GEOLGY AND GEOPHYSICS

Kline Geology Laboratory, 203.432.3124
http://earth.yale.edu
M.S., M.Phil., Ph.D.

Chair
Jay Ague

Director of Graduate Studies
Jun Korenaga

Professors Jay Ague, David Bercovici, Ruth Blake, Mark Brandon, Derek Briggs, David Evans, Alexey Fedorov, Debra Fischer, Jacques Gauthier, Shun-ichiro Karato, Jun Korenaga, Jeffrey Park, Peter Raymond, Danny Rye, James Saiers, Ronald Smith, Mary-Louise Timmermans, John Wettlaufer

Associate Professors Kanani Lee, Maureen Long, Trude Storelvmo

Assistant Professors Bhart-Anjan Bhullar, Pincelli Hull, Noah Planavsky, Alan Rooney

FIELDS OF STUDY
Fields include geochemistry and petrology, geophysics, ice physics, mineral physics, seismology and geodynamics, structural geology and tectonics, paleontology and paleoecology, oceanography, meteorology, cryospheric dynamics, and climatology.

SPECIAL ADMISSIONS REQUIREMENTS
The department welcomes applicants oriented toward the earth sciences who have a bachelor’s or master’s degree in such fields as biology, chemistry, engineering, mathematics, meteorology, or physics, as well as those trained in geological, geophysical, and geochemical sciences. Scores from a pertinent GRE Subject Test are desirable but not required. The TOEFL or IELTS exam is required of all applicants for whom English is a second language.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE
There is no formal language requirement and no required curriculum. Students plan their course of study in consultation with their adviser to meet individual interests and needs and to lay the foundations for dissertation research. At the end of the first year the faculty reviews the standing of each student. A student recommended for continuation in the Ph.D. program will be so notified. Some students may be encouraged at that time to pursue only the M.S. degree. At the end of the second year the faculty reviews each student’s overall performance to determine whether the student is qualified to continue for the Ph.D. degree. In order to qualify, a student must have met the Graduate School Honors requirement and maintained a better than passing record in the areas of concentration. Also, a student must have satisfied the requirements of the Qualifying Exam by having completed two Research Discourses termed (according to their degree of development) the Minor and the Major Discourses. The Major Discourse will be presented at the Qualifying Presentation, followed by an extended question period wherein the student must successfully defend both Discourses. Remaining degree requirements include a dissertation review in the third year; the preparation and defense of the dissertation; and the submission of the dissertation to the Graduate School.

Teaching experience is regarded as an integral part of the graduate training program in Geology and Geophysics. For that reason all students are required to serve as teaching fellows (5 hours per week) for two terms during the course of their predoctoral training.

In addition to all other requirements, students must successfully complete G&G 710, Responsible and Ethical Conduct of Research, prior to the end of their first year of study.

MASTER’S DEGREES

M.Phil. See Degree Requirements under Policies and Regulations.

M.S. Awarded only to students who are not continuing for the Ph.D. Students are not admitted for this degree. Minimum requirements include satisfactory performance in a course of study (typically six or more courses with at least one Honors grade in a graduate-level class) that is approved by the director of graduate studies (DGS), and a research project with the approval of the DGS and the student’s thesis committee.

Program materials are available at http://earth.yale.edu or upon request to the Director of Graduate Studies, Department of Geology and Geophysics, Yale University, PO Box 208109, New Haven CT 06520-8109; e-mail, dgs@geology.yale.edu.
COURSES

G&G 505Lb, Practical Paleontology  Marilyn Fox
½ Course cr

G&G 510a, Introduction to Isotope Geochemistry  Alan Rooney and Noah Planavsky
An overview of the fundamental principles of stable and radiogenic isotope geochemistry. Emphasis is placed on applications to specific geologic problems, including petrogenesis, geochronology, geothermometry, surface processes, hydrology, and biogeochemistry.

G&G 512b, Structure and Deformation of the Lithosphere  Mark Brandon
An introduction to the origin and structure of the lithosphere and continental and oceanic crust. Topics include what controls the solid versus fluid behavior of rocks during deformation, and what controls the character and motion of tectonic plates. Laboratory exercises and field trips.

G&G 519a, Introduction to the Physics and Chemistry of Earth Materials  Shun-ichiro Karato
Basic principles that control the physical and chemical properties of Earth materials. Equation of state, phase transformations, chemical reactions, elastic properties, diffusion, kinetics of reaction, and mass/energy transport.

G&G 522b, Physics of Weather and Climate  Alexey Fedorov
The climatic system; survey of atmospheric behavior on time scales from days (i.e., weather) to decades (i.e., climate); formulation of mathematical equations describing weather and climate with selected applications to small- and large-scale phenomena.

G&G 525a, Introduction to Continuum Mechanics  Jacques Gauthier
Phylogeny and evolution of the major clades of vertebrates from Cambrian to recent, as inferred mainly from the fossilized remains of the musculoskeletal system (cranial, axial, and appendicular skeletons). Special attention to the evolution of vertebrate feeding, locomotor, and sensory systems.

G&G 526a, Introduction to Earth and Planetary Physics  Kanani Lee
An introduction to the structure and dynamics of Earth and other planets in the context of cosmic evolution. Review of basic physical principles and their applications to geophysics and planetary physics. Star formation and nucleosynthesis; planetary accretion and the birth of the solar system; heat flow, plate tectonics, and mantle dynamics; seismology and geodesy; core dynamics, geomagnetism, and planetary magnetism. Prerequisites: PHYS 181 and MATH 120 or equivalents.

G&G 528a, Science of Complex Systems  Jun Korenaga
Introduction to the quantitative analysis of systems with many degrees of freedom. Fundamental components in the science of complex systems, including how to simulate complex systems, how to analyze model behaviors, and how to validate models using observations. Topics include cellular automata, bifurcation theory, deterministic chaos, self-organized criticality, renormalization, and inverse theory.

G&G 535a, Physical Oceanography  Alexey Fedorov
An introduction to ocean dynamics and physical processes controlling the large-scale ocean circulation, ocean stratification, the Gulf Stream, wind-driven waves, tides, tsunamis, coastal upwelling, and other oceanic phenomena. Equations of motion. Modern observational, theoretical, and numerous other techniques used to study the ocean. The ocean role in climate and global climate change.

G&G 538a / ASTR 520a, Computational Methods in Astrophysics and Geophysics  Paolo Coppi
The analytic and numerical/computational tools necessary for effective research in astronomy, geophysics, and related disciplines. Topics include numerical solutions to differential equations, spectral methods, and Monte Carlo simulations. Applications are made to common astrophysical and geophysical problems including fluids and N-body simulations.

G&G 555b, Thermodynamics of Mountain Belts  Jay Ague
Examination of the fundamental principles governing the formation of metamorphic and igneous rocks during mountain building. Topics include processes of heat and mass transfer in orogenic belts, generation of igneous rocks in continental and subduction settings, ultra-high-pressure and ultra-high-temperature metamorphism, spatial and temporal patterns of petrologic processes throughout geologic time, and pressure-temperature-time paths of metamorphic and igneous rocks.

G&G 562b / ARCG 762b / EMD 548b, Observing Earth from Space  Ronald Smith
A practical introduction to satellite image analysis of Earth’s surface. Topics include the spectrum of electromagnetic radiation, satellite-borne radiometers, data transmission and storage, computer image analysis, the merging of satellite imagery with GIS and applications to weather and climate, oceanography, surficial geology, ecology and epidemiology, forestry, agriculture, archaeology, and watershed management.
A survey of the numerous ways in which theories, approaches, techniques, and data from the earth and environmental sciences are used to address archaeological research questions. A range of interfaces between archaeology and the geological sciences are considered. Topics include stratigraphy, geomorphology, site formation processes, climate reconstruction, site location, and dating techniques.

G&G 650b, Deformation of Earth Materials
Shun-ichiro Karato
Microscopic physics of deformation of minerals and rocks and its applications to global geophysics.

G&G 658a, Seismic Data Analysis
Jeffrey Park
This course covers several techniques of seismic data analysis, revisiting some classical results from global seismology that helped to define our knowledge of Earth's interior. Wave-propagation behavior in the context of simple theories of ray tracing, tommography, shear-wave birefringence, free-oscillation frequency shifts, attenuation, receiver functions, surface-wave dispersion, and other observables.

G&G 659b, Time Series Analysis with Geoscience Applications
Jeffrey Park
Introductory course in geoscience data analysis and time series methods, with emphasis on multiple-taper time series techniques. Examples drawn from seismological, paleoclimate, and historical climate data. Weekly computer assignments. Python proficiency helpful.

G&G 690a or b, Directed Research in Geology and Geophysics
Staff
By arrangement with faculty.

G&G 691a or b, Independent Research
Staff
In addition to the seminars noted below, others on special topics like evolution, invertebrate and vertebrate paleontology, statistical mechanics and spectroscopy, structural geology and tectonics, petrology, volcanology, and physics of oceans and atmospheres are offered according to student interest, by arrangement with department faculty. Seminars are often organized around the research interests of visiting faculty as well. Prerequisite: approval of DGS and adviser.

G&G 701a, The Warming Papers
Trude Storelvmo
Weekly presentation and discussion of papers representing the scientific foundation for the climate change forecast. Open to graduate students and advanced undergraduate students. No formal prerequisites, but basic calculus and university-level physics are helpful.

G&G 703a or b / E&EB 930a or b, Seminar in Systematics
Jacques Gauthier
A seminar on using molecular evolutionary models in Bayesian phylogenetic analyses. Topics are chosen by the participants but may include "models" in phylogenetics, understanding and comparison of model selection criteria, effects of model under- and overparameterization on parameter value estimates and phylogenetic inferences, and accommodating model uncertainty and model-averaging.

G&G 710a, Responsible and Ethical Conduct of Research
Jun Korenaga
A 5-to-6-week lecture course (1 hour) that is required of all graduate students and must be completed within the first year. Course topics include record keeping and data management/retention; plagiarism and fraud; collaboration, coauthorship, and ownership of research materials and intellectual property; laboratory dynamics and sexual harassment. G&G 710 is in addition to the existing online ethics module, The Yale Guide to Professional Ethics, that must be completed by all GSAS students within the first term of study, regardless of source of financial support. 0 Course cr

G&G 744a or b, Seminar in Mantle and Core Processes
Staff
The seminar covers advanced topics concerning physical and chemical processes in the mantle and core of the Earth and planets. Specific topic and hour are arranged in consultation with enrolled graduate students.

G&G 745b, Seminar in Climate and Energy
Michael Oristaglio
This seminar looks at prospects for decarbonization of the world's energy supply along the lines envisioned in the Paris Agreement adopted at the conclusion of the twenty-first session of the United Nations Conference of the Parties (COP 21). The course studies the details of the Paris Agreement in light of two key reports published by the International Energy Agency (IEA) before the Paris talks: World Energy Outlook 2015 and World Energy Outlook Special Report: Energy and Climate Change. Topics include emissions reductions through Intended Nationally Determined Contributions (INDCs); the role of new technologies such as bio-energy with carbon capture and storage; transitional energy models, including renewable energy finance; and climate trajectories for the twenty-first century.

G&G 775a or b, Seminar in Lithosphere and Surface Processes
Staff
The seminar focuses on advanced topics in the evolution and structure of the lithosphere. The theme for the seminar changes each term, covering topics such as the restoration of continents in deep time, true polar wander, lithospheric instabilities, orogenesis at convergent plate boundaries, interactions between climate and tectonics. Meetings are for 1.5 hours, once a week, and are organized around readings from the primary research literature.
G&G 800a or b, Tutorial in Paleobiology  Staff
G&G 810a or b, Tutorial in Structural Geology and Tectonics or Solid Earth Geophysics  Staff
G&G 820a or b, Tutorial in Meteorology, Oceanography, or Fluid Dynamics  Staff
G&G 830a or b, Tutorial in Geochemistry, Petrology, or Mineralogy  Staff
G&G 840a or b, Tutorial in Sedimentology  Staff
G&G 860a or b, Tutorial in Remote Sensing  Staff