and ERTH 3120 (all minimum grade C-).

Grading Basis: Letter Grade

ERTH 4721 (2) Field Methods in Active Tectonics

Analysis of active geologic structures, including strike slip fault systems, secondary structures in stepovers and related eruptive centers. Includes the use of digital imagery, elevation models, offset geomorphic features and Quaternary deposits to determine local deformation rates and their relation to plate motions. Formerly GEOL 4721.

Requisites: Requires prerequisite courses of ERTH 2700 and ERTH 3120 (all minimum grade C-).

Recommended: Prerequisite ERTH 4712.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

ERTH 4723 (2) Field Studies in Sedimentology

Provides students experience in observing and interpreting sedimentary rocks in the field. We will visit outcrops in CO and UT spanning a range of depositional environments, including eolian, lacustrine, fluvial, and marine. Developing observational and notetaking skills will be emphasized; students will be responsible for contributing to a group field guide based on their guided field observations at each site. Formerly GEOL 4723.

Requisites: Requires prerequisite courses of ERTH 2700 and ERTH 3430 (all minimum grade C-).

ERTH 4725 (1-4) Field Based Special Topics in Earth Science

Explores selected geological subjects of special interest in a field setting.

Equivalent - Duplicate Degree Credit Not Granted: ERTH 5725

Repeatable: Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ERTH 4750 (2) Field Techniques in Snow Hydrology

The purpose of this course is to provide students with a basic introduction to snow hydrology, with training in field methods for measuring snowpack characteristics and geospatial analysis techniques (GIS). Formerly GEOL 4750.

ERTH 4755 (2) Field Geobiology

Provides students technical fieldwork skills in the interdisciplinary field of geobiology, spanning modern environments and to ancient environments in preserved in rock record, and spanning techniques from geochemistry, environmental microbiology, and sedimentology.

Equivalent - Duplicate Degree Credit Not Granted: ERTH 5755

Repeatable: Repeatable for up to 8.00 total credit hours.

Requisites: Requires prerequisite courses of ERTH 2700 and ERTH 3430 (all minimum grade C-).

ERTH 4833 (3) Teaching and Learning Earth Systems

Learn and develop pedagogically effective strategies for teaching and understanding Earth Science concepts. Particular emphasis is placed on understanding the importance of geoscience habits of mind (i.e. spatial/temporal reasoning, multiple working hypotheses, geographic context). Focuses upon inquiry and evaluation of evidence, the importance of background knowledge and misconceptions, and developing effective discourse within and outside the classroom.

Equivalent - Duplicate Degree Credit Not Granted: EDUC 5833 and EDUC 4833 and ERTH 5833

Requisites: Requires prerequisite course of ATOC 1060 or ENVS 1000 or ERTH 1010 or ERTH 1020 or ERTH 1060 (minimum grade C-).

Grading Basis: Letter Grade

ERTH 4862 (1-4) Earth Science Independent Study

Students may not enroll in this course without completing the Independent Study Application.

Equivalent - Duplicate Degree Credit Not Granted: ERTH 5862

Repeatable: Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

ERTH 4990 (1-3) Honors Thesis

Supervised project involving original research in any area of the geological sciences. The thesis is submitted to the Honors Program of the College of Arts and Sciences and is orally defended. Must be accepted by the departmental honors committee. Formerly GEOL 4990.

Requisites: Requires prerequisite of minimum cumulative GPA 3.30.

Additional Information: Arts Sciences Honors Course

GEOL 4060 (4) Oceanography

Examines the ocean as a system influencing the Earth's surficial processes and climate. Composition and properties of seawater, ocean circulation, waves, tides, coastal-, shallow-, and deep-water processes, biogeochemical cycles, deep sea sediments. Laboratory emphasizes the use of oceanographic data. Department enforced prerequisite: one semester chemistry or physics or geology.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 5060

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

GEOL 4070 (3) Paleoclimatology

Covers the primary forcings and feedbacks that determine Earth's energy balance and the resultant climate system on decadal to millennial time scales. Covers ocean/atmosphere circulation, the role of ice sheets in the climate system, monsoons, Holocene climate change and 20th Century warming. Includes coverage of the proxies available to reconstruct climates of the past and the archives that contain these proxies. Department enforced prerequisite: environmental science or geology introduction sequence courses.

Requisites: Requires prerequisite course of EARTH 2001 (minimum grade C-).

Recommended: Prerequisite natural science majors only.

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

GEOL 4160 (3) Introduction to Biogeochemistry

Covers fundamentals of biogeochemical cycling, emphasizing water, carbon and nutrient dynamics in terrestrial ecosystems; chemical interactions of atmosphere, biosphere, lithosphere and hydrosphere; natural and human-managed environments. Department enforced prerequisites: GEOL 3320 or EBIO 3270 and CHEM 1011.

Equivalent - Duplicate Degree Credit Not Granted: EBIO 4160 and ENVS 4160

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

GEOL 4660 (3) Sedimentology and Geobiology of Carbonates

Focuses on how carbonate sediments are formed, deposited, and lithified and what influences the preservation and alteration of textural and geochemical signals. We will cover facies identification, interpreting depositional environment, and carbonate geochemistry, with a particular emphasis on recent advances and unanswered questions at the intersection of carbonates and geobiology, including the role of microbial carbonate precipitation and/or dissolution in the formation and degradation of stromatolites, carbonate mud, ooids, etc.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 5660

Requisites: Requires prerequisite course of GEOL 3430 (minimum grade C-).

Recommended: Prerequisites GEOL 3320, GEOL 4185.

GEOL 4675 (3) Stable Isotopes in Paleoclimate and Paleoecology

Explores the use of stable isotope geochemistry for research questions in paleoclimatology and paleoecology. Covers physical and biological drivers of isotopic fractionation, systematics and applications of light elements such as carbon, nitrogen, oxygen, hydrogen, sulfur and boron and some less traditional isotopic systems. Applications include marine and terrestrial paleoclimate proxies and some uses for ecology and paleoecology.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 5675

Requisites: Requires prerequisite course of CHEM 1113 (minimum grade C-).

Grading Basis: Letter Grade

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

GEOL 4747 (3) Unconventional Resources

To introduce the concepts, principles, methods, and techniques of unconventional reservoirs. Unconventional reservoirs can be defined informally as those reservoirs that need artificial stimulation to produce. Accumulations in conventional traps are due to buoyancy. Seven common kinds of unconventional reservoirs: tight-gas sandstones, shale gas, shale oil, coal-bed methane, heavy-oil sands, oil shale, gas hydrates. Formerly offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: GEOL 5747

Requisites: Requires prerequisite courses of GEOL 2001, GEOL 2005, GEOL 2700, and GEOL 3430 (all minimum grade C-).

GEOL 4840 (1-3) Independent Study in Geology

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4841 (1-3) Independent Study-Economic Geology

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4844 (1-3) Independent Study-Structure/Tectonics

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4845 (1-3) Ind Study-Geochemistry

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4846 (1-3) Independent Study-Geophysics

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4847 (1-3) Independent Study-Hydrology

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4849 (1-3) Independent Study-Paleontology

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

Repeatable: Repeatable for up to 7.00 total credit hours.

GEOL 4851 (1-3) Independent Study in Geoscience Education

Repeatable: Repeatable for up to 3.00 total credit hours.