

Geology Department Courses Spring 2010



The Grand Teton Mountains of Wyoming. Seventy million years ago, when dinosaurs roamed the earth, the land seen here lay beneath the sea. Today, the Tetons reach more than 13,500 feet above sea level.

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Geology is . . .

Geology is the science of the earth. It is an interdisciplinary exploration of our planet's 4.5 billion year history, and a study of the dynamic processes that form and continuously modify the rocks and minerals of the earth.

Geologists study earthquakes, volcanic eruptions, rock deformation, and the motion of enormous earth plates. They seek to understand the origin and occurrence of mineral and fuel resources, the evolution of the oceans and their interaction with land, and the delicate interplay of human and geological environments. They investigate glaciers, landforms, water resources, the development of life as revealed in the fossil record, and many other areas as well.

Geological studies take place in the field and laboratory; they may depend on a rock hammer, compass, and map, or on a microscope, X-ray spectrograph, or other sophisticated analytical equipment. These studies are as varied and interesting as scientific curiosity will allow, and deal with every facet of the development of the earth through the past, present, and on into the future.

Come join us for a semester-long exploration of the geological world around us!

Geology Programs at Tufts

Concentration Recommendations

The Geology Department offers two programs: the Geological Sciences major, intended for students who wish to pursue graduate study in geology and related fields or entry level employment; and the Geology major, which emphasizes breadth and flexibility for students seeking a double major, teaching certification, medical programs, careers in multidisciplinary fields such as environmental law, or a broad-based liberal arts major.

Geological Sciences Major

Students intending to continue with geology after graduation should complete Geology 1 and 2, eight or more geology courses above Geology 9, plus Math 12, Chemistry 2, and Physics 1 and 2 (or 11 and 12) and their labs. The geology courses should normally include Geology 11, 12, 22, 32, 35, and at least one of the following: Geology 36, 102, 115, or 131. Approved related fields courses may replace up to two upper level geology courses. Research experience and a six-week geology summer field camp are strongly recommended.

Geology Major

Students electing this option should complete Geology 1 and 2, eight other geology courses (except Geology 9), plus Chemistry 1 and Physics 1 with labs. Approved related fields science courses may replace as many as three of the upper level geology courses. Upper level engineering courses may substitute for up to two of the upper level geology courses with prior written consent.

There are 2 minors available. Engineering students may do the Geology Minor, and Liberal Arts students already majoring in Biology, Chemistry, Mathematics, Computer Science, Physics, or Archaeology may do the Geosciences Minor. Consult with Professor Anne Gardulski for more information.

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Students considering a major in GEOLOGY or GEOLOGICAL SCIENCES should discuss their course selections with one of the professors in the Geology Department. This is particularly important because upper level courses are offered in alternate years. Careful planning will give students the opportunity to participate in more course offerings, optional field trips, and student-faculty research as an undergraduate.

Geology Course Suggestions for Spring 2010

Geology

Completed

No previous Geology
 Geology 1 only
 Geology 2 only
 Geology 1 and 2
 Geology 1, 2, and 32
 Geology 131/CE113 and Chem 1
 Graduate Standing

Course Suggestions

Geology 2 and/or Geo 192-04
 Geology 2 and/or Geo 22
 Geology 36 and/or Geo 192-04
 Geology 22 and 36
 Geology 22 and 36
 Geology 132
 Geology 188

Environmental geology is an introduction to geologic environments and the processes that shape and modify the earth's surface. Of particular interest are the roles of water, ice, wind, and gravity and their effects in different surface environments and climates. These modern surficial processes strongly influence humans and their ability to live and interact with their surroundings. They also provide us with much of the evidence for interpreting ancient geologic environments, allowing us to understand how the earth has evolved over time and to predict the changes we can expect it to undergo in the future.

Specific topics covered in environmental geology include an overview of earth materials, groundwater and processes of the hydrologic cycle. Also considered from a geological and human perspective are weathering and erosion, landslides, river and shoreline systems, and environments ranging from arid to periglacial (cold climate). The past history of the earth is deciphered in terms of the evolution of the atmosphere and world ocean, climate and sea level change over geologic time, and the activity of modern and ancient glaciers.

The course has three lectures plus one lab period per week. Laboratories include three field trips in the Boston area to investigate local sedimentary rock sequences, glacial deposits, and modern coastal environments.

No Prerequisite

<u>Lecture Section</u>	<u>Time Block</u>	<u>Instructor</u>
01	C	Jack Ridge
02	E	Jack Ridge

<u>Lab Section</u>	<u>Time Block</u>	<u>Instructor</u>
LA	5+	Labs will be taught by: Jack Ridge, Anne Gardulski Jake Benner, Molly McCanta
LB	6+	
LC	7+	
LD	8+	
LE	9+	

Deformation of the earth's crust occurs on all scales, from microscopic crystal lattice dislocations to huge structures such as the San Andreas Fault that are hundreds of kilometers long. This course will address different aspects of structural analysis, with the ultimate goal of understanding structures in hand samples and outcrops as well as the regional and tectonic significance of structurally deformed rocks.

The structure course is organized into three major sections and will begin with methods of evaluating the strain or deformation in rocks. Quantification of stretching or compression of geologic structures will be undertaken through geometrical construction, as well as measurement and calculation. The array of structures that can occur in rocks, including folds, faults, joints, and cleavage, will be discussed in the second section of the course. Structural information from folds, for example, can be gleaned from many characteristics, such as the fold orientation and relative thicknesses of limbs and hinges. The last section will be concerned with dynamic analysis of structures, the orientations and magnitudes of stresses that produced deformation. Finally, the tectonic context of structures will complete the semester.

A field mapping project, involving a required weekend trip in early April, will allow you to study certain structures in their natural setting. Weekly laboratory exercises and field trips will emphasize experimentation and practical techniques for structural study and interpretation.

Prerequisite: Geology 1

Three lectures and one laboratory or field trip per week.

<u>Lecture</u>	<u>Lab</u>	<u>Instructor</u>
C	6	Anne Gardulski

One of the fundamental goals of geology is to reconstruct environments and events in the Earth's history. Many features in sedimentary and interlayered volcanic rocks record events such as mountain-building episodes, sea level changes, extinctions, and the splitting apart of continents at rifts. Stratigraphy encompasses the study of how depositional environments change in time and space, by examining the lateral and vertical variations in the rocks deposited in these environments.

Further information about tectonic settings can be derived by examining how these environments were assembled. For example, by studying sections of Devonian rocks over a large area of New York and Pennsylvania, the transitions of shallow-water limestones can be identified - demonstrating the presence of a large shallow sea in the northeastern United States 400 million years ago. The influence of a rising mountain range to the east is evident in the increasing amounts of siliciclastic sand in the younger sedimentary rocks. Careful reconstruction of the environments reveals the onset of the collision between North America and Gondwana (Africa and Europe), leading to uplift of the Appalachian Mountains.

The Stratigraphy course will be process-oriented. That is, we will address the types of depositional processes that operate in various marine and continental environments, and we will integrate the tectonic, climatic, and oceanographic processes and events that may lead to changes in the environments. Recognition criteria for many common sedimentary systems will be presented. In addition to these descriptive aspects, the course will deal with methods for analyzing "time slices" through reconstructed environments and how to track the changing environments through time.

Stratigraphic studies require a detailed record of the timing of sedimentary depositional units. A number of techniques can provide such age constraints, such as isotopic compositions of certain fossils (isotope stratigraphy), radiometric dating of interbedded volcanic units, the pattern of polarity changes recorded in magnetic minerals (magnetostratigraphy), and assemblages of fossils in the strata (biostratigraphy). These methods and others will be studied to resolve sedimentary correlation problems and to evaluate and effects of events such as change in sea level, from one location to another.

Prerequisite: Geology 2 (Geology 35 is helpful but not required. See Anne Gardulski for details.)

Two lectures per week. There will be one required weekend field trip.

Lecture

Instructor

D+ TR

Anne Gardulski

A Geographic Information System (GIS) is a computer-based tool which combines the capabilities of a computerized mapping program with a powerful database. GIS allows geographic data to be visualized, manipulated, and queried quickly and easily. A GIS can analyze spatial relationships and aid in solving complex analytical problems that would be nearly impossible, if not time consuming, otherwise. Urban planners have used GIS for decades, and now its usage is becoming wide spread in the natural sciences.

This course covers the basic functions of the ESRI software program "ArcGIS" with a particular focus on geological applications. Assignments are derived from the textbook "Getting to Know ArcGIS", and tailor made geologic tutorials. The geologic tutorials are designed for upper level geology majors who are familiar with the concepts and methods involved in geologic interpretation.

With this software, you will learn how to manipulate and display complex data as maps, charts, and graphs. Technical skills learned in this class are readily applied to geological and environmental fields.

Prerequisite: Geo 1 or Geo 2, one upper level course or consent of the instructor.

One-half credit

One class meeting per week

Class

F + R

Thurs: 12:00 – 1:15

Instructor

Jacob Benner

Geology 132

Groundwater Chemistry and Quality

Spring 2010

Hydrogeologic processes affecting the chemistry and quality of groundwater. Topics include: chemical principles; geochemical thermodynamics; mineral solubility; oxidation-reduction; ion exchange/sorption; isotopes and age dating; diffusion and dispersion in soil, sediment and fractured rock; numerical modeling of reactions and solute transport; geologic characterization; measures of water quality; case studies of contamination, nuclear-waste disposal, and carbon sequestration.

Co-listed CE-194-A

Prerequisites: Geo 131/CE 113 and Chem. 1

Lecture

K + MW

Instructor

Grant Garven

Geology 188

Groundwater Modeling

Spring 2010

Numerical analysis of groundwater flow, with applications. Topics include: numerical formulation of the governing equations using finite difference, finite element, integrated finite difference, particle tracking, boundary element, and discrete element techniques; matrix and iterative solutions; algorithms for 1-D, 2-D, and 3-D flow; stability and accuracy; applications using popular software in the public domain. Students may be expected to program 1-D solutions. *Garven*

Co-listed CE 294-B

Graduate standing

Lecture

E+ MW

Instructor

Grant Garven

Geo 192

Ring of Fire: Volcanoes

Spring 2010

This course will examine the physical and chemical mechanisms responsible for volcanologic phenomena on earth and other geologically active planets in our solar system. Students will learn about the causes of volcanic activity, the physical and chemical properties of magmas and their influence on eruptive activity, the physiographic expression of volcanic features, and the effects of volcanoes on humankind. There are no prerequisites for this course. It meets twice a week.

This course is not a substitute for GEO 1, 2.

Lecture

E+ MW 10:30-11:45 AM

Instructor

Molly McCanta

Geology 92 Geological Research

Guided laboratory and field research on one of a broad range of geological topics. Five hours (half-credit option) to ten hours (full-credit option) are required per week, including one hour of consultation with the research supervisor. Final written or oral presentation. Does not count toward the concentration in geology.

Prerequisite: Consent

Instructor: Members of the Department

Geology 194 Senior Thesis

Intensive laboratory or field investigations designed and carried out by the student, culminating in a written thesis and oral defense.

Prerequisites: Consent

Instructor: Members of the Department

Projected Course Offerings for Spring 2010 through 2012

Spring 2010

GEO 2 Environmental Geology
GEO 22 Structural Geology
GEO 36 Stratigraphy
GEO 104 Geol. Applications of GIS
GEO 132 Groundwater Chem & Quality
GEO 188 Groundwater Modeling
GEO 192 Ring of Fire: Volcanoes

Fall 2010

GEO 1 The Dynamic Earth
GEO 11 Mineralogy
GEO 115 Quaternary & Glacial Geol.
GEO 131 Groundwater

Spring 2011

GEO 2 Environmental Geology
GEO 12 Igneous/Meta. Petrology
GEO 35 Sedimentology
GEO 104 Geol. Applications of GIS
GEO 132 Groundwater Chem. & Quality

Fall 2011

GEO 1 The Dynamic Earth
GEO 32 Geomorphology
GEO 38 Historical Geol/Paleontology
GEO 131 Groundwater

Spring 2012

GEO 2 Environmental Geology
GEO 22 Structural Geology
GEO 36 Stratigraphy
GEO 104 Geol. Applications of GIS
GEO 132 Groundwater Chem. & Quality
GEO 188 Groundwater Modeling

The following courses will be offered each year:

Geo. 91, 92 Undergraduate Research
Geo. 191, 192 Selected Topics
Geo. 193, 194 Senior Thesis

Projected offerings are our best estimate of which courses will be taught in future semesters and are not guaranteed.

All Course Offerings

1 The Dynamic Earth. Origin and occurrence of rocks and minerals of the earth's crust. Dynamic processes which form mountains, canyons, and ocean basins. Topics include volcanic eruptions, earthquakes, rock deformation, energy and mineral resources, plate tectonics, geologic time, and the geology of selected national parks. Three lectures, one field trip or laboratory. Fall. *Gardulski, Ridge, McCanta, Benner*

2 Environmental Geology. Geologic processes at the earth's surface. Groundwater, the development of erosional and depositional landforms, glaciation and climate, and sea level change. Modern geologic environments as analogs for past environments and climate. Geologic processes and humans. Field trips illustrating glacial and coastal environments. Three lectures, one field trip or laboratory. Spring. *Ridge, McCanta, Benner*

5 Introduction to Oceanography. Physical, geological, biological, and chemical aspects of the world ocean. Origin of ocean basins, currents, tides, waves, biological productivity, and marine sedimentation in the shallow to deep realm. Influence of human activity along coasts. Prerequisite: high school chemistry. *Gardulski*

11 Mineralogy. Physical and chemical properties, formation, and geologic occurrence of important economic and rock-forming minerals. Introduction to the use of the polarizing microscope. Laboratory emphasis on mineral identification and morphological crystallography. Three lectures, one laboratory. Fall 2010 and alternate years. Prerequisite: Geology 1 (may be taken concurrently) or consent. *McCanta*

12 Igneous and Metamorphic Petrology. Classification, occurrence, and origin of igneous and metamorphic rocks. Laboratory emphasis on hand specimen and microscope identification and interpretation. Three lectures, one laboratory or field trip. Spring 2011 and alternate years. Prerequisite: Geology 11 or consent. *McCanta*

22 Structural Geology. Deformation of the earth's crust. Stress and strain analysis, plate tectonic theory, and description and interpretation of deformational structures in rocks. Kinematic analysis of structures, reinforced by fieldwork to study rock structures in their natural setting. Three lectures, one field trip or laboratory. Spring 2010 and alternate years. Prerequisite: Geology 1. *Gardulski*

32 Geomorphology. Morphogenesis of landscapes. Classical through modern denudation theories. Weathering, soil formation, erosion, and deposition as influenced by climate, tectonics, and rock composition. Three lectures, one laboratory. Fall 2011 and alternate years. Prerequisite: Geology 2 or consent. *Ridge*

35 Sedimentology. Origin, deposition, and lithification of siliciclastic and carbonate sediments. Sedimentary rock description and classification, water and wind as transport agents, provenance, diagenesis, sedimentary structures, and statistical analysis of sediment grain parameters. Three lectures, one laboratory or field trip. Spring 2011 and alternate years. Prerequisite: Geology 2 or consent. *Gardulski*

36 Stratigraphy. Basic stratigraphic principles applied to subaerial to deep marine environments. Tectonic, climatic, and oceanographic processes that control sedimentation patterns. Correlation techniques using biostratigraphy, isotope stratigraphy, seismic stratigraphy, and magnetostratigraphy. One or two weekend field trips. Spring 2010 and alternate years. Prerequisite: Geology 2 or consent. *Gardulski*

38 Paleontology: Historical Geology. Introduction to the origin, evolution, morphology, and paleoecology of life forms throughout the history of the earth. Laboratory emphasis on description, classification, and recognition of the most important index fossils of North America. Fall 2011 and alternate years. Prerequisite: Geology 1 and 2 or consent. *Benner*

91, 92 Geological Research. Guided laboratory and field research on one of a broad range of geological topics. Five hours (half-credit option) to ten hours (full-credit option) are required per week, including one hour of consultation with the research supervisor. Final written or oral presentation. Does not satisfy concentration in geology. Prerequisite: consent. *Members of the department*

Courses for Undergraduate and Graduate Students

102 Petrographic and X-ray Analysis. Origin of igneous, sedimentary, and metamorphic rocks based on field, hand specimen, thin section, and X-ray data. X-ray powder diffraction and X-ray fluorescence analysis. Research based on field and laboratory work. Three lectures, one laboratory. Prerequisite: Geology 12 or consent.

103 Geological Applications of SEM Analysis. Theory and use of the scanning electron microscope and energy-dispersive analyzer applied to study of minerals, rocks, crystals, fossils, archaeological objects, and other solid materials. Individual research projects using imaging, qualitative, and quantitative methods. Oral presentation in lieu of final exam. One-half course credit. One lecture and two hours lab per week. Prerequisites: Geology 1 and 2, permission of the instructor, and two of the following geology courses: Geology 11, 12, 32, 35, 36, 115.

104 Geological Applications of GIS. Basic Geographic Information Systems (GIS) theory and application in the geological sciences. A series of self-directed tutorials in basic GIS skills complemented by a weekly lecture and geological extension exercise. A final independent project focused on a geological application of GIS will reinforce and extend basic skills. Final project to be presented in lieu of final exam. One half course credit. Spring. Prerequisite: Geo 1 or 2, and one upper level Geology course. *Benner*

115 Quaternary and Glacial Geology. Climatic oscillation and glaciation of the past three million years. Glacial effects on landscapes, oceans, and organisms. Glacial processes and deposits. Techniques used to study chronology, environments, climatic change, and recent deposits, including isotopes, dating, fossil analysis, and paleomagnetism. Fall 2010 and alternate years. Prerequisite: Geology 2 or consent. *Ridge*

131 Groundwater. Water in geologic systems. Budget analysis, groundwater flow, aquifers, and natural water chemistry. Fundamental concepts for environmental and engineering groundwater analyses. Fall. Prerequisite: One calculus course and one geology course, or consent. *Garven*

132 Groundwater Chemistry and Quality. Hydrogeologic processes affecting the chemistry and quality of groundwater. Topics include: chemical principles; geochemical thermodynamics; mineral solubility; oxidation-reduction; ion exchange/sorption; isotopes and age dating; diffusion and dispersion in soil, sediment and fractured rock; numerical modeling of reactions and solute transport; geologic characterization; measures of water quality; case studies of contamination, nuclear-waste disposal, and carbon sequestration. Spring. Prerequisites: Geo 131 and Chem. 1 *Garven*

191, 192 Selected Topics. Exploration of special topics in geology through seminars or guided individual study. One-half or one course credit. *Members of the department*

193, 194 Senior Thesis. Intensive laboratory or field investigations designed and carried out by the student, culminating in a written thesis and oral defense. Prerequisites: Geological sciences major and consent. *Members of the department*

Courses for Graduate Students

287 (formerly 187) Subsurface Fluid Dynamics Advanced theory in groundwater hydrology. Topics include: hydrodynamics of groundwater flow; Darcy's Law in porous sediments and fractured rocks; fluid potential; flow nets and hodographs; vorticity of inhomogeneous fluids; physics of the unsaturated zone; two-phase flow in petroleum reservoirs and carbon sequestration; flow in deforming media; aqueous mass transport in reactive formations; fluid and heat transport in geothermal reservoirs. *Garven*

288 (formerly 188) Groundwater Modeling. Numerical analysis of groundwater flow, with applications. Topics include: numerical formulation of the governing equations using finite difference, finite element, integrated finite difference, particle tracking, boundary element, and discrete element techniques; matrix and iterative solutions; algorithms for 1-D, 2-D, and 3-D flow; stability and accuracy; applications using popular software in the public domain. Students may be expected to program 1-D solutions as part of lab section. Spring 2010 and alternate years. *Garven*

289 (formerly 189) Geofluids. (*this course is now Geo 289*) Study of groundwater flow in geologic processes. Topics include: theory and equations governing coupled fluid flow with heat and mass transport in deep geologic systems; continental-scale groundwater flow; hydrogeologic applications in studies of weathering, sediment diagenesis, petroleum migration, hydrothermal ore formation, metamorphism, deformation and earthquake mechanics. This advanced course will introduce students to current literature and software for theoretical analysis of reactive hydrothermal flows in the Earth's crust. *Garven*