

Department of Geology

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Degrees offered: Bachelor of Science (BS), Bachelor of Arts (BA), Master of Science (MS), and Doctor of Philosophy (PhD) in Geology; BS and MS in Applied Environmental Geoscience; BS in Earth Science Composite Teaching

Undergraduate emphases: *BS in Geology*—Hydrogeology-Engineering Geology and Geoarchaeology

Graduate Specializations: *MS in Geology*—Geochemistry, Hydrogeology, Igneous Petrology, Paleogeology, Sedimentary Petrology, Structural Geology, and Surficial Geology

Undergraduate Programs

Objectives

Geology is the study of the planet Earth, the materials of which it is made, the processes that act on these materials, the products formed, and the history of the planet and its life forms since its origin. Geology considers the physical forces that act within and on the Earth, the chemistry of its constituent materials, and the biology of its past inhabitants as revealed by fossil evidence. Geologists integrate biology, chemistry, engineering, mathematics, and physics in the study of our natural surroundings. The knowledge thus obtained is used by geologists to explore for energy, mineral, and water resources; to identify geologically stable sites for major structures; and to provide foreknowledge of some of the dangers associated with the mobile forces of a dynamic Earth. Geologists provide fundamental information required by modern society to plan for cultural and industrial development, reduce geological hazards, identify potential resources, and assist in the design of waste-disposal facilities.

The Department of Geology prepares students for professional careers in the geosciences and provides the background required for advanced studies. The department offers three options of study to meet the growing demand for geoscientists with training in general geology (BS in geology without an emphasis), hydrogeology-engineering geology emphasis, or geoarchaeology emphasis. All options provide exposure to the sciences and an appreciation of our physical surroundings. The BS program in Geology meets the curriculum standards established by the American Institute of Professional Geologists.

The BS in Applied Environmental Geoscience is an interdisciplinary program that combines parts of the traditional geology curriculum with a variety of courses in related subject areas, such as watershed sciences, soils, biology, statistics, and GIS/remote sensing. This degree prepares graduates for careers with the environmental industry, government regulatory agencies, and policy organizations. Environmental geoscience is applied in a range of diverse situations, such as urban development, waste disposal, resource management, engineering, soils and agriculture, and assessment of natural and artificial hazards.

The department also offers the Earth Science Composite Teaching Major to prepare teachers of earth science at the secondary school level. Requirements for this major meet or exceed the standards of the National Science Teachers Association. Those students who major in earth science should be aware that state licensure is required of secondary education teachers. The Earth Science Composite Teaching Major fulfills the requirements that provide eligibility for licensure. Licensure requirements vary from state to state, and students should investigate the requirements for the states in which they intend to seek employment. Advising for the Secondary Teacher Education Program (STEP) and State of Utah secondary education licensure is provided by the USU School of Teacher Education and Leadership (TEAL).

The Department of Geology is housed within the Geology Building, which is located at the northeast corner of the Old Main Quad. The Geology Building provides spacious, well-equipped teaching labs, classrooms, and facilities, including a display and study area for students, computer access, document room, map room, preparation facilities, and research labs.

General College of Science Requirements

All general College of Science requirements are embedded within the various major requirements listed below. No extra coursework is required to fulfill the general college requirements.

Requirements

Departmental Admission Requirements

New freshmen admitted to USU in good standing qualify for admission to this major. Transfer students from other institutions need a 2.2 GPA, and students transferring from other USU majors need a 2.0 GPA for admission to this major in good standing. Students seeking admission to the Earth Science Composite Teaching Major should be aware that a 2.75 minimum GPA is required for admission to the Secondary Teacher Education Program (STEP) in the School of TEAL. Students in the Hydrogeology-Engineering Geology emphasis must meet all College of Engineering GPA standards appropriate for the courses to be taken having either the ENGR or CEE prefix.

Field Trips and Labs

Most Geology courses have required laboratories and/or field trips. Those enrolled are expected to dress properly for the conditions and observe safety precautions issued by the instructors. Most courses require modest lab fees.

Bachelor of Arts Degree

For a BA in Geology, the foreign-language requirement must be satisfied in addition to the Bachelor of Science in Geology requirements.

Geology Major—General Geology Option

GEO 1110 (BPS) The Dynamic Earth: Physical Geology (F,Sp).....	4
GEO 3200 (DSC) The Earth Through Time (Sp).....	4
GEO 3500 Mineralogy and Crystallography (F).....	4
GEO 3520 Optical Mineralogy and Petrography (Sp).....	2
GEO 3550 (CI) Sedimentation and Stratigraphy (F).....	4
GEO 3600 Geomorphology (F).....	4
GEO 3700 Structural Geology (Sp).....	4
GEO 4500 Igneous and Metamorphic Petrology (Sp).....	4
GEO 4700 (CI) Geologic Field Methods (F).....	3
GEO 5200 Geology Field Camp (Su).....	5

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CHEM 1210 Principles of Chemistry I (F,Sp).....	4
CHEM 1215 Chemical Principles Laboratory I (F,Sp).....	1
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su).....	4
CHEM 1225 Chemical Principles Laboratory II (F,Sp).....	1
MATH 1210 (QL)¹ Calculus I (F,Sp,Su).....	4
STAT 3000 (QI) Statistics for Scientists (F,Sp,Su) (3 cr) or	
MATH 1220 (QL) Calculus II (F,Sp,Su) (4 cr).....	3 or 4
CS 1050 Problem Solving with Computers (Sp) (3 cr) or	
CS 1400 Introduction to Computer Science—CS 1 (F,Sp,Su) (3 cr) or	
CEE 5190 Geographic Information Systems for Civil Engineers (Sp) (3 cr) or	
WATS 4930 Geographic Information Systems (F) (4 cr).....	3 or 4
PHYS 2210 (QI) General Physics—Science and Engineering I.....	4
PHYS 2220 (BPS/QI) General Physics—Science and Engineering II ..	4

Students must also select 12 credits from any Geology courses numbered 4900 or above, except GEO 5200 (Geology Field Camp).

Geology Major—Hydrogeology- Engineering Geology Emphasis

GEO 1110 (BPS) The Dynamic Earth: Physical Geology (F,Sp).....	4
GEO 3200 (DSC) The Earth Through Time (Sp).....	4
GEO 3500 Mineralogy and Crystallography (F).....	4
GEO 3550 (CI) Sedimentation and Stratigraphy (F).....	4
GEO 3600 Geomorphology (F).....	4
GEO 3700 Structural Geology (Sp).....	4
GEO 4700 (CI) Geologic Field Methods (F).....	3
GEO 5200 Geology Field Camp (Su).....	5
GEO 5510 (QI) Groundwater Geology (F).....	3
GEO 5600 Geochemistry (F).....	3
CHEM 1210 Principles of Chemistry I (F,Sp).....	4
CHEM 1215 Chemical Principles Laboratory I (F,Sp).....	1
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su).....	4
CHEM 1225 Chemical Principles Laboratory II (F,Sp).....	1
MATH 1210 (QL)¹ Calculus I (F,Sp,Su).....	4
MATH 1220 (QL) Calculus II (F,Sp,Su).....	4
MATH 2250 (QI) Linear Algebra and Differential Equations (F,Sp,Su) ..	4
CS 1050 Problem Solving with Computers (Sp) (3 cr) or	
CS 1400 Introduction to Computer Science—CS 1 (F,Sp,Su) (3 cr) or	
CEE 5190 Geographic Information Systems for Civil Engineers (Sp) (3 cr) or	
WATS 4930 Geographic Information Systems (F) (4 cr).....	3 or 4
PHYS 2210 (QI) General Physics—Science and Engineering I.....	4
PHYS 2220 (BPS/QI) General Physics—Science and Engineering II ..	4
ENGR 2010 Engineering Mechanics Statics (F,Sp).....	2
ENGR 2030 Engineering Mechanics Dynamics (F,Sp,Su).....	3
ENGR 2140 Strength of Materials (F,Sp,Su).....	2
CEE 3430 Engineering Hydrology (Sp) (3 cr) or	
CEE 4300 Engineering Soil Mechanics (Sp) (4 cr).....	3 or 4
CEE 3500 Civil and Environmental Engineering Fluid Mechanics (F,Sp).....	3
SOIL 3000 Fundamentals of Soil Science (F) (4 cr) or	
SOIL 5130 Soil Genesis, Morphology, and Classification (F) (4 cr)	4

Geology Major—Geoarchaeology Emphasis

GEO 1110 (BPS) The Dynamic Earth: Physical Geology (F,Sp).....	4
GEO 3200 (DSC) The Earth Through Time (Sp).....	4
GEO 3500 Mineralogy and Crystallography (F).....	4
GEO 3550 (CI) Sedimentation and Stratigraphy (F).....	4
GEO 3600 Geomorphology (F).....	4
GEO 3700 Structural Geology (Sp).....	4
GEO 4700 (CI) Geologic Field Methods (F).....	3
GEO 5430 Paleontology (F).....	2
ANTH 1030 (BSS) World Archaeology (F [Sp online]).....	3

ANTH 5300 Archaeology Field School (Su).....	4-5
ANTH 5310 Archaeology Lab.....	1-3

CHEM 1210 Principles of Chemistry I (F,Sp) (4 cr) and	
CHEM 1215 Chemical Principles Laboratory I (F,Sp) (1 cr) and	
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su) (4 cr) and	
CHEM 1225 Chemical Principles Laboratory II (F,Sp) (1 cr).....	10

BIOL 3010 (CI/DSC) Evolution (Sp).....	3
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Two courses selected from:

BIOL 2220 General Ecology (F,Sp) (3 cr) and/or	
BIOL 3030 (DSC) Genetics and Society (Sp) (3 cr) and/or	
BIOL 3040 (DSC) Plants and Civilization (F) (3 cr) and/or	
BIOL 3220 (QI) Field Ecology (F) (2 cr).....	5 or 6

MATH 1210 (QL)¹ Calculus I (F,Sp,Su).....	4
STAT 3000 (QI) Statistics for Scientists (F,Sp,Su).....	3
WATS 4930 Geographic Information Systems (F).....	4
SOIL 3000 Fundamentals of Soil Science (F) (4 cr) or	
SOIL 5130 Soil Genesis, Morphology, and Classification (F) (4 cr)	4

Applied Environmental Geoscience Major

GEO 1060 (BPS) Introduction to Environmental Geoscience (Sp) (3 cr) or	
GEO 1110 (BPS) The Dynamic Earth: Physical Geology (F,Sp) (4 cr).....	3 or 4
GEO 3500 Mineralogy and Crystallography (F).....	4
GEO 3550 (CI) Sedimentation and Stratigraphy (F).....	4
GEO 3600 Geomorphology (F).....	4
GEO 3700 Structural Geology (Sp).....	4
GEO 4700 (CI) Geologic Field Methods (F).....	3
GEO 5200 Geology Field Camp (Su).....	5
GEO 5600 Geochemistry (F).....	3

Geology Electives (12 credits required)

Students must complete at least 12 credits, selected from the following:

GEO 5150 Fluvial Geomorphology (F).....	3
GEO 5410 Introduction to Clay Mineralogy (Sp).....	2
GEO 5510 (QI) Groundwater Geology (F).....	3
GEO 5520 (CI) Techniques of Groundwater Investigations (Sp).....	3
GEO 5530 (QI) Petroleum Systems: Principles of Exploration and Development (Sp).....	3
GEO 5540 (QI) Quantitative Methods in Geology (F).....	3
GEO 5550 Geochemical Application of Electron Microprobe and X-Ray Fluorescence Analysis (Sp).....	4
GEO 5630 Photogeology (Sp).....	3
GEO 5650 Senior Thesis (F,Sp).....	3-4
GEO 5680 Paleoclimatology (Sp).....	3

Required Support Courses (39-40 credits)

Chemistry Group (10 credits)

CHEM 1210 Principles of Chemistry I (F,Sp).....	4
CHEM 1215 Chemical Principles Laboratory I (F,Sp).....	1
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su).....	4
CHEM 1225 Chemical Principles Laboratory II (F,Sp).....	1

Mathematics and Statistics Group (7 credits)

MATH 1210 (QL)¹ Calculus I (F,Sp,Su).....	4
STAT 3000 (QI) Statistics for Scientists (F,Sp,Su).....	3

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Physics Group (4 credits)

PHYS 2110 The Physics of Living Systems I (4 cr) **or**
PHYS 2210 (QI) General Physics—Science and Engineering I (4 cr) ... 4

Environmental Group (18-19 credits)

BIOL 1610 Biology I (F)..... 4
BIOL 1620 (BLS) Biology II (Sp)..... 4
WATS 3700 (CI) Fundamentals of Watershed Science (Sp)..... 3
SOIL 3000 Fundamentals of Soil Science (F)..... 4
CEE 5190 Geographic Information Systems for
 Civil Engineers (Sp) (3 cr) **or**
WATS 4930 Geographic Information Systems (F) (4 cr)..... 3 or 4

Support Electives (12 credits required)

No more than 8 credits may be chosen from any one group.

Group A: Hydrologic Science

ENVS 5320 Water Law and Policy in the United States (Sp)..... 3
WATS 4490 (d5490) Small Watershed Hydrology (F)..... 4
WATS 5660 Watershed and Stream Restoration (Su) 2
WATS 5670 Watersheds and Stream Restoration Practicum (Su)..... 2

Group B: Ecology, Soils, and Environmental Chemistry

BIOL 2220 General Ecology (F,Sp)..... 3
BIOL 3220 (QI) Field Ecology (F)..... 2
CHEM 3650 (DSC) Environmental Chemistry (Sp)..... 3
SOIL 5050 (d6050) Principles of Environmental Soil
 Chemistry (Sp odd) 3
SOIL 5130 (d6130) Soil Genesis, Morphology,
 and Classification (F)..... 4
SOIL 5560 (d6560) Analytical Techniques for the
 Soil Environment (Sp) 2
SOIL 5620 Aquatic Chemistry (F)..... 3

Group C: GIS/Remote Sensing

WATS 4750 Fundamentals of Remote Sensing Science (F)..... 3
WATS 4930 (d6920) Geographic Information Systems (F)..... 4
WATS 5250 (d6250) Remote Sensing of Land Surfaces (Sp) 4
WATS 5760 (d6760) Remote Sensing: Modeling and Analysis (Sp)..... 3
WILD 5750 Applied Remote Sensing (F) 3

Earth Science Composite Teaching Major

GEO 1110 (BPS) The Dynamic Earth: Physical Geology (F,Sp) 4
GEO 2500² Geology Field Excursions (F,Sp)..... 2
GEO 3200 (DSC) The Earth Through Time (Sp)..... 4
GEO 3500 Mineralogy and Crystallography (F) 4
GEO 3550 (CI) Sedimentation and Stratigraphy (F)..... 4
GEO 3600 Geomorphology (F) 4
GEO 3700 Structural Geology (Sp)..... 4
GEO 4700 (CI) Geologic Field Methods (F) 3
PHYS 1040 (BPS) Introductory Astronomy 3
PHYS 2210 (QI) General Physics—Science and Engineering I..... 4
PHYS 2220 (BPS/QI) General Physics—Science and Engineering II .. 4
CHEM 1210 Principles of Chemistry I (F,Sp)..... 4
CHEM 1215 Chemical Principles Laboratory I (F,Sp)..... 1
CHEM 1220 (BPS) Principles of Chemistry II (F,Sp,Su) 4
CHEM 1225 Chemical Principles Laboratory II (F,Sp)..... 1
ENVS 5110 Environmental Education (Sp) (3 cr) **or**
WILD 2200 (BLS) Ecology of Our Changing World (F,Sp) (3 cr) 3
CLIM 2000 (BPS) The Atmosphere and Weather (F,Sp) 3
WATS 3000 (DSC) Oceanography (Sp) (3 cr) **or**
GEO 3300 (DSC) Geology of the World's Oceans (Sp) (3 cr)..... 3
SCI 4300 Science in Society (F,Sp)..... 2
MATH 1210 (QL)¹ Calculus I (F,Sp,Su)..... 4
STAT 3000 (QI) Statistics for Scientists (F,Sp,Su) 3
CS 1050 Problem Solving with Computers (Sp) (3 cr) **or**
CS 1400 Introduction to Computer Science—CS 1 (F,Sp,Su) (3 cr)..... 3

Students must also complete the Secondary Teacher Education Program (STEP) as follows:

Level 1

SCED 3100 Motivation and Classroom Management (F,Sp) 3
SCED 3210 (CI/DSS) Educational and Multicultural Foundations
 (F,Sp)..... 3
SCED 3300 Clinical Experience I (F,Sp) 1
SCED 3400 Teaching Science I (Sp)..... 3
INST 3500 Technology Tools for Secondary Teachers (F,Sp,Su)..... 1

Level 2

SPED 4000 Education of Exceptional Individuals
 (may be taken anytime) (F,Sp,Su)..... 2
SCED 4200 (CI) Reading, Writing, and Technology (F,Sp) 3
SCED 4210 Cognition and Evaluation of Student Learning (F,Sp) 3
SCED 4300 Clinical Experience II (F,Sp) 1
SCED 4400 Teaching Science II (F)..... 3

Level 3 (12 credits)

SCED 5500 Student Teaching Seminar (F,Sp)..... 2
SCED 5630 Student Teaching in Secondary Schools (F,Sp) 10

Notes

The Teaching Science I and II courses (SCED 3400 and 4400) are *only* taught once per year. Therefore, it is important for students to consult with their advisor to fit these courses in the correct sequence into their plan of study.

This curriculum meets the standards of the Utah Core Curriculum—Science 7-12.

All USU teacher education candidates will be required to take and pass the content exam approved by the Utah State Office of Education in their major content area prior to student teaching.

A 2.75 minimum GPA is required for *both* admission to *and* graduation from the Secondary Teacher Education Program (STEP).

Geology Minor

GEO 1010 (BPS) Introduction to Geology:
 Geology of National Parks (F,Su) (3 cr) **or**
GEO 1110 (BPS)⁴ The Dynamic Earth: Physical Geology
 (F,Sp) (4 cr) 3 or 4
GEO 3200 (DSC) The Earth Through Time (Sp)..... 4

Students must also select 10 elective credits from Geology courses at the 3500 level or above.

¹Students may need to complete prerequisite courses prior to enrolling in MATH 1210.

²GEO 2500 (a 1-credit course) is repeatable for credit, and must be taken *twice* for the student to earn the required 2 credits.

³PHYS 1020 may also be listed as USU 1360, IPS: Energy.

⁴GEO 1110 is preferred.

Senior Thesis

Geology majors in good academic standing may elect to complete a senior thesis. This is an endeavor which normally spans a year in its preparation and presentation. Senior thesis credits may be applied toward the elective requirements in the General Geology option. For further information, students should contact their geology advisor or the geology department head.

Suggested Four-year Plans

Suggested semester-by-semester four-year plans for students working toward a bachelor's degree within the Geology Department can be found at: <http://www.usu.edu/degreeplans/>

Students should consult with their advisor to develop a plan of study tailored to their individual needs and interests.

Departmental Honors

Students who would like to experience greater academic depth within their major are encouraged to enroll in departmental honors. This is a departmental recognition which is separate from the University Honors program. Through original, independent work, Honors students enjoy the benefits of close supervision and mentoring, as they work one-on-one with faculty in select upper-division departmental courses. Honors students also complete a senior project, which provides another opportunity to collaborate with faculty on a problem that is significant, both personally and in the student's discipline. Participating in departmental honors enhances students' chances for obtaining fellowships and admission to graduate school.

Geology majors with a minimum GPA of 3.30 may elect to complete the requirements for the Geology Honors degree option. For further information, students should contact their geology advisor or the geology department head.

Undergraduate Research Opportunities

The Department of Geology offers a range of opportunities for undergraduate students to participate in research activities under the guidance of a faculty mentor. All departmental undergraduate research activities are coordinated by the departmental undergraduate advisor, Joel Pederson, (435) 797-7097, joel.pederson@usu.edu.

Learning Objectives

Upon graduation, geology majors are expected to be able to: (1) identify common minerals; (2) identify common fossils, as well as their ages and the conditions under which they lived; (3) describe sedimentary rocks and measure a stratigraphic section in the field; (4) create a surficial geologic map; (5) define and distinguish between, and determine the type of stress responsible for forming various structural features; (6) use a Brunton compass; (7) read topographic maps, as well as construct profiles from them; (8) read and make geologic maps, as well as construct cross sections from them; (9) know the ages of important geologic features and events in the Earth's history, as well as explain how and why the Earth has changed over time; (10) know the Earth's internal processes and the features produced by them; (11) collect and evaluate geologic data; (12) interpret and create graphs of quantitative data; and (13) communicate observations and interpretations, both orally and in writing.

Assessment

The Department of Geology relies on a variety of tools to periodically assess its undergraduate program, including: (1) student input in assessment; (2) value-added assessment; (3) college-level assessment; (4) alumni participation in assessment; and (5) faculty program assessment. For more information, please refer to the Geology Department assessment website at:

<http://www.usu.edu/geo/assessment/assessment.htm>

Additional Information

For more information about bachelor's degree requirements for Geology programs, see the Geology Major Requirement Sheet, available from the department, or online at:

<http://www.usu.edu/majorsheets/>

Graduate Programs

Admission Requirements

See general admission requirements on pages 36-37. In addition, applicants must have acceptable GRE scores and an acceptable GPA. For the Master of Science program, minimum scores of 40th percentile on the Verbal and Quantitative sections, a combined minimum of 1,000, and a GPA of 3.0 are required. For the PhD program, minimum scores of 50th percentile on the Verbal and Quantitative sections, a combined minimum of 1,200, and a GPA of 3.4 are required. For both programs, a member of the Geology faculty must agree to serve as the major professor for the applicant prior to acceptance.

Applications will be considered throughout the year, but program entry in fall semester is preferred. Students who wish to be considered for assistantships or other financial aid must have complete applications on file no later than February 15 for entry into the program the following fall semester.

Prerequisites for Matriculation

Completion of a BS or BA in geology, biology, physics, chemistry, or engineering is required for matriculation status. Suggested prerequisite courses include: CHEM 1210, 1215, 1220, 1225; PHYS 2210, 2220; MATH 1210; STAT 3000; and CS 1050 or CS 1400 or CEE 5190 or WATS 4930. Deficiencies in geology are determined based on current USU undergraduate degree requirements for either the Geology or Hydrogeology-Engineering Geology option, as appropriate. The following geology courses or their equivalents are expected: GEO 1110, 3200, 3500, 3550, 3600, 3700, 4700, and 5200. It is expected that any deficiencies will be made up before the end of the first year of graduate study.

Degree Programs

Master of Science Degree—Geology

The department offers advanced study and research opportunities leading to the MS degree in Geology. Although many research specialties require advanced courses selected primarily from Geology offerings, additional courses may be selected from other departments on campus, such as Biology; Civil and Environmental Engineering; Environment and Society; Mathematics and Statistics; Plants, Soils, and Climate; Watershed Sciences; and Wildland Resources.

Master of Science Degree—Applied Environmental Geoscience

The department offers advanced study leading to the MS degree in Applied Environmental Geoscience. This terminal degree program requires a combination of advanced courses selected from Geology offerings, as well as additional courses from other units on campus, such as Civil and Environmental Engineering; Plants, Soils, and Climate; Biology; Chemistry and Biochemistry; Mathematics and Statistics; and the College of Natural Resources.

Doctor of Philosophy Degree

The Doctor of Philosophy degree in Geology requires original research in a specific area of geology, demonstration of broad knowledge in the field of geology, and demonstration of depth of knowledge in at least two areas of geology. The successful candidate must demonstrate a breadth of understanding in geology, as well as a depth of understanding in his or her chosen area(s) of emphasis. Potential students must show an ability to do creative research. This

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research should be carried out during a significant period of time (i.e., during at least one year or three semesters in residence). Thus, each successful PhD candidate will produce a significant piece of original research, presented in a written dissertation and defended in an oral examination. This work should be of such scope and quality that more than one journal or conference article can be derived from it.

Research Areas

Fields of graduate research include the following: geophysics, hydrogeology, igneous petrology, paleobiology (including invertebrate paleontology and paleoecology), sedimentology (including petrology, basin analysis, sedimentation, stratigraphy, and petroleum geology), process geomorphology, Quaternary geology, structural geology, and regional tectonics.

Degree Requirements

Master of Science Degree—Geology

Only the Plan A thesis option is allowed for the MS degree in Geology. The recommended distribution is 20 credits of coursework and 10 credits of thesis to obtain the required 30 credits for the MS degree. A minimum of five 6000-level geology courses (other than GEO 6800) is recommended for the degree program. Only two grades of less than *B* (*C* to *B*-) will be accepted as part of the required degree program as listed on the "Program of Study for Master's Degree." A 3.0 grade point average must be obtained in required coursework as listed on the Program of Study. Thesis credits will be graded *P-F* only (i.e., no letter grade will be given). Geology graduate students using department or University facilities and/or under geology faculty supervision must register for a minimum of 3 credits every semester, up to and including the semester in which the thesis is cleared by the School of Graduate Studies. Registration may not be required during the summer.

Master of Science Degree—Applied Environmental Geoscience

Only the Plan B nonthesis option is allowed for the MS degree in Applied Environmental Geoscience, which requires 32 credits. The Plan B option requires the production of a paper. At least 2 credits of thesis research are required, but no more than 3 credits of thesis credit can be included on the Program of Study. The Plan B paper is usually a review of literature, with conclusions drawn after conceptualizing an area of inquiry, planning a systematic search, and analyzing and critiquing the acquired information. The summary and conclusions developed should enhance knowledge in the discipline. Plan B papers and reports should follow the same format specifications as theses and dissertations and are expected to reflect equivalent scholarship standards, even though they may be less intensive and not demand the originality of a Plan A thesis. Plan B papers are defended, but are not reviewed by the School of Graduate Studies assistant dean or signed by the graduate dean. Plan B papers must be submitted to the Merrill-Cazier Library to be microfiched, and the binding receipt must be returned to the School of Graduate Studies.

Doctor of Philosophy Degree

There are two program tracks for this degree: academic and professional. The **academic track** is designed to prepare graduates for a career in academia or other teaching-related settings. It includes both coursework in education and classroom teaching experience under the supervision of a faculty teaching mentor. The **professional track** is designed to prepare graduates for work in professional careers with the petroleum industry, with other extractive industries, or in environmental and hydrologic consulting. It includes coursework in statistics, information systems, remote sensing, and GIS. Completion of a professional internship is encouraged.

Students completing a PhD in Geology must fulfill the following requirements:

1. Complete at least 90 credits of graduate coursework (including at least 21 credits of GEO 7970, Dissertation Research) beyond a BS degree *or* at least 60 credits (including at least 15 credits of GEO 7970, Dissertation Research) beyond an MS degree, with a minimum class grade of *B* and a minimum cumulative GPA of 3.3.
2. If an MS degree is completed first, then *no more than* 12 credits of the 60 credits required for the PhD degree may be taken in coursework numbered below the 6000 level. If an MS degree is *not* completed first, then *no more than* 21 credits of the 90 credits required for the PhD degree may be taken in coursework numbered below the 6000 level.
3. Complete at least 30 credits of advanced coursework (6000 level and above) beyond the BS degree *or* 21 credits of advanced coursework beyond the MS degree, including at least 15 credits of 7000-level geology coursework, and excluding GEO 6900, 7970, and 7990.
4. Complete 3 credits of GEO 7800 (Graduate Seminar Series).
5. **Academic Track:** Complete 9-12 credits of department-approved education or instructional technology courses, and successfully teach one geology course under the supervision of a faculty mentor. ELED/SCED 6190 and GEO 6900 (teaching internship) are required.

Professional Track: Complete 9-12 credits of department-approved courses in statistics, remote sensing, and/or geographic information systems. Completion of a professional internship program is encouraged. Approved courses include BIE/CLIM/WATS 6250, ENV5 6550, WATS 4930, 6760, WILD 6740, 6750.
6. Pass a written comprehensive examination showing depth and breadth of knowledge in geology and in the student's area(s) of emphasis. The student may be required to take additional classes to satisfy any deficiencies.
7. Successfully complete a written dissertation research proposal, present that proposal orally to the department, and defend it during an oral examination. The oral examination will include questions of a deep and probing nature, and may range beyond the dissertation proposal into areas unrelated to the student's specialization.
8. Complete at least 15 credits in GEO 7970 (Dissertation Research) if admitted with a prior master's degree, *or* 21 credits in GEO 7970 (Dissertation Research) without an earned master's degree.
9. Successfully complete and defend a dissertation. The dissertation will be a written document and may consist of several papers submitted or accepted for publication. The defense will be oral, including a presentation of the work and successful defense of the work to the faculty.

Research

There are six broad areas of research emphasis for graduate students and faculty within the department: (1) geomorphology, (2) geophysics, (3) hydrology, (4) petrology, (5) sedimentology, and (6) structural geology and regional tectonics. Summaries of these activities follow.

Geomorphology research has included the study of climate, tectonic, and anthropogenic controls on landscape change, erosion, and sedimentation. This includes studies on hillslope processes, landscape evolution of the Colorado Plateau and Grand Canyon, the downstream effect of dams, and river restoration.

Geophysics examines the earth through quantitative methods, such as seismology, magnetics, GPS, geodesy, and gravity. Current geophysics research in the Department of Geology examines rates and magnitudes of crustal deformation through GPS techniques.

Recent research in **hydrogeology** includes determining the feasibility of constructing an artificial salmon spawning channel; characterizing, modeling, and monitoring groundwater flow systems; and investigating the hydraulic properties of faults in sandstones as they relate to carbon dioxide sequestration.

Research in **petrology** focuses on the origin and evolution of magmatic systems, hotspots, oceanic lithosphere, collisional orogens, and convergent margin systems. These efforts use field relations, phase chemistry, and whole rock geochemistry to decipher these systems, as well as determine their relationship to the tectonic and geochemical evolution of the Earth.

Research in **sedimentology** currently includes sequence stratigraphy of Paleozoic mixed carbonate-siliciclastic systems in the Great Basin; ecology, paleoecology, and sedimentology of coral reefs; tectonics of sedimentary basins at plate margins; and basin analysis, isotope geochemistry, and paleobiology of Proterozoic rocks in the western United States.

Research in **structural geology** and **regional tectonics** has included the examination of the mechanical and chemical evolution of fault zones; the structural and tectonic development of extensional structures in the Great Basin; the development of fold-and-thrust structures in Idaho, Montana, Wyoming, and Utah; and the characterization of fluid-flow properties in fractured crystalline rocks.

Geology faculty members commonly interact with the faculty and staff of the Utah Water Research Laboratory, the Department of Watershed Sciences, the Department of Plants, Soils, and Climate, and the Department of Civil and Environmental Engineering.

Financial Assistance

Departmental financial support for incoming graduate students consists primarily of graduate teaching assistantships, which are awarded on a competitive basis. There is often other financial support available, such as research assistantships, resulting from grants or other external funding. Students requesting financial support should apply directly to the department no later than February 15. Admission to the MS or PhD program does not guarantee financial assistance.

Additional Information

Additional information on the research activities of faculty and graduate students may be obtained directly from the Department of Geology's website at <http://www.usu.edu/geo/>

Geology Faculty

Professors

James P. Evans, structural geology, structural petrology

Mary S. Hubbard, tectonics, structural geology,

Dean of College of Science

Susanne U. Janecke, tectonics, structural geology

W. David Liddell, marine ecology, paleoecology, sedimentology

John W. Shervais, igneous petrology, geochemistry, tectonics

Professor Emeritus

Robert Q. Oaks, Jr., sedimentary petrology, stratigraphy

Associate Professors

Donald W. Fiesinger, igneous petrology

Thomas E. Lachmar, hydrogeology

Joel L. Pederson, process geomorphology, Quaternary geology

Associate Professor Emeritus

Peter T. Kolesar, carbonate petrology, geochemistry

Assistant Professors

Carol M. Dehler, sedimentation, geochemical cycles

Anthony R. Lowry, geophysics

Tammy M. Rittenour, geomorphology, geochronology

Lecturer

Susan K. Morgan, science education, carbonate petrology

Adjunct Faculty

Reese Barrick, vertebrate paleontology

Janis L. Boettinger, soil mineralogy

Craig B. Forster, hydrogeology

James P. McCalpin, neotectonics

John C. Schmidt, fluvial geomorphology

David G. Tarboton, water resources and hydrology

Course Descriptions

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