GEOLOGY

Chair, *Associate Professor Walter "Bill" Sullivan*
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If you are interested in Earth—how it developed and what may happen to it in the future, how it functions as a complex physical and chemical system and why we should care, where life originated and how and why our planet supports us, and how our actions affect the world around us—a major in geology may be right for you.

The Department of Geology possesses extensive rock, mineral, and fossil collections as a basis from which to investigate Earth, a micro X-ray-fluorescence (micro-XRF) spectrometer for mapping rock and mineral elemental compositions, a powder X-ray diffractometer (XRD) for determining mineral identities, research-grade stereo and petrographic microscopes, and rock and sediment-sample processing equipment. The department also houses the College's scanning electron microscope (SEM) equipped with an energy-dispersive X-ray-fluorescence spectrometer (EDS) for micron-scale elemental analyses. Additional research equipment available for student use, shared with other departments in the Division of Natural Sciences, includes a C,H,N,O,S elemental analyzer, an inductively coupled plasma emission spectrometer (ICP-ES) for determining elemental compositions, and the *Colby Compass*, a research boat equipped with an array of instrumentation for real-time environmental analyses.

Colby's setting provides an intriguing and exciting area for field study, enabling students to integrate field and laboratory experiences. Students are encouraged to engage in independent and honors research projects with faculty. Research opportunities are offered routinely during the summer by departmental faculty at Colby and abroad.

Fieldwork is an integral part of geology courses and introduces students to various aspects of local and regional geology. Multi-day off-campus trips are scheduled regularly to localities and areas of particular geologic interest, such as the Hartford Basin of Connecticut, the Mohawk Valley or Catskill Mountains of New York, the classic Joggins and Brule localities in Nova Scotia, and late Paleozoic rocks of New Brunswick. The department also provides off-campus international experiences, including study in Bermuda.

The Geology Department offers both a major and a minor for students with different interests. The point scale for retention of the major applies to all courses taken in the major; no requirement may be taken satisfactory/unsatisfactory. Students should consult regularly with their advisor in selecting courses appropriate for meeting their goals for post-graduation employment and/or graduate study.

Requirements for the Major in Geology

Requirements for the geology major are:

- A 100-level gateway course (Geology 122, 123, 125, 141, or 146)
- Four core courses (Geology 225, 231, 254, and 262)
- Four geology elective courses numbered 200 or above
- Three credits of geology seminar (Geology 391)
- Geology 494 or six credits of honors-thesis research (Geology 483/484); and
- Two cognate courses from the following list: Biology 163, 164; Chemistry 121, 122, 141, 142, 147; Computer Science 151, 152, 153; Physics 141, 143, 145; Math 121, 122; and Statistics 212.

Geology majors may substitute one course in biology, chemistry, computer science, GIS, mathematics, physics, or statistics numbered 200 or above (excluding Statistics 212) for one of the four elective courses. A single independent research project earning at least four credit hours of Geology 491/492 during the student's senior year also may count as a major elective. Additional course work in chemistry, physics, and mathematics beyond the minimum requirements is strongly encouraged to broaden students' skill sets and maximize options after graduation. Students should consult one of the major advisors in the first and second years regarding election of languages and other Colby-required courses.

Requirements for Honors in Geology

The Geology Department's honors program involves a substantial research component in the student's senior year, with no fewer than six credit hours of Geology 483/484 and completion of a thesis detailing this work. Participation in the honors program requires a 3.5 GPA in the major by the end of the junior year before a faculty sponsor can consider the project. The honors program involves presentation of a research proposal to a faculty committee early in the fall semester, drafting and approval of introductory sections before January, submission of a full draft of the thesis for review by spring break, and approval of the final thesis by the faculty committee. Satisfactory progress will result in credit for Geology 483 and 484. Successful completion of an honors research project, and the major, will enable the student to graduate with "Honors in Geology." Students who wish to pursue an even more intensive research agenda should consider the Senior Scholars Program, an all-campus honors program in which half the student's academic credits in the senior year are devoted exclusively to a major research project.

Requirements for the Minor in Geology

A minor in geology is available to students majoring in other disciplines who also desire an introductory understanding of the geosciences. Minor programs are tailored to the needs of individual students; courses should be elected in consultation with the minor advisor. Requirements are:

- A 100-level gateway course (Geology 122, 123, 125, 141, or 146)
- Four geology courses selected from courses numbered 225 and above.

Course Offerings

[GE111] Geology of National Parks U.S. national parks and monuments will provide the focus for an introduction to basic geologic processes, including plate tectonics, geologic time, weathering and erosion, volcanism, earthquakes, caverns, shorelines, and the rock cycle. After an introduction to the regional geology of the United States, the focus will shift to the parks and monuments within these regions. Students will become aware of aspects of physical and historical geology, regional geography, environmental issues, the aesthetics of nature, and the interactive processes that have shaped the country. A field trip to Acadia National Park is included. Lecture only. *Three credit hours.* **N.**

GE121f Earth Systems Chemistry I Listed as Chemistry 121. *Four credit hours.* **N, Lb.** KOFFMAN, MCKINNEY

GE122s Earth Systems Chemistry II Listed as Chemistry 122. *Four credit hours.* **N, Lb.** DROZD, KOFFMAN

GE123s How to Build a Habitable Planet Examines fundamental chemical and physical Earth processes operating at timescales from minutes to billions of years; how these processes evolved over Earth's 4.56-billion-year history and changed Earth into an ideal environment for complex life; the methods scientists use to understand Earth processes and develop this deep-time record of global change; and how human activity is currently altering global processes and impacting Earth's habitability. High-school-level chemistry is recommended but not required to succeed in the course. *Prerequisite:* Credit cannot be earned for both this course and Geology 122, 125, 141, or 146. *Four credit hours.* **N, Lb.** SULLIVAN

GE125fs From Stardust to Planets Explores the physical and chemical evolution of the Earth in the context of solar system formation. By studying the development of the terrestrial (rocky) planets, students will be introduced to fundamental concepts in geology. As students investigate geologic processes on other planetary bodies, they will develop a deeper understanding of our own planet's evolution and geology. We will focus on important questions, such as "How did Earth become a habitable planet?" and "How has humanity impacted the Earth's evolution?" High-school-level chemistry is recommended but not required to succeed in the course. *Prerequisite:* Credit cannot be earned for both this course and Geology 122, 123, 141, or 146. *Four credit hours.* **N, Lb.** DUNN

GE141f Earth and Environment The geosciences encompass the study of the Earth, its formation, its history, the processes that continue to shape it today, and our interaction with it. Students learn (1) how Earth processes operate, how they shape the environment we live in, and how they can affect people; (2) where Earth resources come from, the impacts of using these resources, and how we can reduce these impacts; and (3) the methods we use to understand these processes and impacts. Additionally, the course improves students' critical-thinking and data-analysis skills. *Prerequisite:* Credit cannot be earned for both this course and Geology 122, 123, 125, or 146. *Four credit hours.* **N, Lb.** RUEGER

GE146s Deciphering Earth History The Earth's history, from galactic and planetary origins through today. Major concepts include basic plate tectonics, geologic or "deep" time, fossils, sedimentary systems, and evolutionary theory. Students will gain insight into the interrelated nature of the biological, chemical, and physical world and the ways in which the planet and its environments have changed and operated over the past 4.56 billion years. Designed for those with no prior geologic background. Lecture and laboratory. Credit cannot be earned for both this course and Geology 142. *Prerequisite:* Credit cannot be earned for both this course and Geology 122, 123, 125, 141 or 142. *Four credit hours.* **N, Lb.** RUEGER

[GE225] Mineralogy Introduces students to the methods geologists use to identify minerals and the geologic environments in which they form. Students will gain experience using the petrographic microscope, powder X-ray diffractometer, and scanning electron microscope to identify major rock-forming minerals. Students will develop interpersonal, critical-thinking, and communication skills that enable them to discuss the chemical and physical processes controlling mineral formation. Concepts learned serve as the foundation for subsequent upper-level geology courses. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Four credit hours.*

GE231f Structural Geology Structural geologists study the geometry of geologic structures such as faults and folds, how these structures form, their significance to the geologic history of an area, and their relationship to plate-tectonic motions. Enables students to (1) evaluate a suite of geologic structures to draw conclusions about their formation and significance, (2) apply basic structural-analysis

techniques to solve problems in a variety of geoscience disciplines, and (3) develop the three-dimensional thinking skills needed to evaluate subsurface geology using two-dimensional, surficial data sets. Aims to improve students' graphical and written-communication skills, data-collection skills. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Four credit hours.* **N.** SULLIVAN

[GE242] Hydrogeology Examines the fundamental principles of hydrogeology and introduces geophysical techniques (surface and borehole) used to investigate flow through the subsurface. Designed to provide the tools necessary to understand and characterize groundwater systems. Topics include the hydraulic properties of rocks, aquifer storage and subsidence, flow potential, analysis of pumping tests conducted in water wells, and interpretation of geophysical field data. Includes lecture, homework from textbook, oral presentation, and analysis of a variety of geophysical logs. *Prerequisite:* Geology 122, 123, 125, 141, or 146 and Mathematics 121, 122, or 161. *Three credit hours.*

GE254f Principles of Geomorphology Geomorphology is the study of surficial expression of Earth processes and the continuing evolution of the planet as climate-dictated surface processes remold the underlying solid Earth. Students learn the processes at work in the breakdown of rocks into soils and how mountains, valleys, and other landforms originate. They will become familiar with the processes that result in mass-wasting, how streams constantly change the environment, and how wind is active in desert environments and elsewhere; they will come to appreciate the significance of glaciers in the geologic history of Maine and North America, and how coastal processes affect the lives of hundreds of millions of people worldwide. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Four credit hours.* **N.** GEIGER-ORTIZ

[GE256] Sedimentation and Stratigraphy A module-based course in which students learn how to apply sedimentary rocks to interpreting Earth's stratigraphic record and develop a fundamental understanding of sediments and resulting rock types found in Earth's sedimentary successions. Modules include (1) the analysis of drill cores from coastal deposits in the Carboniferous of Alabama, (2) field and laboratory analysis of Silurian-Devonian carbonate sequences in New York State, and (3) an exercise in which the principles of sequence stratigraphy will be modeled. Students will learn to evaluate the sedimentary rock record over space and time using currently accepted approaches and models. Previously listed as Geology 356. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Four credit hours.* **W2.**

GE262s Earth's Climate: Past, Present, and Future Takes a systems approach to studying Earth's climate by linking the primary systems operating at Earth's surface, i.e., lithosphere, atmosphere, biosphere, hydrosphere, cryosphere. Explores the mechanisms that shape environmental evolution across a range of time scales, including the role of humans, and uses past (paleo) records of change to place modern climate change in geological context. Students will engage with material through problem sets, data analysis, interactive lectures, primary literature synthesis, and writing. Laboratory projects will provide hands-on opportunities to develop local records of past environmental change. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Four credit hours.* **N.** KOFFMAN

GE279j Geology of Bermuda Students will learn how the island of Bermuda, subjected to a variety of geologic processes, has evolved over the past two million years. They will be exposed to the scientific method and how geologists study the Earth, its materials, and its processes. During field and laboratory observations, students will investigate how organisms, including humans, and sedimentary processes have shaped Bermuda; how sediment is formed, moved, consolidated, and lithified; and the interrelationships between geology and biology. They will gain an appreciation of the complexities of living on an island and the anthropogenic impacts on a fragile ecosystem. Cost in 2018: $2,700. *Prerequisite:* Geology 122, 123, 125, 141, or 146. *Three credit hours.* **N, Lb.** RUEGER

[GE331] Plate Tectonics Primary-literature-synthesis course that guides students through the topic of plate tectonics from the development of the theory to some modern-day theories on crustal growth and plate-boundary processes. Students will be able to (1) piece together a broad-scale interpretation of the evolution of a plate boundary using data and interpretations gleaned from the primary scientific literature and (2) use basic thermochronologic, geophysical, geological, and geospatial data sets to interpret plate boundaries. Improving students' verbal and written communication skills while providing an experience in accessing, reading, and assimilating scientific literature. *Prerequisite:* Geology 231 or permission of the instructor. *Four credit hours.*

[GE332] Igneous and Metamorphic Petrology Teaches students to identify igneous and metamorphic rocks and to understand the physical and chemical processes responsible for their formation. Students learn how to use and evaluate a variety of data sets, and they develop skills using a petrographic microscope and the scanning electron microscope (SEM). They also develop interpersonal, critical-thinking, and communication skills that enable them to discuss petrologic processes in the broader geologic context of tectonic setting. *Prerequisite:* Geology 225. *Four credit hours.*

[GE335] Geologic Field Methods Students will learn how to conduct and manage multi-day geologic mapping projects; use field observations and data to interpret the geologic history of different environments in Maine; produce detailed geologic reports based on surface geology; and hone their written, graphical, and interpersonal communication skills. Includes two required weekend-long field trips in September and October. *Prerequisite:* Geology 231 or permission of the instructor. *Four credit hours.* **W2.**

[GE351] The Record of Life on Earth Using original research as an educational platform, students learn how to acquire and assess

scientific data, to reference and synthesize primary literature, and to justify their arguments and conclusions in both written and oral forms. Provides a greater understanding of the processes responsible for a fossil record, its classification, the use of these data in evolutionary theory, the dynamics of individuals and populations or organisms over space and time, and the application of paleontological data to understanding ecological response to climate change, perturbation, and extinction mechanisms. Lecture only. Previously listed as Geology 251. *Prerequisite:* Geology 122, 123, 125, 141, or 146 or one year of biology. *Three credit hours.* **N.**

[GE361] Topics in Geochemistry Covers fundamental topics in geochemistry, including principles of equilibrium thermodynamics, pH, alkalinity, weathering reactions, redox reactions, trace elements, and stable and radioactive isotopes. Through lecture, problem sets, and primary literature, students explore the theory and application of a range of geochemical approaches used to study Earth-system processes. Students develop critical thinking skills through the interpretation of primary datasets and literature, and they improve their written and oral presentation skills by communicating scientific findings. *Prerequisite:* Geology 122, 123, 125, 141 or 146, Chemistry 142 and at least one of the following: Geology 225, 231, 254, 256, 262, Chemistry 217, or Environmental Studies 276. *Four credit hours.*

[GE363] Paleoceanography This primary literature synthesis course examines past global change through the lens of the marine sedimentary record. Students explore the major physical and geochemical proxies used in paleoceanographic research and focus on understanding the major scientific questions addressed, methods and instrumentation used, and advantages and limitations of each proxy tool. Students also develop critical thinking skills through the interpretation of primary datasets and literature, and improve their written and oral presentation skills through communicating scientific findings. *Prerequisite:* Chemistry 131 or 141 or 147; and Geology 122, 123, 125, 141, or 146; and one of Chemistry 217, Environmental Studies 276, or Geology 225, 231, 254, or 256. *Four credit hours.*

GE381f Planetary Geology Explores the geological evolution of the planets, satellites, and materials that make up our solar system. Using Earth as an analog, students will study geological processes, such as volcanism, tectonism, and impact cratering, on other planetary bodies. They will learn how to utilize a variety of remote-sensing data sets to interpret the geologic history of planetary bodies. Students will also develop problem solving, critical thinking, and communication skills. *Prerequisite:* Geology 225 or permission of the instructor. *Four credit hours.* DUNN

GE391fs Geology Seminar Paper discussions and presentations from invited guest lecturers on topics of current interest in all areas of the geosciences. Majors must complete three seminars during their course of study. Nongraded. *One credit hour.* DUNN, KOFFMAN

GE398s TBD *Four credit hours.* GEIGER-ORTIZ

[GE483] Senior Honors Project A culminating, research-intensive experience in which students engage in an original project with the expectation that results will be of significantly high caliber to warrant publication after review by committee. The final written report will be in a selected journal format, and project results will be presented formally in a professional context. Students should consult with major advisors during their junior year to learn about on-campus and off-campus opportunities and experiences that can be used in preparation for undertaking an honors program. *Prerequisite:* Permission of the instructor. *Three or four credit hours.*

[GE483J] Senior Honors Project *Noncredit.*

GE491f, 492s Independent Study Independent research experience supervised by a faculty member. Research projects earning three or more credit hours over one or more semesters require a final written report and a formal presentation in a professional setting. *Prerequisite:* Permission of the instructor. *One to four credit hours.* FACULTY

GE494s Topics in Geoscience A capstone experience in which students explore a cutting-edge scientific topic in great depth. Students will hone skills introduced throughout the geology and geoscience majors, including assimilating, analyzing, and interpreting the scientific literature and communicating in writing, orally, and graphically. Students will also gain experience communicating specialized scientific topics to a general audience. May be repeated for credit. *Prerequisite:* Junior or Senior standing. *Four credit hours.* **W3.** SULLIVAN