

# GEOL - GEOLOGY

## GEOL412 Geology of the Terrestrial Planets (3 Credits)

Geological features of Mercury, Venus, Mars and the Moon with an emphasis on results from recent NASA planetary mission. Topics include interior structure, impact cratering, tectonic and volcanic history, surface conditions, climate change, and habitability.

**Prerequisite:** GEOL341 or GEOL340.

**Credit Only Granted for:** GEOL489A or GEOL412.

**Formerly:** GEOL489A.

## GEOL413 Geoscientific Modeling (3 Credits)

A model is a simplified representation of reality. Modeling is implicit or explicit in almost everything we do as geoscientists. Model construction, coding, and the concepts of parsimony vs complexity, robustness, validation, uncertainty, and the scientific interpretation of simulation results. Problem sets, independent study and participatory discussion of modeling applications in the current literature.

**Prerequisite:** MATH115; and two 400-level GEOL courses.

**Recommended:** Some experience in computer programming.

**Restriction:** Non-degree-seeking students require the permission of the instructor. Jointly offered with: GEOL613.

**Credit Only Granted for:** GEOL413, GEOL489G, GEOL613 or GEOL789G.

**Formerly:** GEOL489G.

## GEOL423 Optical Mineralogy (4 Credits)

The optical behavior of crystals with emphasis on the theory and application of the petrographic microscope.

**Prerequisite:** GEOL100 or GEOL120; and GEOL110; and GEOL322. And CHEM131 and CHEM132; or (CHEM135 and CHEM136); or CHEM103.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

## GEOL431 Vertebrate Paleobiology (4 Credits)

A survey of the evolution of the vertebrates, encompassing information from the diversity of living members, but concentrating on the contribution of the fossil record. Emphasis is on the phylogenetic systematics, comparative and functional anatomy, developmental biology, and stratigraphic distribution of major extinct and extant groups.

**Prerequisite:** BSCI207, BSCI392, GEOL104, GEOL204, or GEOL331; or permission of CMNS-Geology department.

## GEOL435 Environmental Geochemistry (3 Credits)

An understanding of geochemical cycles of Earth's surface systems including soils, rivers, lakes, and estuaries and causes and implications of alteration of geochemical cycles. Topics include chemical weathering, soils, chemical composition of inland waters, hydrologic tracers, salinization, eutrophication, nutrient and metal pollution, and global geochemical cycles.

**Prerequisite:** MATH115; and (GEOL100 or GEOL120); and (GEOL436 or GEOL444). And CHEM131 and CHEM132; or (CHEM135 and CHEM136).

**Restriction:** Nondegree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL489W or GEOL435.

**Formerly:** GEOL489W.

## GEOL436 Principles of Biogeochemistry (3 Credits)

An introduction to the basic principles of biogeochemistry including aspects of organic geochemistry, biochemistry, microbiology, global geochemical cycles, the origin of life and paleoenvironmental evolution.

**Prerequisite:** MATH120 or MATH140; or must have completed MATH220. And (GEOL100 or GEOL120); and GEOL322. And CHEM131 and CHEM132; or (CHEM135 and CHEM136).

**Restriction:** Non-degree-seeking students require the permission of the instructor. Cross-listed with: AOSC436.

**Credit Only Granted for:** GEOL436 or AOSC436.

## GEOL437 Global Climate Change: Past and Present (3 Credits)

Introduction to the processes by which climate varies, the paleoclimate record, and projections of climate change into the 21st century, including discussion of climate sensitivity to external radiative forcing.

**Prerequisite:** MATH115 or MATH140; and (GEOL100 or GEOL120); and (CHEM131 or CHEM135); and (CHEM132 or CHEM136). Cross-listed with: AOSC437.

**Credit Only Granted for:** AOSC437 or GEOL437.

## GEOL443 Petrology (4 Credits)

Study of igneous and metamorphic rocks: petrogenesis, distributions, chemical and mineralogical relations, macroscopic and microscopic descriptions, geologic significance.

**Prerequisite:** GEOL322. And CHEM131 and CHEM132; or (CHEM135 and CHEM136); or CHEM103. And must have completed or be concurrently enrolled in GEOL423; and (GEOL100 or GEOL120); and GEOL110.

**Corequisite:** Permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

## GEOL444 Low Temperature Geochemistry (4 Credits)

Basic chemical principles, thermodynamics, and kinetics of low-temperature inorganic and organic geochemical reactions in a wide range of surface environments. These geochemical tools will be used to provide a context for understanding elemental cycling and climate change.

Laboratories will include problem sets as well as wet chemical and mass spectrometric techniques used in low temperature geochemistry.

**Prerequisite:** GEOL322, GEOL100, and MATH115. And CHEM103; or (CHEM131 and CHEM132); or (CHEM135 and CHEM136).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

## GEOL445 High Temperature Geochemistry (4 Credits)

Review of chemical principles and their use in understanding processes of Earth, and solar system formation and differentiation. Topics include nucleosynthesis and cosmochemical abundances of elements, bonding and element partitioning, equilibrium thermodynamics and phase stabilities, radiogenic isotopes and geochronology, kinetics, and diffusion.

**Prerequisite:** GEOL322, GEOL100, and MATH115. And CHEM131 and CHEM132; or (CHEM135 and CHEM136); or CHEM103.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

## GEOL446 Geophysics (3 Credits)

An introduction to modern geophysics. Topics include: global plate tectonics, plate motion, triple junctions, geomagnetism, earthquakes and faulting, reflection and refraction seismology, gravity and isostasy, heat flow and mantle dynamics, deep interior of the Earth, geophysical observations and measurements.

**Prerequisite:** PHYS141, MATH141, and MATH140; and (GEOL100 or GEOL120).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL447 Observational Geophysics (3 Credits)**

An introduction to practical signal processing, data analysis, and inverse theory in geophysics.

**Prerequisite:** MATH140 and MATH141; and (PHYS141, PHYS161, or PHYS171).

**GEOL451 Groundwater (3 Credits)**

An introduction to the basic geologic parameters associated with the hydrologic cycle. Problems in the accumulation, distribution, and movement of groundwater will be analyzed.

**Prerequisite:** GEOL110 and MATH140; and (GEOL120 or GEOL100); and (CHEM131 and CHEM132; or (CHEM135 and CHEM136); or CHEM103). Or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor; and junior standing or higher.

**GEOL452 Watershed and Wetland Hydrology (3 Credits)**

Physical processes by which water moves in watershed and wetland systems. Topics include: precipitation, infiltration, flow in the unsaturated zone, streamflow generation processes, and groundwater flow.

**Restriction:** Junior standing or higher; and all other students require the permission of the instructor.

**GEOL453 Ecosystem Restoration (3 Credits)**

Overview of ecosystem functions across biomes/geologic settings, and considerations and tradeoffs in ecosystem restoration strategies. Specific case studies and discussions will be aimed at understanding how structure can influence biophysical and biogeochemical processes supporting ecosystems, and then describes how rates, timing, and location of physical, chemical, and ecosystem processes can be altered by different restoration strategies to enhance ecosystem services.

**Prerequisite:** MATH120 or MATH140; or must have completed MATH220. And (CHEM131 or CHEM135); and (CHEM132 or CHEM136); and (GEOL100, GEOL120, or ENST200).

**Restriction:** Junior standing or higher; and permission of instructor is required of non-degree-seeking students.

**Credit Only Granted for:** GEOL453 or GEOL489L.

**Formerly:** GEOL489L.

**GEOL455 Marine Geophysics (3 Credits)**

Plate tectonics, earthquakes and faulting, isostasy and gravity, heat and mantle dynamics, ocean ridges and transform faults, hydrothermal vents, trenches and oceanic islands, subduction zones, accretionary and erosion wedges, sedimentary basins and continental rifts. Exploration of the oceans using geophysical methods.

**Prerequisite:** MATH141 and MATH140; and (GEOL120 or GEOL100). Or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL455 or GEOL489E.

**Formerly:** GEOL489E.

**GEOL456 Engineering Geology (3 Credits)**

An overview of engineering geology with an emphasis on physical understanding of natural hazards and natural resources. General theories of stress and strain, failure criteria, frictional stability, fluid flow in porous media and poroelasticity are introduced. Quantitative approaches on earthquakes, landslides, land subsidence, and geotechnical aspects of oil/gas exploration are discussed.

**Prerequisite:** PHYS141 and MATH141; and (GEOL120 or GEOL100). Or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL456 or GEOL489Z.

**Formerly:** GEOL489Z.

**GEOL457 Seismology (3 Credits)**

General overview of the basics of seismology, starting with wave propagation, seismic reflection and refraction. Applications to the determination of the seismic velocity and anisotropy structure of the Earth. Earthquake generation, postseismic deformation and creep events, relation to faulting and plate tectonics.

**Prerequisite:** GEOL120 or GEOL100; and (MATH141, GEOL110, and MATH140). Or permission of CMNS-Geology department.

**Recommended:** PHYS171, PHYS141, or PHYS161.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL457 or GEOL489A.

**Formerly:** GEOL489A.

**GEOL460 Field Geophysics (4 Credits)**

Students will become familiar with geophysical instrumentation used for both scientific and industrial applications. Students will be given an introduction to the use of geophysical instrumentation for data collection, processing, and analysis, design of field experiments for investigating field geophysical problems, and an introduction to the theory of instrument design and use. Instruments that will be covered include (but are not limited to): broadband seismometers, geophones, ground-penetrating radar, magnetotellurics, and Global Positioning Satellites.

**Prerequisite:** GEOL100 or GEOL120, MATH140, MATH141, and (PHYS141, PHYS161, or PHYS171).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL463 Economic Geology (3 Credits)**

The geological setting, and mineralogy of ore bodies, as well as the chemical and physical factors affecting the source, transport and deposition of metallic ores, petroleum and natural gas will be covered. The economics of mineral resources will be discussed.

**Prerequisite:** GEOL322; and (CHEM131 or CHEM135); and (CHEM132 or CHEM136).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL489Q or GEOL463.

**Formerly:** GEOL489Q.

**GEOL471 Geochemical Methods of Analysis (3 Credits)**

Principles and application of geochemical analysis as applied to a variety of geological problems. X-ray and optical spectroscopy, X-ray diffraction, atomic absorption, electron microprobe, and electron microscopy.

**Prerequisite:** CHEM131 and CHEM132; or (CHEM135 and CHEM136); or CHEM103.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL472 Tectonics (3 Credits)**

Study of the development of the lithosphere on Earth and other rocky planets and moons. Emphasis on student-led discussions. Improvement of scientific writing.

**Prerequisite:** GEOL120 or GEOL100; and (GEOL102, GEOL341, and GEOL110).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL473 Origin and Evolution of the Continents (3 Credits)**

Introduction to current theories regarding the origin and evolution of the continents. Emphasis on development of critical reading and reasoning skills, and improvement of verbal and written communication.

**Prerequisite:** GEOL445 and GEOL443; or permission of instructor.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Formerly:** GEOL489I.

**GEOL488 Geology Colloquium (1 Credit)**

Contemporary research topics and issues in geosciences are explored through the weekly Geology departmental colloquium and discussion of its contents.

**Prerequisite:** At least one 300 or 400-level Geology course of at least 3 credits.

**Restriction:** May not be taken concurrently with GEOL497 or GEOL497H.

**Repeatable to:** 4 credits.

**GEOL489 Special Topics (3 Credits)**

Recent advances in geology.

**Prerequisite:** Must have completed at least 2 upper-level GEOL courses plus one additional GEOL course.

**Corequisite:** GEOL393.

**Restriction:** Must be in Geology program; and junior standing or higher.

**GEOL490 Geology Field Camp (6 Credits)**

Intense field geology course taught off campus during the summer.

Students describe and compile maps of formations and structures from outcrops, subsurface, and remotely sensed data. Special fees required.

**Prerequisite:** GEOL341 and GEOL443.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL491 Environmental Geology Field Camp (3-6 Credits)**

Intensive field course designed for students of environmental geology.

Students will learn to make maps, to describe soil profiles and site characteristics, to monitor hydrologic and groundwater conditions, and to measure geologic structures and stratigraphic sections.

**Prerequisite:** GEOL341, GEOL342, and GEOL451; or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL490 or GEOL491.

**GEOL497 Recent Advances: Geology (3 Credits)**

A survey of important recent advances in geological sciences in the context of the methods and practices of scientific research.

**Prerequisite:** Must have completed at least 2 upper-level GEOL courses.

**Corequisite:** GEOL393; and a third upper-level geology course.

**Restriction:** Must be in Geology program; and GPA of 3.0 or better in both overall and in all courses required for the major; and senior standing; and to be taken as late as possible in the program.

**Credit Only Granted for:** GEOL497 or GEOL489H.

**Formerly:** GEOL489H.

**GEOL499 Special Problems in Geology (1-3 Credits)**

Intensive study of a special geologic subject or technique selected after consultation with instructor. Intended to provide training or instruction not available in other courses which will aid the student's development in his or her field of major interest.

**Prerequisite:** (GEOL120 or GEOL100; and (GEOL102 and GEOL110)); or students who have taken courses with comparable content may contact the department. And permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL612 Geology and Geophysics of the Terrestrial Planets (3 Credits)**

Geological features of Mercury, Venus, Mars and the Moon with an emphasis on results from recent NASA planetary mission. Class is organized to follow geological processes or observation throughout the inner solar system. Topics covered include interior structure, impact cratering, tectonic and volcanic history, surface conditions and climate change.

**Prerequisite:** Permission of CMNS-Geology department; or (GEOL446 and MATH141).

**Recommended:** Familiarity with MATLAB or MATHEMATICA.

**Credit Only Granted for:** GEOL680 or GEOL789A.

**Formerly:** GEOL789A.

**GEOL613 Geoscientific Modeling (3 Credits)**

A model is a simplified representation of reality. Modeling is implicit or explicit in almost everything we do as geoscientists. Model construction, coding, and the concepts of parsimony vs complexity, robustness, validation, uncertainty, and the scientific interpretation of simulation results. Problem sets, independent study and participatory discussion of modeling applications in the current literature.

**Prerequisite:** Must have completed MATH115 or equivalent; and any two 400 level GEOL courses, or equivalent. Or permission of instructor.

**Recommended:** Some experience in computer programming will be helpful but not necessary.

**Restriction:** Non-degree-seeking students require the permission of the instructor. Jointly offered with: GEOL413.

**Credit Only Granted for:** GEOL413, GEOL489G, GEOL613 or GEOL789G.

**Formerly:** GEOL789G.

**GEOL614 Thermodynamics of Geological Processes (3 Credits)**

Thermodynamics and its application to problems in mineralogy, petrology and geochemistry. Systematic development of the laws of thermodynamics and the principles of chemical equilibrium as applied to geological problems.

**Prerequisite:** PHYS142, GEOL322, and MATH141; and must have completed CHEM113.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL615 Planetary Habitability and Surface Chemistry (3 Credits)**

Introduction to emerging areas of research pertaining to the formation of planetary bodies, the evolution of habitable environments, and the capacity of life to emerge in environments found within and/or outside of our Solar System.

**Prerequisite:** GEOL445; or permission of instructor.

**Credit Only Granted for:** GEOL615 or GEOL789B.

**Formerly:** GEOL789B.

**GEOL635 Environmental Geochemistry (3 Credits)**

Geochemical cycles of Earth's surface systems including soils, rivers, lakes, and estuaries and causes; and implications of their alteration. Topics include chemical weathering, soils, chemistry of inland waters, hydrologic tracers, salinization, eutrophication, nutrient and metal pollution, and global geochemical cycles.

**Prerequisite:** MATH115; and (GEOL100 or GEOL120); and (GEOL436 or GEOL444). And CHEM131 and CHEM132; or (CHEM135 and CHEM136).

**Restriction:** Nondegree-seeking students require the permission of the instructor. Jointly offered with GEOL435.

**Credit Only Granted for:** GEOL635, GEOL789W, GEOL435 or GEOL489W.

**Formerly:** GEOL789W.

**GEOL636 Ecosystem Restoration (3 Credits)**

A further understanding of ecosystem functions across biomes/geologic settings, and developing practical applications in ecosystem restoration strategies through a graduate level project. Specific case studies and discussions will be aimed at understanding how structure can influence biophysical and biogeochemical processes supporting ecosystems, and then describes how rates, timing, and location of physical, chemical, and ecosystem processes can be altered by different restoration strategies to enhance ecosystem services. A project will then be used to apply restoration principles towards solving tangible environmental problems and communication to managers.

**Prerequisite:** MATH120 or MATH140; and (CHEM131 or CHEM135); and (CHEM132 or CHEM136); and (GEOL100, GEOL120, or ENST200).

**Restriction:** Equal preference is given to students enrolled in GEOL, MEES, CONS, ENST, AOSC, and civil and environmental engineering graduate programs; and permission of Instructor required for non degree seeking students.

**Credit Only Granted for:** GEOL453 or GEOL489L.

**Formerly:** GEOL489L.

**GEOL647 Observational Geophysics (3 Credits)**

Introduces graduate students to instrument design and performance, signal processing, data analysis and inverse theory in geophysics.

**Prerequisite:** MATH140, MATH141, and PHYS141; and (PHYS161 or PHYS171).

**Credit Only Granted for:** GEOL7890 or GEOL647.

**Formerly:** GEOL7890.

**GEOL650 Isotope and Trace Element Geochemistry (3 Credits)**

Trace elements and isotopes in geology, including modern applications in geochronology and petrogenesis.

**Prerequisite:** GEOL443; or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL651 Statistics for Geoscientists (3 Credits)**

Practical approach to basic statistics applied in the geosciences. Experimental design, elementary statistics and probability, sequence analysis, spatial analysis, linear regression, nonparametric statistics, bivariate, multivariate and principal components analysis of variance, hypothesis testing. Problem sets and participatory discussion of statistical applications in the current literature.

**Prerequisite:** MATH115; and non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL789V or GEOL651.

**Formerly:** GEOL789V.

**GEOL652 Advanced Watershed and Wetland Hydrology (3 Credits)**

Physical and chemical processes in watershed and wetland systems; with an emphasis on redox reactions.

**Prerequisite:** GEOL452; or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL653 Advanced Problems in Economic Geology (3 Credits)**

A systematic study of particular ore deposit types or areas of mineralization, primarily involving major economically important metals. Geologic setting, mineralogy and form and character of the ore bodies, chemical and physical factors affecting source, transport and deposition of ore forming fluids.

**Prerequisite:** GEOL453.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL654 Fluvial Geomorphology Seminar (3 Credits)**

Fluvial geomorphology is the study of the movement of water and sediment in stream channels. This includes: formation of channels, open channel hydraulics, sediment transport or bedload and suspended load, river morphology and landscape evolution. The course is designed for graduate students and advanced undergraduates.

**Recommended:** GEOL452 and GEOL340.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL654 or GEOL789B.

**Formerly:** GEOL789B.

**GEOL655 Marine Geophysics (3 Credits)**

An introduction to geophysical aspects of global tectonics. Quantitative geophysical approaches are introduced for: past and present plate motions, seismology and interior of the Earth, gravity and isostasy, heat and mantle dynamics. Ocean ridges, hydrothermal vents, transform faults, oceanic core complex, ocean trenches and subduction zones, accretionary and erosion wedges, rift and rift margins, convergence and collisions, sedimentary basins.

**Prerequisite:** Permission of CMNS-Geology department.

**Recommended:** GEOL120 or GEOL100; and MATH141.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL655 or GEOL789E.

**Formerly:** GEOL789E.

**GEOL656 Engineering and Environmental Geology (3 Credits)**

An overview of mechanical aspects of earthquakes as a result of fault instability. Quantitative approaches on soil and rock strength, instability on earthquakes, landslides, land subsidence, and geotechnical aspects of oil/gas exploration are discussed. Emphasis is on theoretical framework of mechanics of earthquake and faulting, earthquake source mechanisms, earthquake scaling relations, the seismic cycle etc.

**Prerequisite:** GEOL100, GEOL110, MATH141, and PHYS141; or permission of instructor.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL656 or GEOL789Z.

**Formerly:** GEOL789Z.

**GEOL657 Seismic Wave Propagation (3 Credits)**

A description of the physics of seismic wave propagation and their applications to the determination of the structure of the Earth and the mechanics of earthquakes.

**Prerequisite:** MATH140 and MATH141; and (PHYS141, PHYS161, or PHYS171); and permission of CMNS-Geology department.

**Recommended:** GEOL100 or GEOL120; and (MATH241 and MATH246); and (PHYS260 or PHYS273).

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL657 or GEOL789A.

**Formerly:** GEOL789A.

**GEOL670 Physical Oceanography (3 Credits)**

Ocean observations. Water masses, sources of deep water. Mass, heat, and salt transport, geochemical tracers. Western boundary currents, maintenance of the thermocline. Coastal and estuarine processes. Surface waves and tides. Ocean climate.

**Prerequisite:** Permission of CMNS-Atmospheric & Oceanic Science department; or permission of CMNS-Geology department. Cross-listed with: AOSC670.

**Credit Only Granted for:** GEOL670, AOSC670 or AOSC420.



**GEOL671 Analytical Methods in Mineralogy (3 Credits)**

An intensive study in the operation and application of instrumentation in mineralogical problems. Emphasis on designing and testing methods of analysis for use in the student's research problems in geology.

**Prerequisite:** CHEM471.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**GEOL672 Tectonics (3 Credits)**

The study of the development of the lithosphere on Earth and other rocky planets and moons. Emphasis on the student led discussion and improvement of scientific writing.

**Prerequisite:** GEOL341; or permission of CMNS-Geology department.

**Restriction:** Non-degree-seeking students require the permission of the instructor.

**Credit Only Granted for:** GEOL672 or GEOL789C.

**Formerly:** GEOL789C.

**GEOL680 Geodynamics (3 Credits)**

The mechanics and dynamics of the Earth's interior and their applications to problems of Geophysics. This course considers several rheological descriptions of Earth materials (brittle, elastic, linear and nonlinear fluids, and viscoelastic) and emphasizes analytical solutions to simplified problem.

**Prerequisite:** Permission of CMNS-Geology department; or (MATH241, MATH462, and GEOL446).

**Recommended:** Familiarity with MATLAB or MATHEMATICA.

**Credit Only Granted for:** GEOL680 or GEOL789J.

**Formerly:** GEOL789J.

**GEOL681 Physics of Planetary Interiors and Surfaces (3 Credits)**

Formation of planets in the solar system; segregation and core formation in terrestrial planets; formation of early atmosphere; tectonics and volcanism; geochemical and cosmochemical constraints; planetary geomorphology.

**Prerequisite:** Advanced undergraduate geophysics, astronomy or geochemistry; and GEOL446. Or permission of CMNS-Geology department.

**Credit Only Granted for:** GEOL681 or GEOL789X.

**Formerly:** GEOL789X.

**GEOL682 Computational Geodynamics (3 Credits)**

An introduction to the techniques used to model geodynamics processes. The focus is on understanding and applying techniques, not on proving their worth and programming. Students will learn about Finite Element, Boundary Elements, and Finite Differences methods. We will not explore these topics with the rigor expected by Applied Mathematics but focus instead on practical aspects and their application to geodynamics.

**Prerequisite:** Permission of CMNS-Geology department; or (MATH462, GEOL680, and MATH240).

**Recommended:** Familiarity with MATLAB.

**Credit Only Granted for:** GEOL682 or GEOL789M.

**Formerly:** GEOL789M.

**GEOL683 Cosmochemistry (3 Credits)**

Introduction to current theories behind the origin, age and evolution of our solar system. The primary focus will be on the interpretation of petrologic, chemical and isotopic data obtained from meteorites, and planetary materials collected by sample return missions to the Moon and asteroids. Includes in-depth discussion of the mechanisms of formation of the asteroids and planets and the origin of the Moon and Mars. Includes hands-on examination of lunar samples from the Apollo missions as well as various types of meteorites.

**Recommended:** GEOL650.

**Credit Only Granted for:** GEOL683 or GEOL789K.

**Formerly:** GEOL789K.

**GEOL688 Geology Colloquium (1 Credit)**

Contemporary research topics and issues in geosciences are explored through the weekly Geology departmental colloquium and discussion of its contents.

**Restriction:** Restricted to graduate students in Geology who have not yet advanced to PhD candidacy. Repeatable for credit with changing content. May not be taken for credit concurrently with GEOL497 or GEOL497H.

**Repeatable to:** 4 credits.

**GEOL690 Geoscience Communications (3 Credits)**

Explores the style and logic of scientific writing including abstracts, articles, and proposals, as well as the preparation of clear and concise presentations, in order to enhance the quality of scientific communication and hasten the pace of successful publications.

**Credit Only Granted for:** GEOL690, GEOL789R, or GEOL789S.

**Formerly:** GEOL789R and GEOL789S.

**GEOL789 Recent Advances in Geology (2-4 Credits)**

Recent advances in geology research.

**GEOL798 Seminar in Geology (1-3 Credits)**

Discussion of special topics in current literature in all phases of geology.

**Repeatable to:** 9 credits if content differs.

**GEOL799 Master's Thesis Research (1-6 Credits)****GEOL898 Pre-Candidacy Research (1-8 Credits)****GEOL899 Doctoral Dissertation Research (1-8 Credits)**