GEOL0GY AND GEOPHYSICS

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

Chair
David Bercovici

Director of Graduate Studies
Maureen Long

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

Associate Professor Kanani Lee

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 510a, Introduction to Isotope Geochemistry Alan Rooney
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, Structural Geology  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 520a, Physics and Chemistry of Earth Materials II  Shun-ichiro Karato
Basic principles that control the transport properties of Earth materials. Chemical reactions, anelasticity, diffusion, kinetics of reaction, and mass/energy transport.

G&G 521b, Geophysical Fluid Dynamics  David Bercovici
A survey of fluid dynamics, with applications to circulation in the ocean, atmosphere, mantle, and core. Mathematical models illustrate the fundamental dynamical principles of geophysical fluid phenomena such as convection, waves, boundary layers, flow stability, turbulence, and large-scale flows. Prerequisite: differential equations, or mathematical physics or equivalent.

G&G 522a, 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, Vertebrate Paleontology  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 528b, Introduction to Geodynamics  Jun Korenaga
This introductory course starts with the basics of continuum mechanics and covers a range of topics in geodynamics and relevant fields including the structure and dynamics of lithosphere, thermal convection and magmatism, Rayleigh-Taylor instability and plume dynamics, geoid and dynamic topography, and the thermal history of the core and geodynamo.

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 538a, Introduction to Seismology  Maureen Long
Earthquakes and seismic waves, P and S waves, surface waves and free oscillations. Remote sensing of Earth's deep interior and faulting mechanisms. Prerequisites: MATH 120, 222, and PHYS 181 or equivalents.

G&G 562b / ARCG 762b / F&ES 726b, Observing Earth from Space  Xuhui Lee and 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.

G&G 614a, Biogeochemical Cycles through Time  Noah Planavsky
In this class we will explore the role that biological innovation and changes in tectonic process have played in shaping global biogeochemical cycles through time. The class will focus on extensively investigated elements (C, S) nutrients (N, P) and redox-sensitive metals (e.g., Fe, Mo, Cr, Zn, Cd). The aim of the class is twofold: 1) we will do a survey of key historical papers that provide the foundation for our understanding of geochemical cycles, basic modeling approaches, and widely utilized geochemical tracers; 2) we will explore recent literature with the goal of discussing major uncertainties and key unanswered questions concerning the co-evolution of life and Earth surface processes. Students will be expected to actively participate and help steer discussions, as well as to individually explore a specific aspect of the evolution of global biogeochemical cycling in detail over the course of the class.

G&G 625a, Oceanography  Pincelli Hull, Ronald Smith, and Noah Planavsky
This course provides an introduction to the basics of oceanography. It is structured as an interdisciplinary overview, designed to ensure that graduate students working in the oceans (i.e., those from paleontology, geochemistry, and/or AOC) have the ability to form interdisciplinary collaborations through shared vocabulary and concepts, and to answer such basic questions as: why are there currents?
what makes sea water salty? where is most life in the ocean? Topics are treated in interactive lectures, flipped classroom discussions/activities, and labs and are rigorously tested in one-on-one oral exams.

G&G 632b, Evolution of Lizards Jacques Gauthier

G&G 655a, Extraordinary Glimpses of Past Life Derek Briggs
Study of exceptionally well preserved fossil deposits (lagerstaetten) that contain nonmineralized animal skeletons and casts of the soft parts of organisms. Examples such as the Burgess Shale and Solnhofen limestones; what they can reveal about the history and evolution of life, ancient lifestyles and environments, and preservational processes.

G&G 666a / AMTH 666a / ASTR 666a, Classical Statistical Thermodynamics John Wettlaufer
Classical thermodynamics is derived from statistical thermodynamics. Using the multi-particle nature of physical systems, we derive ergodicity, the central limit theorem, and the elemental description of the second law of thermodynamics. We then develop kinetics, transport theory, and reciprocity from the linear thermodynamics of irreversible processes. Topics of focus include Onsager reciprocal relations, the Fokker-Planck equation, stability in the sense of Lyapunov, and time invariance symmetry. We explore phenomena that are of direct relevance to astrophysical and geophysical settings. No quantum mechanics is necessary as a prerequisite.

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 Staff
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. o Course cr

G&G 742a, Seminar on Ocean Turbulence Mary-Louise Timmermans
This course is a forum for discussing and understanding a selection of readings on ocean turbulence and the physics of ocean mixing.

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 746b, Seminar in Climate and Energy Michael Oristaglio and Cary Krosinsky
This seminar looks at four multidisciplinary topics through readings and guest lectures: (1) the global outlook for world energy, (2) the near-term prospects for disruptive energy technologies, (3) deep decarbonization and carbon management, and (4) risks and opportunities of climate change. Readings focus on the recently issued IPCC Special Report on Global Warming and the U.S. Fourth National Climate Assessment report. No prerequisites. Open to undergraduates, with preference given to senior Energy Studies scholars.

G&G 757b, Studies in Global Geoscience Mary-Louise Timmermans and Alan Rooney
Reading seminar devoted to a specific geographic region of the Earth, selected as the destination of the departmental field trip for the current year. Topics of discussion include a broad range of geoscience disciplines, to be determined in part by the interests of participating students.

G&G 775b, Seminar in Lithosphere and Surface Processes Mark Brandon
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 810a, 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, The Geochemistry of Earth's Past Climates Staff
This seminar focuses on advanced topics in climate science from a geochemical perspective. We cover intervals from Deep Time to the Anthropocene. Meetings are for two hours, once a week, and are organized around readings from the primary research literature. Undergraduates require permission from the instructor. Enrollment limited to twelve.

G&G 840a or b, Tutorial in Sedimentology Staff

G&G 860a or b, Tutorial in Remote Sensing Staff