

GEOLOGY – B.S.

Program director

Kevin E. Nick

The Department of Earth and Biological Sciences offers a program leading to the Bachelor of Science degree in geology. This program provides the student with a field-oriented education, emphasizing the application of geological principles. Sedimentary geology, paleontology, igneous petrology, and environmental geology are areas of emphasis. The curriculum is designed as a degree-completion program; two years of college-level coursework should be completed before admission. The integrated core course sequence provides the background to take the National Association of State Boards of Geology (ASBOG) Fundamentals of Geology (FG) examination leading to Geologist-In-Training (GIT) certification. The program aims to maintain affordability through tuition rates and scholarships. Please contact the department at ebs@llu.edu for assistance in planning for program entry or with any questions or comments.

Objectives

The integrated core course (major) sequence of the geology degree provides students with a general background in geology as preparation for careers or graduate studies in geology, paleontology, and environmental geology. An emphasis on fieldwork provides the link to basic geological data beyond the classroom and laboratory. Students apply the scientific method to resolve geologic problems throughout the geology curriculum. Students are encouraged to consider the relationship among science, faith, and societal responsibility during this process.

Program learning outcomes

By the end of the program, the graduate should be able to:

1. **Foundational Knowledge and Skills.** Characterize earth materials and their stratigraphic relations, demonstrating understanding of current geologic processes and geoscience theory at a level required for their chosen degree program.
2. **Research.** Conduct research in their chosen field of specialization, acquiring professional-level knowledge and expertise appropriate to their degree.
3. **Professionalism.** Demonstrate professional attributes necessary for interacting with colleagues and contributing to their discipline.
4. **Societal Interaction and Impact.** Interact with others on issues in philosophy of science and public interest.

Curriculum

The Bachelor of Science degree in geology requires a total of 192 quarter units. The total units are divided according to general studies requirements, major requirements, and electives.

The following summarizes the general categories and numbers of credits required for the degree and will help in planning the course schedule. All units are quarter units.

Major requirements—60 units

Major electives—14 units

Minimum general studies in the natural sciences—44 units

Minimum other general studies requirements—38 units

Other electives (this number will decrease if units in the above categories are greater)—36 units

Total—192 units

Residence requirements

Minimum requirements include one year of full-time residence at Loma Linda University, completing at least 32 of the last 48 units; or a minimum of 45 total units of coursework for the degree at Loma Linda University. If the student has attended an institution that does not grant bachelor's degrees, a maximum of 105 quarter units of credit can be transferred from a two-year junior or community college.

Undergraduate thesis

Students will prepare an undergraduate thesis based on a field or laboratory experience supervised by a faculty advisor. Students must register for at least two units of undergraduate research, conduct research under a faculty member's direction, submit a written undergraduate thesis, and deliver a public oral presentation.

Geology careers

A baccalaureate degree in geology prepares a student to enter graduate programs in geology, paleontology, or environmental geology as well as for employment in environmental and energy-related industries, or (with the necessary education courses) for teaching in secondary schools. Most employment opportunities are for those with graduate degrees and may be found in industry, research, or college teaching.

In addition to the geology major, a student preparing to teach at the elementary or secondary level will need to complete the requirements for a teaching credential. The student should consult the Geology Program director for further information. Education courses will count toward general studies requirements.

Scholarships and discounts for earth and biological sciences undergraduate students

Tuition, fees, and other cost-of-attendance items are located on the Find a Program (<https://llu.edu/academics/programs/>) webpage.

- Academic scholarships based on test results
 - a. American College Test (ACT) score of 30 or above: \$1,600 (or 16 percent of tuition). For a student who maintains a cumulative G.P.A. of at least 3.5, renewable for successive years.
 - b. Scholastic Aptitude Test (SAT): The student must maintain a 3.5 cumulative G.P.A., renewable for successive years. If a student qualifies for both an ACT and an SAT scholarship, the scholarship with the largest dollar value will apply.
 - National Merit Finalist Scholarship covers 100 percent of tuition.
 - National Merit Semifinalist Scholarship covers 34 percent of tuition.
 - National Merit Commended Scholarship covers 20 percent of tuition.
- Renewable G.P.A. scholarships (eligibility based on G.P.A. at the end of previous academic year): If a student is eligible for a National Merit Scholarship and/or an ACT scholarship, as well as a G.P.A. scholarship, the scholarship with the largest dollar value will apply.
- G.P.A. between 3.75 and 4.00, \$1,480 per year (or 15 percent of tuition).

- G.P.A. between 3.50 and 3.74, \$1,180 per year (or 12 percent of tuition).
- G.P.A. between 3.25 and 3.49, \$900 per year (or nine percent of tuition).

Additional scholarship guidelines

- The sum of scholarships and other financial awards should not exceed cost for tuition and fees.
- If a student qualifies for more than one scholarship or reduced tuition award, the award with the largest dollar value applies.
- Scholarship or tuition reduction will be applied as a credit to the student's tuition account at the rate of one-third of the total per quarter and is available to full-time students only.
- Loss of scholarship money may result when a student does not maintain the minimum cumulative G.P.A. required by the particular scholarship.
- The deadline for verifying with Student Financial Services that the student qualifies for a scholarship for the academic year is the last day of final tests for the first quarter.
- The scholarships and reduced tuition awards listed here apply only to students enrolled in undergraduate programs in the Department of Earth and Biological Sciences.

Note: Determining the amount of scholarships and awards at Loma Linda University is influenced by FAFSA data. State and federal grants, as well as other grants and subsidies, will be applied before Loma Linda University scholarships and discounts; therefore, some students may be eligible to receive only a portion of their scholarship awards.

Admissions

Applications

Applications are accepted at any time. Review of applications begins in February for Autumn Quarter admission.

In addition to Loma Linda University (<http://llucatalog.llu.edu/about-university/admission-policies-information/#admissionrequirements>) admission requirements, the applicant must also complete the following requirements for admission to the Geology BS program:

- complete two years (minimum of 82 quarter units) of general education and science courses at any accredited institution. This should include the majority of the general studies requirements. Note that this would typically include a year of general chemistry and general physics with associated laboratory sections, and mathematics. Please contact the program director if you have questions about this requirement.
- achieve a minimum of 2.5 G.P.A. during the first two years of coursework.
- submit letters of recommendation from two faculty members at institutions previously attended.

Listed below are the admission and prerequisite requirements to obtain a bachelor's degree from Loma Linda University. These are listed in general education domain order.

Prerequisites

Domain 1: Religion (8 quarter units)

(completed during enrollment at LLU)

Domain 2: Arts and humanities (minimum 16 quarter units)

Units must be selected from at least three of the following content areas: civilization/history, art, literature, language, philosophy, religion, or general humanities electives. A minimum of 3 quarter units in an area are required to meet a "content area."

Domain 3: Scientific inquiry and quantitative reasoning (minimum 12 quarter units)

- Mathematics, including calculus (eight-12 units)
- Statistics (four units)
- General chemistry with laboratory—one full year, complete sequence
- General physics with laboratory—one full year, complete sequence
- Courses in general biology or ecology with laboratory (eight units)

Domain 4: Social sciences (minimum 12 quarter units)

- One course dealing specifically with issues of human diversity is required.
- Select additional units, as needed, from: anthropology, economics, geography, political science, psychology, and sociology

Domain 5: Written and oral communication (minimum 9 quarter units)

- English composition, complete sequence that meets the baccalaureate degree requirements of a four-year college or university.
- Additional courses may include information systems, critical thinking, and public speaking

Domain 6: Health and wellness (minimum 2 quarter units)

- A didactic course in health or nutrition (e.g., personal health, personal nutrition, population health, global health, and community nutrition) minimum of 2 units
- Physical education. Must include at least two separate physical activity courses totaling a minimum of one quarter units.

For total unit requirements for graduation, see LLU General Education Requirements (<http://llucatalog.llu.edu/about-university/division-general-studies/>).

Electives

As necessary, to meet the minimum total requirement of 82 transferable quarter units. These units added to the 110 undergraduate units required in the program fulfill the 192 total units required for the bachelor's degree.

Please note: Grades of C- and below are not accepted for credit toward the degree.

Program requirements

Major

GEOL 204	Physical Geology	4
GEOL 316	Mineralogy	4
GEOL 317	Igneous and Metamorphic Petrology	4
GEOL 318	Sedimentary Petrology	3
GEOL 416	Sedimentology and Stratigraphy	6
GEOL 424	Structural Geology	5
GEOL 436	Low Temperature Geochemistry	4
GEOL 443	Historical Geology	4
GEOL 456	Field Methods of Geologic Mapping	4
GEOL 464	Science Communication Outreach ¹	1

GEOL 475	Philosophy of Science and Origins	4
Select at least one course from the following:		4
GEOL 426	Invertebrate Paleontology (4)	
GEOL 427	Vertebrate Paleontology (4)	
GEOL 444	Paleobotany (4)	
GEOL 485	Seminar in Geology (0.5)	3
GEOL 497	Undergraduate Research (Additional hours may be taken to fulfill Electives)	2
Religion		
Select at least one course from each prefix:		6
RELE 4__	Upper-division ethics	
RELR 4__	Upper-division relational	
Select one of the following:		2
RELT 406	Adventist Beliefs and Life	
RELT 423	Loma Linda Perspectives	
RELT 436	Adventist Heritage and Health	
RELT 437	Current Issues in Adventism	
Geology electives		
Select 14 units from the following or from any unused GEOL courses:		14
BIOL 406	Marine Biology	
BIOL 407	Herpetology	
BIOL 409	Mammalogy	
BIOL 414	Biology of Marine Invertebrates	
BIOL 415	Ecology	
BIOL 449	Biodiversity and Conservation	
GEOL 434	Introduction to GIS for the Natural Sciences (2)	
GEOL 435	GIS Spatial Analysis for the Natural Sciences (3)	
GEOL 455	Modern Carbonate Depositional Systems	
GEOL 465	Hydrogeology	
GEOL 486	Research and Experimental Design	
GEOL 487	Field Geology Studies	
GEOL 488	Topics in Geology	
GEOL 489	Readings in Geology and Paleontology	
GEOL 495	Special Projects in Geology	
HGIS 422	Principles of Geographic Information Systems	
HGIS 424	Desktop GIS Software Applications	
General electives		36
Total Units		110

¹ Fulfills service learning requirement

Seminar attendance requirements

All students must register for and attend in person GEOL 485 Seminar in Geology for each quarter of residence at this University.

Normal time to complete the program

Four (4) years – two (2) years (six [6] quarters) at LLU – based on full-time enrollment; part time permitted

Courses

GEOL 204. Physical Geology. 4 Units.

Introductory geology course that provides the student with a broad picture of geological processes operating on and within the earth. Introduction to minerals, sedimentary and igneous rocks, and fossils. Weathering, earthquakes, volcanism, erosion and sedimentation, and plate tectonics. Three class hours, one three-hour laboratory or field trip per week.

GEOL 316. Mineralogy. 4 Units.

Study minerals and their occurrences including crystallography and crystal chemistry, phase diagrams, and systematic classification. Mineral identification based on hand sample, optical, and other analytical techniques. Three class hours and one three-hour laboratory or field trip per week.

GEOL 317. Igneous and Metamorphic Petrology. 4 Units.

Introduction to classification and origin of igneous and metamorphic rocks. Study phase diagrams and processes controlling magma crystallization. Examine relationship of plate tectonics to the genesis and distribution of igneous and metamorphic rocks. Three class hours and one three-hour laboratory or field trip per week.

GEOL 318. Sedimentary Petrology. 3 Units.

Introduces the classification and origin of sedimentary rocks. Studies common constituents of sedimentary rocks, their classification systems, and analytical approaches, using hand samples and thin sections. One class period, and two three-hour laboratory sessions or a field trip per week. Prerequisite: GEOL 316; or consent of instructor.

GEOL 416. Sedimentology and Stratigraphy. 6 Units.

Focus on the sedimentary rock record through a study of rock types, depositional processes, and models. Stratigraphic nomenclature and approaches to correlation on local, regional, and global scales. Laboratory analysis of primary and diagenetic mineralogy, textures, and sedimentary structures in clastic and carbonate rocks. Field descriptions of sedimentary rocks, structures, and sequences; and field experience in interpreting depositional processes and stratigraphic relationships.

GEOL 424. Structural Geology. 5 Units.

Theory of stress and strain and examination of rock deformation in a framework of plate tectonics. Examples presented in field settings.

GEOL 426. Invertebrate Paleontology. 4 Units.

Structure, classification, ecology, and distribution of selected fossil invertebrate groups. Principles and methods involved in the study and analysis of invertebrate fossils. Three class hours and one three-hour laboratory per week.

GEOL 427. Vertebrate Paleontology. 4 Units.

Systematics, biology, and biogeography of ancient fossil vertebrates, with emphasis on the origins of major groups.

GEOL 434. Introduction to GIS for the Natural Sciences (2). 2 Units.

Principles and practice of GIS data acquisition, data editing, map making, and geodatabase management. Recommended for students beginning a research project.

GEOL 435. GIS Spatial Analysis for the Natural Sciences (3). 3 Units.

Advanced analysis of GIS data; statistical analysis, geographic analysis of spatial data, and methods of displaying, editing, and modeling spatial data using ArcGIS and related GIS tools. Recommended for students who have research data in hand to analyze.

GEOL 436. Low Temperature Geochemistry. 4 Units.

Principles of the chemistry of systems that pertain to surface geological and environmental settings. Major topics include: water quality, mineral solubility, natural systems represented by chemical equations, carbonate equilibrium systems, mineral stability plots, and oxidation-reduction systems. Prerequisite: College chemistry; consent of instructor.

GEOL 443. Historical Geology. 4 Units.

Overview of salient geological and paleontological features in the geological record, explaining the way they are interpreted in the formulation of models of Earth's history.

GEOL 444. Paleobotany. 4 Units.

Fossil plants; their morphology, paleoecology, taphonomy, classification, and stratigraphic distribution. Analyzes floral trends in the fossil record. Three class hours and one three-hour laboratory or field trip per week.

GEOL 455. Modern Carbonate Depositional Systems. 3 Units.

Examines modern and Pleistocene carbonate systems in the field, using these environments as models for understanding sediment production, facies development, and early diagenesis for many ancient carbonates. Presentations and readings on specific environments combined with field descriptions, mapping, analysis, and reports. Requires rigorous hiking and snorkeling in shallow water.

GEOL 456. Field Methods of Geologic Mapping. 4 Units.

Advanced geologic mapping of complex areas, with interpretation of their history; includes mapping of igneous, metamorphic, and sedimentary rocks. Experience in preparation of geologic reports of each mapped locality.

GEOL 464. Science Communication Outreach. 1 Unit.

Guided immersion into science communication outreach. Presentation of principles of communication outreach and small group work. Student teams participate in project that interacts with a specific, identified community. Undergraduate students will work with graduate students in small teams and engage collaborative planning to address a community need, then present, evaluate, and reflect on the experience. Cross-listing: ENVS 464.

GEOL 465. Hydrogeology. 4 Units.

Theory and geology of groundwater occurrence and flow, the relation of ground water to surface water, and the potential distribution of ground water by graphical and analytical methods. Three class hours and one three-hour laboratory per week.

GEOL 475. Philosophy of Science and Origins. 4 Units.

Concepts in the history and philosophy of science, and application of these principles in analyzing current scientific trends.

GEOL 485. Seminar in Geology. 0.5 Units.

Presentations and discussion of selected topics featuring recent developments. Members of all geology meet together.

GEOL 486. Research and Experimental Design. 2 Units.

Concepts, methods, and tools of research—including experimental design and data analysis.

GEOL 487. Field Geology Studies. 1-6 Units.

Special field study trips lasting one or more weeks. Student involvement required, including field presentations and fieldwork assignments, such as the measurement and analysis of sedimentary sections, facies profiling, paleontologic excavation, mapping, or other geological or paleontology field activity. One unit of credit per week. May be repeated for additional credit.

GEOL 488. Topics in Geology. 1-4 Units.

A didactic course in a specified area of earth science to cover time-sensitive subjects or topics on demand. Requires an independent study title request form that describes the specific area covered in the class and course requirements.

GEOL 489. Readings in Geology and Paleontology. 1-4 Units.

Focused readings and discussion of literature with course instructor in a seminar setting. Requires an independent study title request form that describes the specific area covered in the class and course requirements.

GEOL 495. Special Projects in Geology. 1-4 Units.

Special project in the field, laboratory, museum, or library under the direction of a faculty member. Registration indicates the specific field of the project.

GEOL 497. Undergraduate Research. 1-4 Units.

Credit for supervised research activities, including activities related to completion of the senior thesis. Requires an independent study title request form that explains the research and evaluation criteria.

GEOL 510. Orientation to Graduate Geology. 1 Unit.

Provides a platform for introducing students to skills and strategies for successfully navigating through their graduate degree and for planning their future professional career development.

GEOL 512. Invertebrate Paleontology. 4 Units.

Structure, classification, ecology, and distribution of selected fossil invertebrate groups. Considers principles and methods involved in the study and analysis of invertebrate fossils. Per week: Class three hours, plus one three-hour laboratory. Additional work required beyond GEOL 426.

GEOL 513. Vertebrate Paleontology. 4 Units.

Fossil vertebrates, with emphasis on the origins of major groups. Systematics, biology, and biogeography of ancient vertebrates. Additional work required beyond GEOL 427.

GEOL 514. Paleobotany. 4 Units.

Fossil plants, their morphology, paleoecology, taphonomy, classification, and stratigraphic distribution. Analyzes floral trends in the fossil record. Per week: three class hours and one three-hour laboratory or field trip. Additional work required beyond GEOL 444.

GEOL 515. Sedimentology and Stratigraphy. 3 Units.

Studies the weathering, transport, and deposition of sediments as well as the principles of stratigraphy and application of stratigraphic methods. Provides laboratory exercises and field projects to build experience with analysis of sedimentary structures and sequences, and analysis of stratigraphic relationships. Develops skills in illustrating and reporting sedimentological features observed in the field as well as stratigraphy relating to outcrops. Prerequisite: GEOL 318, 529; or consent of instructor.

GEOL 517. Modern Carbonate Depositional Systems. 3 Units.

Examines modern and Pleistocene carbonate systems in the field, using these environments as models for understanding sediment production, facies development, and early diagenesis for many ancient carbonates. Presentations and readings on specific environments combines with field descriptions, mapping, analysis, and reports. Requires rigorous hiking and snorkeling in shallow water. Additional work required beyond GEOL 455.

GEOL 518. Earth Structure, Process, and History. 4 Units.

Study of geological processes and the resulting geological record. Introduces minerals and rocks, sedimentary and igneous processes, fossils, plate tectonics, geological history, and models of earth history. Student prepares a teaching module on the topic. Open only to students in the M.S. degree program in natural sciences. Per week: class three class hours, one three-hour laboratory or field trip.

GEOL 526. Introduction to GIS for the Natural Sciences. 2 Units.

Principles and practice of GIS data acquisition, data editing, map making, and geodatabase management. Recommended for students beginning a research project.

GEOL 527. Earth Materials – Advanced Mineralogy. 4 Units.

Examines mineral groups related to student research. Advances the study of crystallography, chemical variation, microstructures, deformation, and occurrences of minerals. Develops analytical skills using optical properties, SEM/EDS, XRD, gravimetric, and FTIR. Demonstrates competence with characterization of unknown minerals through portfolio projects. Three in-class hours, and one three-hour laboratory or field trip per week. Prerequisite: GEOL 316; or consent of instructor.

GEOL 528. Earth Materials – Advanced Igneous Petrology. 4 Units.

Provides advanced study of the igneous rocks, using whole-rock and mineral chemistry variation, microstructures and microtextures, deformation, and tectonic settings to address processes that affected their evolution in a regional/global geological framework. Develops analytical skills using petrographic and modeling techniques to place quantitative constraints on petrologic processes. Portfolio projects demonstrate competence in the development of petrogenetic models. Prerequisite: GEOL 316; or consent of instructor.

GEOL 529. Earth Materials – Advanced Sedimentary Petrology. 3 Units.

Analyzes, classifies, and describes sedimentary rocks. Uses qualitative and quantitative techniques to produce illustrated reports of texture, composition, diagenesis, and porosity. One class period, and two three-hour laboratory sessions or field trip per week. Prerequisite: GEOL 316; or consent of instructor.

GEOL 535. GIS Spatial Analysis for the Natural Sciences. 3 Units.

Advanced analysis of GIS data; statistical analysis, geographic analysis of spatial data, and methods of displaying, editing, and modeling spatial data using ArcGIS and related GIS tools. Recommended for students who have research data in hand to analyze.

GEOL 537. Field Geology Sedimentology and Stratigraphy. 2 Units.

Develops field geology skills for sedimentary rock sequences as well as field measurements and descriptions of sedimentary lithologies, facies, and sequences. Applies stratigraphic approaches in the field as well as assembly and interpretation of geologic reports based on previously collected and new field data. Prerequisite or concurrent: GEOL 515; or consent of instructor.

GEOL 538. Field Mapping and Geologic Report Writing. 4 Units.

Teaches advanced geologic mapping of complex areas, with interpretation of their history. Explores the use of technology to collect and record field data. Explains how to incorporate published data and field measurements into figures, maps, and geologic reports. Prerequisite: GEOL 424; or consent of instructor.

GEOL 539. Field Geology Structures and Igneous Rocks. 2 Units.

Explores the study of structures and deformation to characterize pluton emplacement. Uses structural and petrographic data derived from systematic geological mapping, detailed petrographic descriptions, and structural characterization carried out in outcrops and rock thin sections—coupled with kinematic studies—in order to determine origin, emplacement conditions, and deformation phases of the rocks. Prerequisite or concurrent: GEOL 424; or consent of instructor.

GEOL 545. Taphonomy. 4 Units.

Processes that affect an organism from death until its final burial and fossilization, and utilization of this information in reconstructing ancient assemblages of organisms. Three class hours per week. One laboratory per week to study, describe, and interpret fossil assemblages of vertebrates, invertebrates, and microfossils.

GEOL 554. Limnogeology. 4 Units.

Ancient lake deposits, including their sedimentologic, paleontologic, mineralogic, geochemical, and stratigraphic characteristics. Investigates as analogs the depositional processes occurring in modern lakes. Laboratory and several extended field trips.

GEOL 555. Carbonate and Evaporite Geology. 4 Units.

Advanced course on the geology of carbonate and evaporite rocks, including: petrography, depositional systems, diagenesis, and overview of current topics of research. Includes weekly laboratory experience in the analysis of carbonate and evaporite samples and a field trip to ancient carbonate sequences.

GEOL 556. Paleoenvironments. 3 Units.

Venue to learn skills to distinguish and reconstruct ancient depositional environments. Applies paleontologic, sedimentologic, and geochemical data and methods to interpretation of paleoenvironments, with emphasis on organism-sediment relationships. Investigates as analogs processes, sediments, and organisms in modern depositional environments.

GEOL 557. Paleoenvironments Field Trip. 1 Unit.

Field-based geology that integrates with GEOL 556, Paleoenvironments. Ten days spent visiting a variety of ancient and modern depositional environments. Published observations reviewed and relived to develop a regional context and collect primary field data.

GEOL 558. Philosophy of Science. 4 Units.

Selected topics in the history and philosophy of science, and application of these principles in analyzing contemporary scientific trends.

GEOL 559. Philosophy of Science and Origins. 1 Unit.

Studies selected topics in the history and philosophy of science, and applies these principles in analyzing current scientific trends. Provides an advanced update in the topic for students who have had a similar course at the undergraduate level. Prerequisite: GEOL 475.

GEOL 565. Analysis of Sedimentary Rocks. 4 Units.

Provides exposure to range of analytical tools used for assessment in sedimentary geology. Tools covered include: saws and grinders, photography through microscope, point counting with optical microscope, x-ray diffraction of bulk and clays, scanning electron microscopy with EDS, magnetic susceptibility, grain size analysis, acid insoluble residues, making thin sections, MP-AES, GPS, image analysis, and error analysis. Participants will use case studies to develop skill in project design.

GEOL 566. Clastic Sedimentary Geology. 4 Units.

Advanced course on the geology of clastic sedimentary rocks—including: petrography, depositional systems, diagenesis, and overview of current topics of research. Includes weekly laboratory experience in the analysis and description of clastic rock samples and a field trip to ancient clastic sequences.

GEOL 567. Stratigraphy and Basin Analysis. 4 Units.

Addresses vertical and lateral relationships of sedimentary units and facies in the context of the development and filling of sedimentary basins within a chronostratigraphic framework. Emphasis on the impact of tectonics, sea level variations, and autogenic processes and their expression as sequences with specific stratal geometries in different basin types. Both surface (field outcrop studies) and subsurface (well logs and seismic stratigraphy) approaches to basin analysis will be covered.

GEOL 575. Hydrogeology. 4 Units.

Theory and geology of groundwater occurrence and flow, the relation of groundwater to surface water, and the potential distribution of groundwater by graphical and analytical methods. Three class hours and one three-hour laboratory per week.

GEOL 588. Topics in Geology. 1-4 Units.

A didactic course in a specified area of earth science to cover time-sensitive subjects or topics on demand. Requires an independent study title request form that describes the specific area covered in the class and course requirements.

GEOL 594. Readings in Geology and Paleontology. 1,2 Unit.

Focused readings and discussion of the literature with the course instructor in a seminar setting. Requires an independent study title request form that describes the specific area covered in the class and course requirements.

GEOL 595. Readings in Limnogeology. 1 Unit.

Readings and analysis of current and classic scientific literature dealing with modern and ancient lake environments—including geochemistry, sedimentology, biology and paleontology, and related subjects. Activities include student presentations of papers, discussion, and research proposals and reports. One extended, multiday field trip required.

GEOL 607. Seminar in Geology. 0.5 Units.

Presentations and discussion of selected topics featuring recent developments. Members of all geology programs meet together.

GEOL 616. Research and Experimental Design. 2 Units.

Concepts, methods, and tools of research, including experimental design and data analysis. Cross-listing: BIOL 616.

GEOL 617. Proposal Writing and Grantsmanship. 2 Units.

Develops skills in writing proposals and in acquiring funding for research. Increases understanding of the culture of research. Reviews the infrastructure of science funding and identifies individualized sources of potential funding. Presents successful proposal-writing strategies for both governmental and nongovernmental sources of funding. Emphasizes development of effective writing skills during preparation of the student's thesis or dissertation proposal.

GEOL 618. Writing for Publication. 1 Unit.

Explores the mechanics and processes of preparing, submitting, revising, and resubmitting a manuscript for publication in a peer-reviewed journal. Designed for students who are well along in the process of writing their first manuscript for publication. Prepares students to handle the manuscript revision process when the manuscript is returned from reviewers, as well as the final stage of resubmission to the journal.

GEOL 658. Advanced Philosophy of Science readings (2). 2 Units.

Reading and discussion of selected references in the philosophy of science, and the application of these concepts in the practice of scientific research and interpretation, including their influence on scientific study of origins. Best taken near the end of a student's graduate program. Two-hour class session per week.

GEOL 664. Science Communication Outreach. 1 Unit.

Guided immersion into science communication outreach. Principles of communication outreach and small group work presented. Student teams devise project that engages a specific, identified community. Small teams collaboratively interact with community to address a need, present findings, evaluate impact, and reflect on experience. Cross-listing: BIOL 664.

GEOL 695. Special Projects in Geology. 1-4 Units.

Special project in the field, laboratory, museum, or library under the direction of a faculty member. Registration indicates the specific field of the project.

GEOL 697. Research. 1-8 Units.

Credit for supervised research activities. Requires an independent study title request form that explains the research and evaluation criteria.

GEOL 698. Thesis Research. 1-8 Units.

Credit for supervised research activities and for writing of the master's thesis. Requires an independent study title request form that explains the research and evaluation criteria. Grade received does not indicate whether thesis is completed and approved.

GEOL 699. Dissertation Research. 1-8 Units.

Credit for supervised research activities and for writing the doctoral dissertation. Requires an independent study title request form that explains the research and evaluation criteria. Grade received does not indicate whether dissertation is completed and approved.