Geosciences

Chair and Professor: Ben Crosby
Professors: Link, Rodgers, Thackray, Tapanila
Associate Professors: Kobs Nawotniak, Godsey, Delparte, Pearson
Assistant Professors: Bottenberg, Murray
Joint Appointment Faculty: Finney, Lohse
GIS TReC Director: Weber
Emeritus Professors: Blount, Hughes, McCurry
Affiliate Faculty: Hailemichael, Krumenacker, McLing, Sherwin

Goals - All Programs
1. Graduates will think critically and comprehend written and verbal communications about geoscience topics.
2. Graduates will have specific skills for careers in geoscience and related industries, licensure, or to continue in graduate study.
3. Graduates will attain employment in geology or related fields or gain admission to graduate programs.

Goals - Graduate Degree Programs
1. Graduates will be prepared to communicate effectively at the professional level.
2. Graduates will be prepared to define, implement, and complete geologic investigations.
3. Graduates will have professional skills for employment or further graduate study.

Objectives
1. Provide graduate students with coursework, laboratory experiences, field exercises, and research opportunities in order to achieve all goals set forth above.
2. Provide graduate students with a professional interactive environment that improves their opportunities to enter successful careers in geoscience.
3. Increase graduate students’ probability of obtaining employment in academia or industry, or of being accepted for doctoral studies.

General Admission Requirements
A complete graduate application for classified status in the Idaho State University Geosciences Department consists of:
1. The student must apply to and meet all criteria for admission to the Graduate School. An Idaho State University Graduate School application and official copies of transcripts from all previous coursework are required. In addition to the requirements of the Graduate School, applicants must meet the requirements of the department.
2. Departmental GRE requirements: 50th percentile or above in two of the three categories or strengths clearly demonstrated in other components of the application;
3. A letter of intent and statement of goals in graduate school; and
4. Three letters of recommendation.

Doctor of Philosophy in Geosciences

Brief Description
The Ph.D. program in geosciences is offered to those students who have demonstrated strong aptitude for research and scholarly activity. Research can be conducted in any field of the geosciences in which ISU faculty have expertise. The student’s course of study will be determined in consultation with his or her advisor and doctoral committee. Continued enrollment in the program is contingent upon maintaining a 3.0 grade point average and making satisfactory progress toward the degree. In order to complete the research and prepare the dissertation, the program normally requires at least four years of full-time study beyond the master’s degree. In some cases, students without an appropriate M.S. degree but demonstrating an exceptional undergraduate academic record and aptitude for research may be directly admitted to the Ph.D. program.

Admission Requirements
All applicants must meet Idaho State University Graduate School admission requirements for doctoral programs. In addition, applicants must have attained a minimum of a bachelor’s degree in geosciences or a closely related field (environmental science, physics, engineering, chemistry, biology, etc.) and have maintained at least a 3.0 GPA in their previous degree(s) unless special circumstances are demonstrated.

A complete graduate application for classified status in the Idaho State University Geosciences Department Ph.D. program consists of:
1. GRE scores (a minimum of 50th percentile is required in both verbal and quantitative categories); Students for whom English is a second language who do not meet the minimum verbal GRE score must meet the Graduate School minimum TOEFL score.
2. An Idaho State University Graduate School application form, fee, and official copies of transcripts;
3. Three letters of recommendation; and
4. A statement outlining the student's motivation for graduate school and their longer term career goals.

General and Course Requirements
The doctoral degree requires completion of at least 84 graduate credits. Of these, at least 32 credits must be doctoral dissertation credits (GEOL 8850) and another 35 credits must come from coursework at the graduate level, two to four of which must be a graduate seminar. Of the total 84 credits, at least 40 must be taken from the ISU Department of Geosciences. Pre-Thesis credits (GEOL 6649) are not included in the credits counted toward the degree. Students entering the program with a master’s degree may receive credit for up to 30 credits toward the doctorate, split between dissertation and coursework as appropriate, subject to the department chair’s approval. Classes and seminars may be taken at, or in collaboration with, Boise State University and/or the University of Idaho. Students may be required to complete any missing course material that is required for the B.S. degree in geosciences at Idaho State University.

Program of Study
An initial Doctoral Committee of at least three, composed of the candidate’s major professor (committee chair) and two graduate faculty will guide each student in establishing his or her program of study based upon the student’s background and research interests. The majority of any committee must consist of graduate faculty from the ISU Department of Geosciences. It is the responsibility of the initial Doctoral Committee chair to arrange the first meeting.
The committee has the responsibility of ensuring that the student has adequate knowledge in his or her area of research. The initial Doctoral Committee should be assembled early in the candidate’s program to discuss the process, timeline, and recommendations for the Program of Study and the Written Qualifying Exam.

During the third semester, the student is allowed two attempts to pass the Written Qualifying Exam. The student will be admitted to candidacy upon passing. Following passing, the full-time candidate, with guidance from the major professor, will assemble their final Doctoral Committee. This committee is composed of at least five, inclusive of the candidate’s major professor, at least three graduate faculty, and a Graduate Faculty Representative (GFR). The majority of any committee must consist of graduate faculty from the ISU Department of Geosciences.

By the end of the fourth semester, under the supervision of the final Doctoral Committee, the doctoral candidate will also have completed a satisfactory research Prospectus and passed an Oral Prospectus Defense. Exceptions to this schedule may be made when a student has academic deficits to make up, in which case the student may be granted an additional year.

The research and dissertation preparation must be done under the close supervision of the final Doctoral Committee and must include at least one full year of work performed under the supervision of Idaho State University graduate faculty. The dissertation must demonstrate the student’s ability in independent investigation and must be a contribution to scientific knowledge. It must display mastery of the literature of the subject field and must demonstrate an organized, coherent development of ideas, with a clear exposition of results and a creative discussion of the conclusions.

Dissertation approval requires a public presentation of the dissertation and a satisfactory oral defense to the final Doctoral Committee. The oral defense is open to all regular members of the graduate faculty as observers. Further, oral presentations are open to the public until the oral defense begins. Additional details regarding the graduate timeline are available on the ISU Department of Geosciences website.

**Doctor of Philosophy in Engineering and Applied Science**

A doctoral program in Engineering and Applied Science, administered through the College of Science and Engineering, is available to Geoscience students. The complete program description is provided elsewhere in the College of Science & Engineering section of the Graduate Catalog.

**Master of Science in Geology**

The M.S. degree is offered to those students who have a degree in the sciences, and have demonstrated the potential for research and a professional career. Classified (degree-seeking, fully accepted) admission to the program is recommended by the graduate faculty of the Geosciences Department.

The student’s course of study will be determined by consultation and possibly an entrance examination. Students will normally be required to complete deficiencies, at the undergraduate level, in any courses required for the B.S. in Geology at Idaho State University. Continued enrollment in the program is contingent upon maintaining a 3.0 grade point average and making satisfactory progress toward the degree.

Unclassified status is used for students with large numbers of deficiencies or with low undergraduate GPAs. Unclassified students may apply for classified status when their performance warrants.

**General Requirements**

A student who wants to earn a master's degree in geology must complete at least 30 credits of coursework. These credits must be earned under the following conditions:

1. The student must earn at least 17 credits (including six thesis credits) at the 6600 level in geology. GEOL 6649 credits are not included in this count.
2. The remaining 13 credits may be earned at the 5500 or 6600 level, of which eight credits may come from a related discipline. GEOL 6649 credits are not included in this count.

In addition to the 30 required credits, each student must take two approved courses from outside the Geosciences Department (e.g., technical writing, anthropology, etc.) or may opt to take the foreign language challenge exam at the elementary level.

The department requires that the following core courses be completed. These classes are normally taken during the first and second semesters of graduate study:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 5591</td>
<td>Seminar</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 6601</td>
<td>Advanced Physical Geology</td>
<td>2</td>
</tr>
<tr>
<td>GEOL 6603</td>
<td>Geologic Writing Seminar</td>
<td>2</td>
</tr>
</tbody>
</table>

Graduate students may not sign up for GEOL 6650 (Thesis) until their thesis prospectus has been submitted and approved by the Thesis Committee. Additionally, all graduate students are required to present at least one geology colloquium dealing with their thesis topic prior to taking their oral examination.

**Master of Science in Geology with Emphasis in Environmental Geoscience**

A geology master's degree may be awarded with the annotation “Emphasis in Environmental Geoscience” added if the student completes the requirements for a master's degree plus at least 9 credits in approved graduate-level courses in the general area of Environmental Geoscience. Students who wish their master's degree to contain the added designation “With Emphasis in Environmental Geoscience” need to file an amended program of study form with the Graduate School. The curriculum may be developed in, but is not limited to, the following areas: surface and groundwater hydrology; environmental geochemistry; surficial geological processes; geomorphology; volcanic, earthquake, and other geologic hazards; environmental geophysics; assessment and remediation of hazardous waste sites; or Neogene and Quaternary geology. Courses in related sciences and engineering disciplines may also be included.

The curriculum must be approved by the student’s graduate committee and may include components taken at Boise State University and/or the University of Idaho. Inter-university graduate committees are encouraged.

**Master of Science in Geographic Information Science**

The M.S. in GISci degree is offered to students who wish to become competent geospatial researchers and Geographic Information Systems (GIS) analysts. The program focuses on advancing knowledge to acquire, store and manage, visualize, model, and analyze information about spatial features and phenomena, with strong emphasis on real world geospatial applications. The M.S. in GISci is designed as an interdisciplinary study of the nature, function, and development of spatial information systems and the application of these systems in research. Students will be involved in the technical study of the design and evaluation of scientific inquiry methods, tools, and techniques that will involve formulating
hypotheses, collecting spatial information, and developing techniques for spatial analysis.

Applicants must hold a degree of Bachelor of Science or Bachelor of Arts in any discipline that allows a research focus on Geotechnologies, including, but not limited to: Geosciences, Anthropology, Biology, Business, Information Technology, Computer Science, and Engineering. Each student in this program will have a member of the current Geotechnology faculty as his/her major advisor.

NOTE: Due to the interdisciplinary nature of this program, applicants should initially contact a faculty member or the Geotechnologies Program Director, in the Department of Geosciences, in order to match his/her interests with those of potential faculty advisors.

**Admission Requirements**

Applicants must apply to and meet all criteria for admission to the Graduate School as well as additional criteria for admission to the Department of Geosciences.

**General Requirements**

In his/her application, a student must state a preference for the Thesis Option or Non-Thesis Option for the master's degree in GISci. The Geotechnologies graduate faculty will determine for which track the student is accepted.

**Thesis Option:** Students desiring to enter careers in research or to pursue a doctorate are encouraged to request the Thesis Option master's degree in GISci. Students supported on research assistantships or teaching assistantships will typically be required to enroll in the Thesis Option. A minimum of 30 credit hours is required for completion of the Thesis Option master's degree in GISci, with a minimum of 15 credit hours (including six thesis credits) completed in 6600-level courses. The student's graduate advisory committee (major advisor and co-advisor) will establish specific research goals, thesis topic, and the course electives in the program of study.

**Non-Thesis Option:** The Non-Thesis Option master's degree in GISci is particularly suited for working professionals who are interested in earning additional education without interrupting their careers. Typically students are not awarded research assistantships or teaching assistantships in the Non-Thesis Option. A minimum of 30 credit hours is required for completion of the Non-Thesis Option master's degree in GISci, with a minimum of 15 credit hours completed in 6600-level courses. The student must prepare and submit to the Geotechnologies program director a program of study in his or her first semester indicating the courses to be taken to meet these requirements. In his/her final semester, all Non-Thesis Option students will complete a written and oral capstone exam administered by Geotechnologies graduate faculty and a graduate faculty representative.

All master's degree students are required to take a 1 credit hour graduate seminar in any related discipline and eleven credit hours of core courses. Generally these will be taken during the first year of study. Prerequisites for core courses are designed to permit students entering the master's degree program from all disciplines. Students entering with some or all of the core courses taken at the undergraduate level may, with permission from the student's advisory committee, substitute other graduate-level courses in the program of study.

**Program Requirements:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Graduate Seminar (taken in a related discipline)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Core Geotechnologies Courses</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Electives 12 Thesis; 18 Non-Thesis</td>
<td></td>
</tr>
</tbody>
</table>

**Section A - Core Courses**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 5504</td>
<td>Advanced Geographic Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5507</td>
<td>GPS/GNSS Applications in Research</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5508</td>
<td>GeoTechnology Seminar</td>
<td>2</td>
</tr>
<tr>
<td>GEOL 5509</td>
<td>Remote Sensing</td>
<td>3</td>
</tr>
</tbody>
</table>

**Section B - Electives**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTH 6641</td>
<td>Research Project</td>
<td>1-6</td>
</tr>
<tr>
<td>BIOL 6651</td>
<td>Advanced Studies in Ecology (Advanced Data Analysis for Biologists)</td>
<td>3</td>
</tr>
<tr>
<td>INFO 5507</td>
<td>Database Design and Implementation</td>
<td>3</td>
</tr>
<tr>
<td>CS 5551</td>
<td>Database Theory Design and Programming</td>
<td>3</td>
</tr>
<tr>
<td>CS 5542</td>
<td>GUI Development</td>
<td>3</td>
</tr>
<tr>
<td>GEMT 5530</td>
<td>Principles and Applications</td>
<td>3</td>
</tr>
<tr>
<td>GEMT 5532</td>
<td>Principles of Photogrammetry</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5502</td>
<td>Geomorphology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 5555</td>
<td>Geologic Data Methods</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5527</td>
<td>Information Technology for GIS</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5528</td>
<td>Programming for GIS</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5571</td>
<td>Historical Geography of Idaho</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5581</td>
<td>GeoTechnology Internship</td>
<td>1-3</td>
</tr>
<tr>
<td>GEOL 6628</td>
<td>Advanced GIS Programming</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 6607</td>
<td>Spatial Analysis</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 6608</td>
<td>Geostatistics Spatial Data Analysis and Modeling</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 6609</td>
<td>Advanced Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 6648</td>
<td>Research Problems</td>
<td>1-6</td>
</tr>
<tr>
<td>GEOL 6604</td>
<td>Watershed Modeling</td>
<td>3</td>
</tr>
<tr>
<td>HIST 6610</td>
<td>Introduction to Digital Humanities</td>
<td>3</td>
</tr>
</tbody>
</table>

Certain graduate courses not shown in the list above may be acceptable with approval of the student's advisory committee. All courses in the program of study require approval by the student's advisory committee and final approval by the Graduate School. Non-Thesis Option master's degree students must have their planned program of study approved by the Geotechnologies program director in their first semester and by the Graduate School in their final semester.

Thesis Option master's degree students are expected to complete a thesis that will be original and encompass all stages of scientific work, including project design, implementation, and communication. A graduate student may sign up for thesis credits only after his/her thesis prospectus has been submitted and approved by the advisory committee. Additionally, all thesis option master's degree students are required to present at least one colloquium dealing with his/her thesis topic prior to taking his/her oral examination.

**Total Credits**

<table>
<thead>
<tr>
<th>Code/Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 6650</td>
<td>Thesis 6 credits; 0 non-thesis</td>
</tr>
<tr>
<td></td>
<td>Total Credits</td>
</tr>
</tbody>
</table>

*Totals includes 15 hours at 6600-level
Post-Baccalaureate GeoTechnology Certificate
(19 credits required)

Goals
1. Graduates will have the knowledge and skills necessary to apply GeoTechnology in their chosen careers or fields of interest.
2. Graduates will have the background to compete successfully for industrial and academic positions.

Objectives
1. Learn and perform techniques in Geographic Information Systems, Global Positioning Systems, Remote Sensing, and related skills.
2. Increase knowledge of how geotechnical applications are incorporated into research, education, and industry.
3. Increase knowledge of geotechnical workforce needs and the future directions of geotechnological applications.

The Graduate Certificate in GeoTechnology is offered to students who wish to become proficient in the collection, management, and analysis of spatial data. Courses in three disciplines — geographic information systems (GIS), global positioning systems (GPS), and remote sensing—are used to teach the theory and application of GeoTechnology. Students may pursue the Certificate independently or in conjunction with another Idaho State University degree.

Admission Requirements
Classified admission is necessary to complete the Certificate and is recommended by the graduate faculty of the Geosciences Department in accordance with standards set by the Graduate School. Applicants must have a bachelor’s degree from an Accredited School and meet the Graduate School admission requirements. All applicants must submit an application to the Graduate School.

Students will complete 14 credits of required coursework and 5 credits of elective coursework to obtain the Certificate. The following courses are relevant:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 5503</td>
<td>Principles of Geographical Information System</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5504</td>
<td>Advanced Geographic Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5507</td>
<td>GPS/GNSS Applications in Research</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 5508</td>
<td>GeoTechnology Seminar</td>
<td>2</td>
</tr>
<tr>
<td>or BIOL 5518</td>
<td>Ecological Topics</td>
<td></td>
</tr>
<tr>
<td>GEOL 5509</td>
<td>Remote Sensing</td>
<td>3</td>
</tr>
</tbody>
</table>

Electives 5

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTH 5582</td>
<td>Independent Problems in Anthropology ((GIS and Anthropology))</td>
</tr>
<tr>
<td>BIOL 5582</td>
<td>Independent Problems</td>
</tr>
<tr>
<td>GEOL 5527</td>
<td>Information Technology for GIS</td>
</tr>
<tr>
<td>GEOL 5528</td>
<td>Programming for GIS</td>
</tr>
<tr>
<td>GEOL 5580</td>
<td>Special Topics in GIS</td>
</tr>
<tr>
<td>GEOL 5581</td>
<td>GeoTechnology Internship</td>
</tr>
<tr>
<td>GEOL 6607</td>
<td>Spatial Analysis</td>
</tr>
<tr>
<td>GEOL 6608</td>
<td>Geostatistics Spatial Data Analysis and Modeling</td>
</tr>
<tr>
<td>GEOL 6628</td>
<td>Advanced GIS Programming</td>
</tr>
</tbody>
</table>

For current information regarding GIS Center and courses, see the website: http://giscenter.isu.edu. (http://giscenter.isu.edu/)

Courses

GEOL 5502 Geomorphology: 4 semester hours.
Process-response approach to landforms and landscapes. Historical perspectives, endo- and exogenetic processes, equilibrium and relict landforms. Emphasis on interrelations among various geologic sub-disciplines. Field trips, some lab exercises. LL at PC. PREREQ: GEOL 3315 or permission of instructor. COREQ: GEOL 5502L.

GEOL 5502L Geomorphology Laboratory: 0 semester hours.
Assignments to apply principles from GEOL 5502. LL at PC. COREQ: GEOL 5502.

GEOL 5503 Principles of Geographical Information System: 3 semester hours.
Study of GIS fundamentals, vector and raster models, introduction to GPS and Global Navigation Satellite Systems, basic spatial analysis, geodatabases, and metadata. Practical application of industry standard software. Requires competence in computer operating systems. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. COREQ: GEOL 5503L.

GEOL 5503L Principles of GIS Laboratory: 0 semester hours.
Computer lab assignments to apply principles from GEOL 5503. LL at PC. COREQ: GEOL 5503.

GEOL 5504 Advanced Geographic Information Systems: 3 semester hours.
Study of relational databases, including spatial analysis, and remote sensing. Practical application of industry standard software. Exercises include digitizing, querying, digital terrain modeling, and image processing. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 5503 and GEOL 5503L or permission of instructor.

GEOL 5505 Volcanology: 3 semester hours.
Aspects of physical and chemical volcanology: types of volcanoes; interpretation of volcanic deposits; properties of magma; generation, rise, and storage of magma; volcanic hazards and prediction.

GEOL 5506 Environmental Geology: 3 semester hours.
Humans and the environment. Topics include: industrial exploitation of fossil fuels, energy sources, soils, water and other materials, environmental health, pollution, waste disposal, hazards, disasters, and land use.

GEOL 5507 GPS/GNSS Applications in Research: 3 semester hours.
Overview of satellite positioning systems usage. Topics include GPS and Global Navigation Satellite theory, basic mapping concepts, use of mapping grade receivers for GIS data collection. Sample design for data collection and spatial analysis in GIS. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: GEOL 4403 or GEOL 5503.

GEOL 5508 GeoTechnology Seminar: 2 semester hours.
GIS applications in natural and social sciences, ethical and legal issues, current status and recent advances in GeoTechnology. Lectures, discussion, readings.

GEOL 5509 Remote Sensing: 3 semester hours.
Fundamentals and applications of multispectral, hyperspectral, radar and lidar remote sensing for the sciences. Emphasis on acquiring, processing, integrating, and interpreting imagery. Requires competence in computer operating systems. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.
GEOL 5510 Science in American Society: 2 semester hours.
Observational basis of science; technology's historical influences on scientific developments; perceptions of science in contemporary America; tools/strategies for teaching science. Equivalent to PHYS 5510.

GEOL 5511 Planetary Petrology: 3 semester hours.
Chemistry, mineralogy, tectonic association and petrogenesis of the principal igneous and metamorphic rock types on Earth and other planetary bodies. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 3314. D

GEOL 5512 Petrology Lab: 2 semester hours.
Microscopic identification of igneous and metamorphic minerals and rocks. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. COREQ: GEOL 5511.

GEOL 5513 Sedimentary Rocks in Thin Sections: 2 semester hours.
A variety of terrigenous, volcaniclastic, and carbonate rocks will be studied. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PRE-OR-COREQ: GEOL 5511. D

GEOL 5515 Quaternary Global Change: 3 semester hours.
Use and interpretation of land forms, sediments, and fossil life in understanding Ice Age climatic cycles that influenced geological events and environments during the Quaternary Period. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. COREQ: GEOL 5515L.

GEOL 5515L Quaternary Global Change Lab: 0 semester hours.
Laboratory exercises, problem sets, and field trips investigating Quaternary geoscience. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5516 Global Environmental Change: 3 semester hours.
Analysis of the causes and effects of both natural and human-induced environmental change. Integrates knowledge from other Earth Systems Science courses, and examines and analyzes relevant problems in global environmental change using scientific methods.

GEOL 5517 Introduction to Soils and Critical Zone Processes: 3 semester hours.
Introduction to soils with emphasis on soil formation and classification and the physical, chemical and biological properties of soils. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: CHEM 1112, CHEM 1112L, or permission of instructor. COREQ: GEOL 5517L. AF

GEOL 5517L Introduction to Soils Laboratory: 1 semester hour.
Assignments to apply GEOL 5517. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: CHEM 1112, CHEM 1112L, or permission of instructor. COREQ: GEOL 5517.

GEOL 5520 Principles of Geochemistry: 3 semester hours.
Chemistry of the earth; discussion of factors controlling abundance, distribution, and migration of chemical elements within the earth. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 3313, CHEM 1112 and CHEM 1112L, or permission of instructor. D

GEOL 5522 Chemical Evolution of the Earth: 3 semester hours.
Approaches to understanding Earth's geochemical evolution from core to clouds, including planetary differentiation, internal processes, plate tectonics, and surficial processes. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: GEOL 3313 or permission of instructor.

GEOL 5527 Information Technology for GIS: 3 semester hours.
Study of servers, networks, system administration, relational database design and management, spatial database engines, and serving maps on the internet. The course uses traditional lectures along with demonstrations and hands-on exercises.

GEOL 5528 Programming for GIS: 3 semester hours.
Course introduces students to programming for GIS. Students will learn the fundamentals of coding (I/O, logical forks, loops, language standards) and integration of GIS libraries (ex., arcpy, GDAL). Students will complete a project where they develop a GIS tool of their choice. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: GEOL 5503 or permission of instructor.

GEOL 5530 Principles of Hydrogeology: 3 semester hours.
Surface and groundwater occurrence, principles of groundwater flow, water quality and pollution, and well construction principles. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: MATH 1147 or both MATH 1143 and MATH 1144; and GEOL 2204 or permission of instructor.

GEOL 5531 Geobiology and the History of Life: 4 semester hours.
Principles of biology and geology applied to the study of fossil invertebrates; consideration is given to morphology, classification, evolution, paleoecology, and the stratigraphic significance of fossils. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. COREQ: GEOL 5531L. AF

GEOL 5531L Geobiology and History of Life Lab: 0 semester hours.
Assignments to apply principles from GEOL 5531. LL at PC. COREQ: GEOL 5531. AF

GEOL 5535 Vertebrate Paleontology: 4 semester hours.

GEOL 5539 Principles of Taphonomy: 3 semester hours.
Effects of processes which modify organisms between death and the time the usually fossilized remains are studied. Emphasis on vertebrates. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. CL at PC. Equivalent to ANTH 5539 and BIOL 5539. PREREQ: Permission of Instructor. D

GEOL 5540 Ore Deposits: 3 semester hours.
Nature, mode of occurrence, and origin of ores with each type related to a given rock association and as the product of a particular environment. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5545 Environmental and Engineering Geophysics: 4 semester hours.
Geophysical applications to environmental and geological engineering problems. Includes seismic, gravity, magnetic, electrical, and electromagnetic methods (includes lab).

GEOL 5550 Field Geology: 6 semester hours.
Five-week summer field camp, applying standard geologic field instruments and geologic concepts to a series of field problems.

GEOL 5551 Field Methods in Environmental Sciences: 3 semester hours.
Practical application of field methods. Students learn the techniques and concepts necessary to build water and carbon budgets for a small watershed. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: Permission of Instructor.
GEOL 5552 Sedimentation-Stratigraphy: 4 semester hours.
Principles of sedimentation from source to diagenesis. The basis of stratigraphic nomenclature, classification, and correlation of rock units. Laboratory covers unconsolidated sediment, hand specimens, subsurface, and field techniques. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 3310 and ENGL 1102 or permission of instructor. PRE-OR-COREQ: CHEM 1111 and CHEM 1111L. COREQ GEOL 5552L. F

GEOL 5552L Sedimentation-Stratigraphy Laboratory: 0 semester hours.
Assignments to apply principles in GEOL 5552. COREQ: GEOL 5552.

GEOL 5554 Basic Engineering Geology: 3 semester hours.
Geology applied to civil engineering projects; rock engineering classification systems and geotechnical parameters such as joint set orientation, ground behavior and underground construction. Preparation of baseline geotechnical reports. Equivalent to CE 5576. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5555 Geologic Data Methods: 3 semester hours.
Geotechnical investigations for civil works projects; geologic mapping for civil engineering purposes; development of engineering geologic profiles; core logging; preparation of Geotechnical Data Reports for civil works projects. Equivalent to CE 5575. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5556 Geology of Idaho: 2 semester hours.
Geologic provinces and plate tectonic history of Idaho. Topics include basement, Belt Supergroup, Phanerozoic passive margin, Cordilleran orogen, accreted terranes, Idaho batholith, Challis volcanics, Idaho mineral deposits, Basin and Range, Snake River Plain and Pleistocene floods. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5557 Geology of North America: 3 semester hours.
Regional geology and tectonics of North America emphasizing the Intermountain West. Graduate students will do extensive additional reading in current literature. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.

GEOL 5558 Petroleum Geology: 3 semester hours.
Occurrence of hydrocarbons, well logs, geophysical methods, generation and migration of petroleum, the reservoir, traps and seals, petroleum basins, unconventional petroleum resources. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 3310 or permission of instructor.

GEOL 5559 Historical Geography of Idaho: 3 semester hours.
Influences of geography and geology on Idaho's economic, political and cultural history. May be team taught and include field trips, discussions, projects, and/or performance. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Equivalent to HIST 5571 and POLS 5571.

GEOL 5570 Essentials of Geomechanics: 3 semester hours.
Essentials of rock fracture relevant to geological engineering including stress and strain, properties and classification of rock masses, rock fracture mechanisms. Equivalent to CE 5576.

GEOL 5572 Engineering Geology Project: 1 semester hour.
Team projects studying actual problems in engineering geology. Equivalent to CE 5576.

GEOL 5575 Historical Geography of Idaho: 3 semester hours.
Influences of geography and geology on Idaho's economic, political and cultural history. May be team taught and include field trips, discussions, projects, and/or performance. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Equivalent to HIST 5571 and POLS 5571.

GEOL 5576 Geotechnical Internship: 1-3 semester hours.
Choose a project with either natural resource or municipal GIS emphasis and work with real-world data at the internship's off-campus location. Projects focus on using/creating geotechnical data. May be repeated.

GEOL 5580 Special Topics in GIS: 1-3 semester hours.
Visual Basic programming for GIS. May be repeated.

GEOL 5581 GeoTechnology Internship: 1-3 semester hours.
May be repeated.

GEOL 5582 Advanced Image Processing: 3 semester hours.
An advanced-level course in image processing techniques, such as using transforms, filters, and classifiers for data derived in the visible, infrared, and microwave. Specific topics include preprocessing, endmember analysis, classification (including spectral unmixing), and accuracy assessment. Practical application of theory for graduate student theses and dissertations.

GEOL 5583 Earthquake Engineering: 3 semester hours.
Mechanism and characterization of earthquakes; seismic risk analysis; site and structural response; applications from points of view of engineer and geologist. Equivalent to CE 3580.

GEOL 5584 Special Topics in Remote Sensing: 1-3 semester hours.
An advanced-level course in remote sensing techniques. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. May be repeated for up to 3 credits. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Graded S/U.

GEOL 5590 Ecosystem Ecology and Global Changes: 4 semester hours.
Examination of the structure and function of ecosystems and their responses to natural and anthropogenic changes emphasizing energy, water, carbon, and nitrogen cycling. Field trip. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Equivalent to BIOL 5590. PREREQ: BIOL 2209 or permission of instructor. PRE-OR-COREQ: CHEM 1111.

GEOL 5591 Seminar: 1 semester hour.
Field trip or discussion of current geologic literature and geologic problems. May be repeated for up to 3 credits. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Graded S/U.

GEOL 5592 Geological Field Methods: 3 semester hours.
Influences of geography and geology on Idaho's economic, political and cultural history. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. LL at PC. PREREQ: GEOL 3310 or permission of instructor.

GEOL 5594E Watershed Modeling: 3 semester hours.
An introduction to the Geosciences department, its faculty, and an evaluation of current research topics in the Geosciences through discussion and critical evaluation of scientific literature.

GEOL 5595 Advanced Geomorphology: 3 semester hours.
Seminar in the treatment of theoretical concepts in classical and modern geomorphology.

GEOL 5596 Special Topics in Geology: 4 semester hours.
Review of quality geologic writing and presentation practices. Topics include databases, abstracts, stratigraphic terminology, poster and manuscript preparation, grant proposals, thesis prospecti, and use of reference library.

GEOL 5598 Geostatistics Spatial Data Analysis and Modeling: 3 semester hours.
Use of geographic information systems and integrated simulation models to study the hydrologic cycle, water quality, agricultural and industrial impacts, environmental and related issues at the watershed scale.

GEOL 6601 Advanced Physical Geology: 2 semester hours.
Examination of the structure and function of ecosystems and their responses to natural and anthropogenic changes emphasizing energy, water, carbon, and nitrogen cycling. Field trip. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Graded S/U.

GEOL 6602 Geographic Information Systems: 3 semester hours.
Use of Geographic Information Systems (GIS) in environmental and related issues at the watershed scale. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Graded S/U.

GEOL 6603 Geologic Writing Seminar: 2 semester hours.
Review of quality geologic writing and presentation practices. Topics include databases, abstracts, stratigraphic terminology, poster and manuscript preparation, grant proposals, thesis prospecti, and use of reference library.

GEOL 6604 Watershed Modeling: 3 semester hours.
Use of geographic information systems and integrated simulation models to study the hydrologic cycle, water quality, agricultural and industrial impacts, environmental and related issues at the watershed scale.

GEOL 6606 Spatial Analysis: 4 semester hours.
This course focuses on advanced techniques for spatial data analysis covering issues in sampling, characterizing, visualizing, exploring and modeling spatial data. Techniques for point patterns, continuous data, area data, and spatial interaction data will be emphasized.

GEOL 6607 Advanced Image Processing: 3 semester hours.
An advanced-level course in image processing techniques, such as using transforms, filters, and classifiers for data derived in the visible, infrared, and microwave. Specific topics include preprocessing, endmember analysis, classification (including spectral unmixing), and accuracy assessment. Practical application of theory for graduate student theses and dissertations.
GEOL 6611 UAS Applications for the Geosciences: 3 semester hours.
As Unmanned Aircraft Systems enter the national airspace, they are emerging as a tool for geoscientists and engineers to collect remotely sensed data. In this course, students will learn the varied applications of UAS and the workflow of data collection, processing, and analysis. Field demos and hands-on training will be part of the course objectives. Students will learn about Federal Aviation Administration (FAA) rules and regulations for UAS flights.

GEOL 6613 Idaho Water Resources Seminar: 1 semester hour.
This course is an interactive discussion focused on water science, issues, and policy across the state. The seminar is a joint effort of Idaho’s universities and multiple institutes, agencies and firms. May be repeated up to two times for credit.

GEOL 6615 Neutron Activation Analysis: 4 semester hours.
Theory and use of neutron activation methods for quantitative chemical analysis of natural and synthetic materials. Applications in geologic systems will be emphasized. Equivalent to CHEM 6615 and PHYS 6615.

GEOL 6617 Environmental Geochemistry: 3 semester hours.
Geochemistry of environmental systems. Emphasis given to low-temperature water-rock interactions, including sorption processes, retardation, reaction kinetics and reaction-mass transport modeling. Equivalent to CHEM 6617.

GEOL 6618 Applied Geophysics: 3 semester hours.
Geologic interpretation of reflection seismic, refraction seismic, gravity, magnetic, and ground penetrating radar data.

GEOL 6620 Geochronology and Thermochronology: 3 semester hours.
An overview of the geochemical methods used to date Earth materials and thus explore the history and dynamics of Earth and planetary processes. This course will cover the fundamentals of radioactive decay and growth, the diffusion of elements in minerals and heat in the Earth, the use of radioisotopes as tracers, and the applications of geochronology and thermochronology to a range of problems in the Geosciences.

GEOL 6621 Advanced Structural Geology: 3 semester hours.
Current aspects of structural geology or tectonics. May focus on regional structures, tectonic theories, orogenic mechanics, global tectonic model(s), or topics of special interest in structural geology.

GEOL 6622 Orogenic Belts: 3 semester hours.
Interdisciplinary analysis of contractional mountain belts including their infrastructure, tectonic evolution, and mechanisms of formation.

GEOL 6623 Tectonics and Sedimentation: 3 semester hours.
Sedimentary basin analysis and mechanisms of subsidence. Extensional, compressional and strikeslip tectonics as related to depositional systems, facies architecture, and provenance.

GEOL 6625 Quantitative Geochemistry Lab: 3 semester hours.
Practical application of theory involving use and operation of instrumental techniques. Equivalent to CHEM 6625.

GEOL 6628 Advanced GIS Programming: 3 semester hours.
Course focuses on advanced topics in GIS programming, particularly processing efficiency for large problems. Students will learn the fundamentals of parallel processing for spatial problem solving, including use of shared and/or distributed memory systems. PREREQ: GEOL 5503, GEOL 5528, and permission of instructor.

GEOL 6630 Advanced Hydrogeology: 3 semester hours.
Advanced topics in hydrogeology, including precipitation and stream flow, soil moisture, principles and modeling of groundwater flow, migration of wastes in both saturated and unsaturated zones, design and impact of production wells, water chemistry.

GEOL 6631 Sedimentology: 3 semester hours.
Provenance, dispersal, and environments of deposition; emphasis on various aspects of surface equilibria.

GEOL 6641 Advanced Petrology: 3 semester hours.
Selected topics in igneous and/or metamorphic petrology, regional and/or global aspects of current interest, including relationship to major advances in other areas of solid earth sciences.

GEOL 6646 The Sedimentary Record: 3 semester hours.
Earth history as revealed in sedimentary facies, provenance, chemical and isotopic excursions. Methods of analysis including sequence stratigraphy, geochronology, biogeochemistry, chronostratigraphy.

GEOL 6648 Research Problems: 1-6 semester hours.
Independent research on non-thesis subject matter, subject to approval of the staff before results receive credit. Course may be repeated until 10 credits are earned.

GEOL 6649 Pre-Thesis: 1-6 semester hours.
Preparation and development of a prospectus for a thesis or dissertation project. May be repeated. Graded S/U. Credits are not counted in the program graduation credit requirement.

GEOL 6650 Thesis: 1-9 semester hours.
Ordinarily a field problem with supporting laboratory work undertaken by the student with approval of the geology graduate faculty, and after a thesis prospectus has been accepted. May be repeated. Graded S/U.

GEOL 6684 Graduate Teaching Practicum: 1 semester hour.
Teaching techniques and tools for use in undergraduate courses. Graded S/U.

GEOL 6699 Experimental Course: 1-6 semester hours.
The content of this course is not described in the catalog. Title and number of credits are announced in the Class Schedule. Experimental courses may be offered no more than three times with the same title and content. May be repeated.

GEOL 8850 Doctoral Dissertation: 1-16 semester hours.
Research toward and completion of the dissertation. Variable credit. May be repeated. Graded S/U.

GEOL 8859 Pre-Thesis: 1-6 semester hours.
Preparation and development of a prospectus for a thesis or dissertation project. May be repeated. Graded S/U. Credits are not counted in the program graduation credit requirement.