

GEOLOGY

The natural setting of Western Washington University adjacent to the Cascade Mountains and Puget Sound provides an ideal situation for study of a wide variety of geologic problems.

FACULTY

At the present time the department consists of 14 faculty members who have a broad range of backgrounds covering the entire field of geology. There are about 120 undergraduate students declaring geology majors and approximately 30 graduate students in the department.

FACILITIES AND EQUIPMENT

Geology is a science that studies the earth, including its surfaces, interior and history and the processes that have altered it through time. It embraces investigation of the natural environment both in the field and in the laboratory. The Department of Geology occupies modern laboratories, classrooms and offices constructed in 1976 in the Environmental Studies Center. Geology laboratory facilities and equipment are available for X-ray diffraction, atomic absorption, sedimentation, air photo interpretation, flume and wave tank studies, paleomagnetic analysis, geochemistry, petrography and scanning electron microscopy. The Sundquist Marine Laboratory at Shannon Point near Anacortes provides facilities for studies in marine geology.

PROGRAMS

Objectives of the department are varied, including preparation of undergraduate and graduate students for careers as professional geoscientists and also preparation of earth science teachers at the primary and secondary levels.

A wide variety of geologic phenomena in the adjacent Cascade Range and the marine environment of Puget Sound provide a broad spectrum of geologic features for study.

The department offers BA, BAE, BS and MS degrees plus specialized courses in the following subjects: economic geology; environmental geology; geochemistry; geomorphology; geophysics; glacial geology; hydrology; paleomagnetism; paleontology; petrology; sedimentation; stratigraphy; and structure and tectonics.

STUDENT INVOLVEMENT IN RESEARCH

The faculty in the Department of Geology are active in a wide variety of ongoing research projects that frequently involve undergraduate and graduate students in special projects and thesis projects or provide employment. Some of this research is funded or partially supported from grants to individual faculty members from the National Science Foundation, U.S. Geological Survey, National Parks Commission, Office of Ecology and geological-related companies. Many of these projects are in the Western Washington region, others include investigations in other parts of the United States, Canada and even overseas.

GEOLOGY FACULTY

RANDALL S. BABCOCK (1967) Chair and Professor. AB, Dartmouth College; MS, PhD, University of Washington.

JACQUELINE CAPLAN-AUERBACH (2006) Assistant Professor. BA, Yale University; PhD, University of Hawaii-Manoa.

DOUGLAS H. CLARK (1998) Associate Professor. BS, MS, Stanford University; PhD, University of Washington.

JULIET G. CRIDER (2001) Associate Professor. BA, Amherst College; MS, University of Washington; PhD, Stanford University.

SUSAN M. DEBARI (1998) Associate Professor. BA, Cornell University; PhD, Stanford University.

DAVID C. ENGBRETSON (1983) Professor. BA, Western Washington University; MS, PhD, Stanford University.

THOR A. HANSEN (1985) Professor. BS, George Washington University; PhD, Yale University.

DAVID M. HIRSCH (2001) Assistant Professor. BS, University of California-Los Angeles; PhD, University of Texas-Austin.

BERNARD A. HOUSEN (1997) Professor. BS, University of Washington; MS, PhD, University of Michigan.

SCOTT R. LINNEMAN (2000) Associate Professor. BA, Carleton College; PhD, University of Wyoming.

ROBERT J. MITCHELL (1996) Associate Professor. BS, University of Wisconsin-River Falls; MS, Michigan Technological University; PhD, Michigan Technological University.

ELIZABETH R. SCHERMER (1990) Professor. BS, Stanford University; PhD, Massachusetts Institute of Technology.

CHRISTOPHER A. SUCZEK (1977) Associate Professor. AB, University of California-Berkeley; PhD, Stanford University.

Research Associates

CLARK M. BLAKE (1993). AB, University of California-Berkeley; PhD, Stanford University.

RUSSELL F. BURMESTER (1978). BS, Stanford University; MA, University of Texas-Austin; PhD, Princeton University.

CHARLES A. ROSS (1992). BA, University of Colorado; MS, PhD, Yale University.

Adjunct Faculty

DAVID TUCKER (2006) BS, MS, Western Washington University.

PETER WILLING (1997). BA, University of Washington; MS, PhD, Cornell University.

BACHELOR OF ARTS

Major - Geology

75 credits

An accompanying minor in one of the sciences or in mathematics is recommended.

- GEOL 211, 212, 213, 306, 310, 318, 406
- 15 credits under advisement from geology courses 200 level and above
- CHEM 121; MATH 124; PHYS 114 and 115 or PHYS 121, 122, (preferred and required for graduate programs); 10 additional credits selected from MATH 125, 240; CHEM 122, 123; BIOL 204

Major — Geology — Thesis Option

74-81 credits

An accompanying minor in one of the sciences or in mathematics is recommended.

- GEOL 211, 212, 213, 306, 310, 318, 406
- 7 credits under advisement from geology courses 200 level and above
- One of the following research methods courses in consultation with advisor: GEOL 411, 413, 415, 423, 425, 440, 450, 451, 452, 453, 454, 456, 457, 461, 463, 472, 473, 474
- Successful application to the department approving the thesis topic
- Complete at least 4 credits of GEOL 490
- CHEM 121; MATH 124; PHYS 114 and 115 or PHYS 121, 122, (preferred and required for graduate programs); 10

additional credits selected from MATH 125, 240; CHEM 122, 123; BIOL 204

MID-PROGRAM CHECKPOINT

Students seeking to complete a BA degree in geology within a four-year time span should have completed GEOL 211 and 212, MATH 124, PHYS 121, and CHEM 121 by the start of their junior year.

BACHELOR OF ARTS IN EDUCATION

The geology department recommends for teaching endorsement those students who have satisfactorily completed requirements for the bachelor's degree in education with 1) an earth science secondary major or 2) a geology minor combined with a major in one of the other physical or biological sciences. Courses required for a state teaching endorsement must be completed with a grade of C (2.0) or better.

Major - Earth Science - Elementary

73-84 credits

This major must be accompanied by the professional preparation program in elementary education. See the *Elementary Education* section of this catalog for program admission, completion, and teacher certification requirements. This major does not lead to an endorsement in Earth & Space Science.

- SCED 201, 202, 203, 294, 370, 480, 490
- GEOL 211, (or 211a), 212, 252, 310, 311 (or 306 and 406), 340
- MATH 114, CHEM 121, PHYS 101 (or 104), ASTR 103 or 113
- Electives (choose two of the following):
 - GEOL 213, 214, 303, 308, 309, 316, 372, 414, 415, 430, 440

Major - Earth Science - Secondary

74-90 credits

This program must be accompanied by the professional preparation program in secondary education. See the *Secondary Education* section of this catalog for program admission, completion, and teacher certification requirements.

This major leads to an endorsement in Earth & Space Science.

- GEOL 211 (or 211a), 212, 213, 252, 310, 311 (or 306 and 406), 340; ASTR 103 or 113
- MATH 114 and 115; or complete MATH 124; MATH 240; PHYS 114 and 115; CHEM 121 and 122; SCED 370, 481, 491
- Electives (choose two of the following):
 - GEOL 308, 309, 314, 316, 318, 407, 414, 415, 430, 440

Combined Major - Earth Science/General Science - Secondary

95-109 credits

This program must be accompanied by the professional preparation program in secondary education. See the *Secondary Education* section of this catalog for program admission, completion, and teacher certification requirements.

This major leads to recommendation for teaching endorsements in Earth & Space Science and Science.

- GEOL 211 (or 211a), 212, 213, 252, 310, 311 (or 306 and 406), 340; ASTR 103 or 113
- MATH 114 and 115; or complete MATH 124; MATH 240; CHEM 121, 122, 251; BIOL 204, 205, 206; PHYS 114,

- 115, 116 (or 121, 122, 123)
- SCED 370, 481, 491
- At least one elective from: GEOL 308, 309, 314, 316, 318, 372, 407, 414, 415, 430, 440

BACHELOR OF SCIENCE

Major — Geology

96-106 credits

This program is recommended for students who are preparing to become professional geologists and intend to enter industry or enroll in a graduate program upon completion of the degree.

Students intending to pursue graduate study are strongly advised to take Math 224 or 204, PHYS 123 and other science support courses appropriate to the specialty.

Students must complete both the Core Program and one of the three concentrations.

Core Program

- GEOL 211, 212, 213, 306, 310, 318, 352, 406, 409, 410, 415
- CHEM 121, 122, 123; MATH 124-125 or 134-135 or 138; PHYS 121, 122

Geology Concentration

96-106 credits

This option is designed to provide students with a broad background in geology, with advanced preparation in earth materials, structural geology, and tectonics. Completion of this program will prepare students for a variety of careers in geology or graduate work in geology.

- Core Program
- GEOL 316, 407
- One of MATH 203, 204, 224, 341
- Two of the following, or substitute courses under advisement: GEOL 411, 423, 424, 425, 428, 430, 449, 450, 451, 454, 456, 463

Geology Concentration — Thesis Option

97-105 credits

- Core Program
- GEOL 316, 407
- One of MATH 203, 204, 224, 341
- One of the following research methods courses in consultation with advisor: GEOL 411, 423, 424, 425, 450, 454, 456, 463
- Successful application to the department approving the thesis topic
- Complete at least 4 credits of GEOL 490

Environmental Geology Concentration

99-105 credits

This option is designed to provide students with a general background in the surficial and hydrologic processes required for the involvement in site assessments, groundwater investigations, hazard evaluations, watershed analyses, stream characterization and restoration, land use planning, location of waste disposal sites and other projects that involve the Earth and the activities of humankind. This option is also suitable preparation for graduate work in geology or environmental sciences.

- Core Program
- GEOL 314, 473
- One of MATH 203, 204, 224, 341
- 9 additional credits from GEOL 413, 430, 440, 449, 450, 451, 452, 461, 462, 470, 472, 474

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Environmental Geology — Thesis Option

96-105 credits

- Core Program
- GEOL 314, 473
- One of MATH 203, 204, 224, 341
- One of the following research methods courses in consultation with advisor: GEOL 413, 430, 440, 450, 451, 452, 461, 462, 470, 472, 474
- Successful application to the department approving the thesis topic
- Complete at least 4 credits of GEOL 490

Geophysics Concentration

98-105 credits

This option will prepare students to apply various geophysical techniques to the study of the Earth. Completion of this concentration will prepare students for careers in environmental geophysics or graduate work in geotectonics and other quantitative aspects of Earth Science.

- Core Program
- GEOL 452
- At least one from GEOL 453, 456, 457, 463
- At least one from GEOL 449, 450, 451, 454, 472, 473 or 4 additional credits from the math or physics courses listed below.
- 8 credits from MATH 203, 204, 224, 225, 331; PHYS 123, 223, 233, 363

Geophysics Concentration — Thesis Option

98-106 credits

- Core Program
- GEOL 452
- At least one course from GEOL 449, 450, 451, 453, 472, 473, or 4 additional credits from the math or physics courses listed below
- One of MATH 203, 204, 224, 225, 331; PHYS 123, 223, 233, 363
- One of the following research methods courses: GEOL 454, 456, 457, 463
- Successful application to the department approving the thesis topic
- Complete at least 4 credits of GEOL 490

Major - Geophysics

93 to 101 credits

This program is recommended for students who are interested in applications of physics as a means of understanding a range of geological processes. Geophysics is distinct from Geology in that a more intensive set of Math and Physics courses, and applications of these skills, are required. Students who complete this degree will be prepared to continue to graduate studies in geology, geophysics, planetary geology/geophysics, physics, or other related fields, or to enter into industry. Students are strongly encouraged to complete a senior thesis project as part of this degree, providing them with an excellent capstone experience. Declaration of this major requires Geol 211, and a completed advising session with a Geophysics faculty advisor.

- GEOL 211, 213, 311, 318, 352, 452
- CHEM 121
- MATH 124 and 125, or MATH 138; and MATH 203, 303, 224, or MATH 204, 304, 224
- PHYS 121, 122, 123, 233, 363, 485
- Three courses from the following electives:
 - GEOL 306, 314, 449, 453, 454, 456, 457, 463, 473
 - PHYS 397

8 credits from:

- GEOL 490 (Senior Thesis – 8 credits)
- Or 8 credits from the following:
 - GEOL 451, 455, 470, 472
 - MATH 225, 430
 - PHYS 326, 368, 369

SENIOR THESIS

An undergraduate thesis is an excellent way to develop research skills, establish closer working relationships with faculty, and gain a more in-depth knowledge of geology. Completion of a thesis is also a notable achievement that highlights a student's ability to do research, providing tangible evidence of research ability to either graduate schools or potential employers. Thesis options are available for the BA and BS degrees in geology. Students interested in pursuing a senior thesis should contact potential advisors during their junior year to discuss possible thesis topics. A formal application to the department must be made, and accepted, prior to the start of the thesis project.

MID-PROGRAM CHECKPOINT

Students seeking to complete a BS degree in geology within a four-year time span should have completed GEOL 211 and 212; MATH 124 and 125; CHEM 121, 122 and 123; and PHYS 121, 122 and, if graduate school is contemplated, PHYS 123, by the start of their junior year. Omissions from this list will make it difficult or impossible to complete this degree within two additional years.

MINOR

Minor - Geology

25 credits

- GEOL 211, 212
- Geology electives 200 level and above

DECLARATION OF MAJOR

Some 300-level geology courses give preference to majors during Phase I of registration, so it is important to declare a major as early as possible.

Students are admitted to the BA or BS major once they have completed GEOL 211. (**NOTE:** Grades of D-, D, or D+ are not acceptable for major and supporting courses.) Students must apply to the department for admission to the major.

WRITING PROFICIENCY COURSE GUIDELINES

The geology department has a multitiered system for upper division writing proficiency courses. Courses are assigned writing proficiency (WP) points based on the percentage of the course grade that is determined by writing assignments.

DEPARTMENTAL HONORS AND DISTINCTIONS

BA or BS students and students in the University Honors program who have completed at least 4 credits of GEOL 490 and have a cumulative GPA of 3.50 or higher meet the requirements for departmental honors. Those students who have completed at least 4 credits of GEOL 490 and have a cumulative GPA higher than 3.20 meet the requirements for departmental distinction.

GRADUATE STUDY

For concentrations leading to the Master of Education or the Master of Science degrees, see the *Graduate School* section of this catalog.

COURSES IN GEOLOGY (GEOL)

Courses numbered X37; X97; 300, 400; 417, 445 are described on page 35 of this catalog.

101 INTRODUCTION TO GEOLOGY (4)

Prereq: MATH 106 or higher. Major ideas of modern geoscience; the study of rocks and minerals, plate tectonics, geologic time, the hydrologic cycle; processes that have produced the Earth and its landforms. Some lecture sections will focus on specific topics within the geological sciences, such as planetary geology, climate and climate change, or national parks. Includes lab. Prospective geology majors, students who had high school geology, and those planning to take GEOL 212 should take GEOL 211 in lieu of GEOL 101.

202 PLATE TECTONICS AND CONTINENTAL DRIFT (4)

Prereq: GEOL 101 or equivalent. Emergence of the theory of plate tectonics and its revolutionary impact on geologists thinking about the history of the earth; an instance of scientific discovery. For non-science majors.

204 GEOLOGY AND SOCIETY (3)

Prereq: GEOL 101 or BIOL 101 or CHEM 101 or PHYS 101 or permission of instructor. Thematic approach to geology, with different themes exploring the relationship between scientific ways of knowing, and geology in particular, with society. Repeatable once as an elective with different topics. May be taken only once for GUR credit.

211 PHYSICAL GEOLOGY (5)

Prereq: MATH 114 or higher and high school or college chemistry. Course for science and geology majors in which the origin, composition and structure of earth are explored. Emphasizes identification of common rocks and minerals; the evolution of the surface features and structures of continents and interpretation of landforms from maps. Includes substantial quantitative work. Students intending to major in geology or affiliated sciences should take GEOL 211 in lieu of GEOL 101. Successful completion of both GEOL 101 and GEOL 211a may substitute for GEOL 211 in all geology department requirements. Includes lab.

211A PHYSICAL GEOLOGY REVIEW (2)

Prereq: GEOL 101 or SCED 202 with a grade of B- or better; MATH 114; high school or college chemistry. This is a laboratory-only course for students who wish to enter the geology major or minor or take upper-division geology courses and who have had a general introduction to geology. Emphasis on rock and mineral identification, geologic structures, map interpretation. Successful completion of both GEOL 101 and 211a or SCED 202 and GEOL 211a may substitute for GEOL 211 in all geology department requirements. GEOL 211a may not be used to fulfill general education requirements.

212 HISTORICAL GEOLOGY (4)

Prereq: GEOL 211. Evolution of the major features of the earth surface and of life; history of the ocean basins, continents and mountain belts related to the theory of plate tectonics; geologic history of North America and the Pacific Northwest. Includes lab.

213 GIS IN GEOLOGY (3)

Prereq: Geology major status or permission of instructor. An introduction to the fundamental elements of geographic information systems (GIS) for spatial data analysis in geology. Emphasis on data sources and ArcGIS tools for data input, display, manipulation, analysis, and output.

214 ENVIRONMENTAL GEOLOGY (3)

Prereq: GEOL 101 or 211. Explores the interactions between geological phenomena and human society. Topics include geologic hazards such as earthquakes, landslides, floods and volcanic eruptions, as well as the effects of human activities on earth systems, such as ground water contamination, resource limits, and global warming.

252 THE EARTH AND ITS WEATHER (4)

Prereq: GEOL 101, CHEM 101 or PHYS 101. An introduction to meteorology from a global viewpoint. A study of the earth's atmosphere, including weather observation and forecasting. Measurement and description of atmospheric properties. Includes lab.

301 GEOLOGY WRITING CO-REQUISITE (1)

Prereq: concurrent registration in either GEOL 308, 309, 310, 311, 314 or 340. A writing-intensive supplement to a geology course. Students will

explore research topics and learn to write scientific papers about those topics. Repeatable up to 3 credits.

303 DINOSAURS AND THEIR ENVIRONMENT (3)

Prereq: GEOL 101. Dinosaurs and their world; their biology, behavior, evolution, and what the world was like during their reign.

306 MINERALOGY (4)

Prereq: GEOL 211; CHEM 121, Prereq or coreq: Chem 122. Introduction to crystal chemistry and crystallography. Origin, occurrence and classification of common minerals; physical and chemical properties of minerals used in identification. Basic petrographic microscopy techniques and identification of common rock-forming minerals in thin-section.

308 EARTHQUAKES (3)

Prereq: GEOL 211. This course is a qualitative survey of the causes, effects and dynamics of local and global earthquakes. Topics include wave propagation, earth structure, and the global distribution of earthquakes, faulting mechanisms, earthquake magnitude, earthquake prediction and seismic hazard. Emphasis is placed on the investigation of earth-quake behavior through case studies of historical earthquakes.

309 VOLCANOLOGY (3)

Prereq: GEOL 211. Processes, products, and hazards of volcanic eruptions. Topics to include eruptive mechanisms, volcanic landforms and their relation to the composition and physical properties of magmas, emplacement mechanisms of pyroclastic flows and characteristics of their deposits, calderas, volcanic gases, effects of volcanic eruptions on climate and the atmosphere, volcanic hazards and their mitigation, and geothermal energy and mineral resources.

309A VOLCANOLOGY LAB (1)

Co-req: GEOL 309. Optional lab to accompany GEOL 309. Observation and interpretation of volcanic rocks and interpretation of volcanic eruption styles.

310 GEOMORPHOLOGY (5)

Prereq: GEOL 211, MATH 114 or higher. Origin and evolution of topographic features by surface processes; analysis of glaciers, streams, wind, waves, ground water and other agents in development of landforms.

311 EARTH MATERIALS (4)

Prereq: GEOL 211; CHEM 121. Examines geologic materials (minerals, rocks, and soils) from the scale of atoms to tectonic plates. Lecture foci range from the esoteric (mineral symmetry) to the practical (economic minerals). Lab exercises emphasize the scientific skills of observation, identification, and classification in lab and in the field. Field trips required.

314 ENGINEERING GEOLOGY (3)

Prereq: GEOL 211, PHYS 121. Introduction to the engineering properties of rock and soil surficial materials and their significance regarding slope stability and natural foundations for buildings, bridges, dams and other engineering works.

315 MINERALS, ENERGY AND SOCIETY (4)

Prereq: GEOL 101 or 211. Mineral resources are vital to society, and yet they are nonrenewable, expensive to find, unevenly distributed and their extraction and consumption can be environmentally damaging. Can we make economically and environmentally sound decisions regarding land-use planning, development vs. conservation, mining vs. environmental protection, recycling vs. waste?

316 RESEARCH IN MARINE PALEONTOLOGY (4)

Prereq: GEOL 212. A problem-solving approach, working on a sequence of problems with reports that build to a core project, report and presentation. Begins with the classification and ecology of marine organisms. Research projects involve data gathering and analysis of fossil samples. Emphasizes hypothesis testing, writing and sharing of data in collaborative research. Includes lab.

318 STRUCTURAL GEOLOGY (5)

Prereq: GEOL 211, 212; PHYS 114 or 121. An overview of deformation in the earth's crust and introduction to tools for analysis of geologic structures. Topics include geometry and development of faults, folds and rock fabrics; stress, strain, and rheology; interpretation of geologic maps and cross sections. Field and laboratory exercises are major components. In alternate years, one section that year is taught entirely in the field.

340 GEOLOGICAL OCEANOGRAPHY (3)

Prereq: GEOL 211, CHEM 121 or equivalent. Students will gain an

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understanding of the nature and origin of oceanic crust and lithosphere. Large-scale chemical and geological processes associated with ocean basins, seawater-rock interactions, and the role of oceanic circulation in climate and climate change will be studied. Additional topics based on student interest will be explored via independent reading assignments.

352 INTRODUCTION TO GEOPHYSICS (4)

Prereq: GEOL 318; PHYS 121. Basic elements of geomagnetism, seismology, gravity and heat flow with reference to the internal structure of the earth.

372 WATERSHED HYDROLOGY (3)

Prereq: GEOL 211. Examination of the hydrologic processes and land characteristics controlling the movement and storage of surface and ground water within a watershed. Topics include the collection and analysis of watershed and hydrologic data, and watershed management issues.

396A,B,C HONORS TUTORIALS (2-5)

Repeatable with no maximum.

401A TEACHING PRACTICUM (1)

Prereq: GEOL 211, with a minimum of a B grade, and permission of chair. Supervised teaching experience in the general geology laboratory. Students will assist in one 2-hour lab section per week. Repeatable to a maximum of 2 credits. S/U grading.

401B TEACHING PRACTICUM (2)

Prereq: permission of chair; student must have received a minimum of a B grade in the course for which they will be a Teaching Fellow. Assisting faculty in teaching advanced undergraduate geology courses. Students will assist in two 2-hour lab sections per week in GEOL 211 or one 2-hour session per week in GEOL 212. Repeatable to a maximum of 4 credits. S/U grading.

406 IGNEOUS AND METAMORPHIC PETROLOGY (4)

Prereq: GEOL 306; Chem 121, 122. Origin, occurrence and classification of igneous and metamorphic rocks, hand specimen identification of rocks. In alternate years, one section that year is taught entirely in the field.

407 ADVANCED PETROGRAPHY (3)

Prereq: GEOL 406. Interaction of light with minerals. Advanced petrographic techniques and identification of minerals with the polarizing microscope. Study of rocks and minerals with a polarizing microscope.

409 FIELD METHODS AND THEORY (6)

Prereq: GEOL 211, 212, 318, 406, 415. Concurrent or successive enrollment in Geol 410 required. Methods of geological field investigations; includes use of field instruments and outcrop studies.

410 GEOLOGIC MAPPING (6)

Prereq: concurrent or immediately prior enrollment in GEOL 409. Application of geological field methods to making geological maps and reports of specific areas; supervised investigation of one or more map areas.

411 FIELD GEOLOGY OF WESTERN UNITED STATES (3)

Prereq: Concurrent or prior enrollment in GEOL 409, 410. Geologic mapping and tectonic analysis of various field sites in the southern U.S. Cordillera, from the plate margin to the craton. Will include outcrop study, reading, independent field research, and discussion of tectonic evolution of the Cordillera.

413 FLUVIAL GEOMORPHOLOGY (4)

Prereq: GEOL 310 or permission of instructor. Stream processes, equilibrium in fluvial environments, channel adjustments, mechanics of sediment erosion and transport. Weekly field trips.

414 GEOLOGY OF WASHINGTON (3-5)

Prereq: GEOL 101 or 211. The significant geologic features of Washington State; field studies. Offered summer only.

415 STRATIGRAPHY AND SEDIMENTATION (4)

Prereq: GEOL 212, 306 and 310 or permission of instructor. Analysis of the transportation, deposition and consolidation of sediments; classification of sedimentary rocks; determination of depositional facies; principles of stratigraphic nomenclature.

423 ADVANCED IGNEOUS PETROLOGY (4)

Prereq: GEOL 406, 407. Advanced course on modern methods of igneous petrology. Focus on magma generation and evolution, utilizing major

element, trace element, and isotope geochemistry. Interpretive methods include use of the petrographic microscope and geochemical modeling exercises. Individual research projects required.

424 ADVANCED SEDIMENTARY PETROLOGY (5)

Prereq: GEOL 406, 407 or equivalent. Description, classification and interpretation of sedimentary rocks, including provenance, depositional history and diagenesis. Advanced lab stresses work with petrographic microscope. Individual research projects.

425 ADVANCED METAMORPHIC PETROLOGY (5)

Prereq: GEOL 406, 407 or equivalent. Advanced course in metamorphic petrology. Emphasizes graphical and mathematical analysis of phase relations, and field and laboratory study of metamorphic structures, minerals and microstructures. Individual research projects performed and presented.

428 DEPOSITIONAL ENVIRONMENTS (3)

Prereq: GEOL 415 or equivalent. Depositional framework of marine and continental sedimentary basins. Study of the means by which depositional environments of sedimentary rocks are determined.

430 IMAGE INTERPRETATION (3)

Prereq: GEOL 310; GEOL 318 recommended. Explores fundamental concepts of identifying and interpreting geologic features using remote imagery, including aerial photographs, topographic data (maps, DEMs), multispectral satellite images, and geophysical imagery. Emphasizes critical evaluation and development of multiple working hypotheses in creating geologic maps from images.

440 GLACIAL GEOLOGY (4)

Prereq: GEOL 310. Explores fundamental concepts of glaciology and glacial geology. Topics include formation and dynamics of glaciers and glacier mass-balance, processes of glacial erosion, transport, and deposition, quaternary climate change associated with global glaciations, and assessing effects of glaciation on the modern landscape. Includes field trips and research components.

442 INTRODUCTION TO REMOTE SENSING (5)

Prereq: upper-division standing in the sciences or permission of instructor. Concepts and applications of remote sensing data collection analysis of earth's surface features using radar, aerial photography and multispectral scanners.

447 INTRODUCTION TO GIS (3)

Prereq: senior status in geology. Introduction of ArcGIS as a tool for manipulating and displaying spatial data. Explores several projects that apply ArcGIS to geologic problems.

448 APPLIED GEOSTATISTICS (3)

Introduction to the visualization of earth science data using a variety of univariate, bivariate, and multivariate statistical techniques, including correlation, regression, ANOVA, principle component analysis and multiple regression.

449 GEOMECHANICS (3)

Prereq: PHYS 121; GEOL 318 or 314; GEOL 352 recommended. Reviews applications of continuum physics to geological problems. Fundamental topics may include a review of elementary mechanics, mathematical descriptions of stress, strain, elasticity, buoyancy, and the flow of viscous materials. Geoscience applications may include faulting, flexure, landslides, propagation of seismic waves, flow of glaciers, debris flows, lava flows, isostatic rebound. The exact curriculum will be decided by participants. The tutorial format requires active participation and discussion by all students. Offered alternate years.

450 ADVANCED TOPICS IN STRUCTURAL GEOLOGY (4)

Prereq: GEOL 318, 406; Geol 409 and 410 recommended. Analysis of geologic structures from microstructural to plate tectonic scales. Includes active and ancient structures, concepts of stress and strain, kinematics and mechanics of deformation, and modeling of deformation. Field trip and research project required. Taught alternate years.

451 ACTIVE TECTONICS SEMINAR (4)

Prereq: GEOL 318, 352. Study of active faults, associated crustal deformation and earthquakes. Examines the mechanics of faulting, earthquake seismology, and GPS geodesy. Regional emphasis on the Pacific Northwest.

452 APPLIED GEOPHYSICS (5)

Prereq: GEOL 352 or equivalent. Geophysical exploration techniques applied

to geological problems. Theory and field application of gravity, magnetics, refraction and earthquake seismology, electrical resistivity and others. Class projects include depth-to-bedrock, buried and subsurface features, groundwater estimates and earthquake potential and grounds response.

453 PLATE TECTONICS (4)

Prereq: GEOL 352. Kinematics and dynamics of plate motions, with applications to geotectonics.

454 MAGNETIC FABRICS AND GEOLOGIC PROCESSES (4)

Prereq: GEOL 352 or equivalent. Theory and laboratory measurement of magnetic anisotropy in rocks, sediments, and minerals. Emphasis on the use of magnetic anisotropy techniques to understand various geological processes including deformation, sediment transport, and magma flow and emplacement. Laboratory project and writing project included.

455 CLIMATE-RELATED GEOLOGIC HAZARDS (3)

Prereq: PHYS 121 or equivalent. The relation of climate and weather to geologic hazards: air masses, fronts, trends in temperature, precipitation, winds and tides. Topics include effects of severe weather on mass wasting, floods and erosion, global climate and sea-level variations for the past two million years.

456 PRINCIPLES OF OROGENY SEMINAR (3)

Prereq: GEOL 318, 352, 406, 409, and 410. Study of geological and geophysical aspects of continental tectonics and mountain-building processes. Topics may include thermochronology, heat flow, metamorphic petrology, structural geology, tectonic geomorphology, plate tectonics, and geodesy. The tutorial format requires reading and discussion of tectonics literature, and active participation and discussion by all students. Field trip and research project required. Taught alternate years.

457 PRACTICAL PALEOMAGNETISM (4)

Prereq: GEOL 352. Application of rock magnetism and paleomagnetism to field-oriented research problems. Seminar style meetings, field trip(s), and laboratory measurements will focus on solution of an original research problem. Results will be used for a required research paper. Project topics will vary; examples include paleomagnetism of displaced terranes, magnetostratigraphy, magnetic fabrics, environmental magnetism.

461 ANALYTICAL GEOCHEMISTRY (2)

Prereq: GEOL 306, CHEM 123. Introduction to analysis of rocks, soil and water. Methods include atomic absorption spectrophotometry, ion chromatography, gas chromatography and quadrupole mass spectrometry as well as gravimetric, volumetric and colorimetric analysis.

462 HYDROGEOCHEMISTRY (3)

Prereq: GEOL 211; CHEM 121, 122. A discussion of the geological and geochemical processes that control the chemical composition of surface and groundwater.

463 INTRODUCTION TO SEISMOLOGY (4)

Prereq: GEOL 352. Investigates the physics of earthquakes, the effects of earthquakes on our world and the insights into the planet provided by seismology. This class is a quantitative introduction to the study of local and global seismology. Topics include stress and strain, wave propagation, power spectra, earthquake magnitude, seismic hazard, earthquake prediction and associated hazards such as tsunamis and volcano seismology. Whenever possible, students will use real seismic data in their analysis.

470 LANDSLIDES AND SLOPE STABILITY (3)

Prereq: GEOL 310 and GEOL 318 or 314. Reviews current research on landslides and slope stability, including landslide types and processes, landslide triggering mechanisms, soil and rock slope stability, soil and rock slope failure modes, landslide hazard analysis. Offered alternate years.

472 SURFACE WATER HYDROLOGY (4)

Prereq: GEOL 211, MATH 125. Components of the hydrologic cycle, including precipitation, infiltration, evapotranspiration, and runoff, and their effect on a water balance in a watershed.

473 GROUND WATER HYDROLOGY (4)

Prereq: GEOL 211, PHYS 122. Introduction to the geologic and hydrologic factors controlling the occurrence and movement of subsurface water. Applications in well hydraulics and groundwater site investigations.

474 GROUND WATER CONTAMINATION (3)

Prereq: GEOL 473 or permission of instructor. Introduction to the principles of some of the important physical, chemical, and biological processes that govern the transport, persistence, and/or degradation of pollutants in saturated and unsaturated groundwater systems.

476 SURFACE WATER QUALITY MODELING AND ANALYSIS (3)

Prereq: senior status in the sciences and computer literacy, e.g., competency in the use of a mathematical analysis program. Application of mass balance concepts to determining water quality concentrations in completely mixed streams. Reaction kinetics are introduced and applied to perturbations caused by impulse loads, step loads, exponential loading, and periodic inputs.

490 SENIOR THESIS (1-5)

Prereq: senior status. Research project under direction of faculty. Repeatable to a maximum of 9 credits.

Graduate Courses

Courses numbered 500; 517; 545; 597 are described on page 35 of this catalog. Admission to Graduate School or special permission required. See the Graduate School section of this catalog.

501 TEACHING PRACTICUM (2)

Prereq: graduate status and permission of chair. Supervised teaching experiences in undergraduate geology laboratories at the 300 level and above courses. Maximum of 2 credits can be applied toward student's graduate course work. Repeatable to a maximum of 12 credits.

513 FLUVIAL GEOMORPHOLOGY (4)

Prereq: GEOL 310 or permission of instructor. Stream processes, equilibrium in fluvial environments, channel adjustments, mechanics of sediment erosion and transport. Weekly field trips.

518 STRUCTURAL GEOLOGY AND TECTONICS OF WASHINGTON (3)

Prereq: graduate status, permission of instructor, GEOL 318 or equivalent. Field methods of structural geology and introduction to the structural and tectonic evolution of Washington, focusing on the building of the Cascade Mountains. Taught during a three-week period prior to the beginning of fall quarter. Involves camping and field work throughout Washington State, including some strenuous hiking.

523 ADVANCED IGNEOUS PETROLOGY (4)

Prereq: GEOL 406 and 407 or equivalent. Advanced course on modern methods of igneous petrology. Focus on magma generation and evolution, utilizing major element, trace element, and isotope geochemistry. Interpretive methods include use of the petrographic microscope and geochemical modeling exercises. Individual research projects required.

524 SEDIMENTARY PETROLOGY AND PETROGRAPHY (5)

Prereq: GEOL 406, 407 or equivalent. Description, classification and interpretation of sedimentary rocks, including provenance, depositional history and diagenesis. Advanced lab stresses work with the petrographic microscope.

525 ADVANCED METAMORPHIC PETROLOGY (5)

Prereq: GEOL 406, 407 or equivalent. Advanced course in metamorphic petrology. Emphasizes graphical and mathematical analysis of phase relations, and field and laboratory study of metamorphic structures, and microscope study of metamorphic structures, minerals and microstructures. Individual research projects performed and presented.

528 DEPOSITIONAL ENVIRONMENTS (3)

Prereq: GEOL 415 or equivalent. Depositional framework of marine and continental sedimentary basins. Study of the means by which depositional environments of sedimentary rocks are determined.

530 IMAGE INTERPRETATION (3)

Prereq: GEOL 310; GEOL 318 recommended. Explores fundamental concepts of identifying and interpreting geological features using remote imagery, including aerial photographs, topographic data (maps, DEMs), multispectral satellite images, and geophysical imagery. Emphasizes critical evaluation and development of multiple working hypotheses in creating geologic maps from images.

536 PALEOBIOLOGY (3)

Prereq: GEOL 316 or permission of instructor. Explores current topics in the study of fossils. Topics may include mass extinctions, community paleoecology,

dinosaur behavior or the effects of extraterrestrial events on the earth's biosphere. Specific topics for each quarter will be decided by the class.

540 GLACIAL GEOLOGY (4)

Prereq: GEOL 310 or equivalent. Explores fundamental concepts of glaciology and glacial geology. Topics include formation and dynamics of glaciers and glacier mass-balance, processes of glacial erosion, transport, and deposition, quaternary climate change associated with global glaciations, and assessing effects of glaciation on the modern landscape. Includes field trips and research components.

542 INTRODUCTION TO REMOTE SENSING (5)

Prereq: graduate status. Concepts and applications of remote sensing data collection analysis of the earth's surface features using radar, aerial photography and multispectral scanners.

547 INTRODUCTION TO GIS (3)

Introduction of ArcGIS as a tool for manipulating and displaying spatial data. Introduces a variety of projections and discusses geodatabases. GPS systems are used in data collection.

548 APPLIED GEOSTATISTICS (3)

Prereq: computer literacy, graduate status. Study of applied statistical analysis using environmental data. Introduces the S-Plus language.

549 GEOMECHANICS (3)

Prereq: PHYS 121, GEOL 314, 318; GEOL 352 recommended. Reviews applications of continuum physics to geological problems. Fundamental topics may include a review of elementary mechanics, mathematical descriptions of stress, strain, elasticity, buoyancy, and the flow of viscous materials. Geoscience applications may include faulting, flexure, landslides, propagation of seismic waves, flow of glaciers, debris flows, lava flows, isostatic rebound. The exact curriculum will be decided by participants. The tutorial format requires active participation by all students. Offered alternate years.

550 ADVANCED TOPICS IN STRUCTURAL GEOLOGY (4)

Prereq: GEOL 318, 406; GEOL 409 and 410 recommended. Analysis of geologic structures from microstructural to plate tectonic scales. Includes active and ancient structures, concepts of stress and strain, kinematics and mechanics of deformation, and modeling of deformation. Field trip and research project required. Taught alternate years.

551 ACTIVE TECTONICS SEMINAR (4)

Prereq: GEOL 318, 352. Study of active faults, associated crustal deformation and earthquakes. Examines the mechanics of faulting, earthquake seismology and GPS geodesy. Regional emphasis on the Pacific Northwest.

552 APPLIED GEOPHYSICS (5)

Prereq: GEOL 352 or equivalent. Geophysical exploration techniques applied to geological problems. Theory and field application of gravity, magnetics, refraction and earthquake seismology, electrical resistivity and others. Class projects include depth-to-bedrock, buried subsurface features, groundwater estimates and earthquake potential and ground response.

553 PLATE TECTONICS (4)

Prereq: GEOL 352. Kinematics and dynamics of plate motions, with applications to geotectonics.

554 MAGNETIC FABRICS AND GEOLOGICAL PROCESSES (4)

Prereq: GEOL 352 or equivalent. Theory and laboratory measurement of magnetic anisotropy in rocks, sediments, and minerals. Emphasis on the use of magnetic anisotropy techniques to understand various geological processes including deformation, sediment transport, and magma flow and emplacement. Laboratory project and writing project included.

555 CLIMATE-RELATED GEOLOGIC HAZARDS (3)

Prereq: PHYS 121 or equivalent. The relation of climate and weather to geologic hazards: air masses, fronts, trends in temperature, precipitation, winds and tides. Topics include: effects of severe weather on mass wasting, floods, and erosion; global climate and sea level variations for the past two million years.

556 PRINCIPLES OF OROGENY SEMINAR (3)

Prereq: GEOL 318, 352, 406, 409, 410. Study of geological and geophysical aspects of continental tectonics and mountain-building processes. Topics may include thermochronology, heat flow, metamorphic petrology, structural geology, tectonic geomorphology, plate tectonics, and geodesy. The tutorial

format requires reading and discussion of tectonics literature, and active participation and discussion by all students. Field trip and research project required. Taught alternate years.

557 PRACTICAL PALEOMAGNETISM (4)

Prereq: GEOL 352. Application of rock magnetism and paleomagnetism to field-oriented research problems. Seminar style meetings, field trip(s), and laboratory measurements will focus on solution of an original research problem. Results will be used for a required research paper. Project topics will vary; examples include paleomagnetism of displaced terranes; magnetostratigraphy; magnetic fabrics, environmental magnetism.

558 PALEOMAGNETISM AND TECTONICS LAB SEMINAR (1-2)

Prereq: GEOL 457/557. Advanced instruction in the operation of paleomagnetic lab equipment, research techniques in rock and paleomagnetism, discussion and evaluation of current paleomagnetic literature. Seminar topics will focus on presentation of research results and current research in the field. Topics related to paleomagnetism and plate tectonics will vary each quarter. Repeatable to a maximum of 4 credits.

559 ROCK MAGNETISM AND GEOMAGNETIC FIELD LAB (1-2)

Prereq: GEOL 457/557 or permission of instructor. The course will involve advanced instruction in the operation of paleomagnetic lab equipment, research techniques in rock and paleomagnetism, discussion and evaluation of current paleomagnetic literature. Seminar topics will focus on presentation of research results and current research in the field. Topics related to the geomagnetic field and rock magnetism will vary each quarter. Repeatable to a maximum of 4 credits.

560 GEOLOGIC PHASE EQUILIBRIA (3)

Prereq: permission of instructor. Analysis of geologic phase equilibria in terms of classical thermodynamics. Review of current research literature and seminar presentations.

561 ANALYTICAL GEOCHEMISTRY (2)

Prereq: permission of instructor. Applications of analytical chemistry to soil, water and rock samples. Methods include atomic absorption spectrophotometry, ion chromatography, gas chromatography, mass spectrometry and X-ray diffraction. Field collection techniques, sample preparation and data processing also are discussed. Course consists of two hours of lecture and two hours of lab per week.

562 ADVANCED HYDROGEOCHEMISTRY (3)

Prereq: GEOL 211; CHEM 121, 122. Discussion and directed research on the physical processes and geochemical equilibria that control the major and trace element composition of water in its various forms on earth.

563 INTRODUCTION TO SEISMOLOGY (4)

Prereq: GEOL 352. Investigates the physics of earthquakes, the effects of earthquakes on our world and the insights into the planet provided by seismology. This class is a quantitative introduction to the study of local and global seismology. Topics include stress and strain, wave propagation, power spectra, earthquake magnitude, seismic hazard, earthquake prediction and associated hazards such as tsunamis and volcano seismology. Whenever possible, students will use real seismic data in their analysis.

570 LANDSLIDES AND SLOPE STABILITY (3)

Prereq: GEOL 310 and GEOL 318 or 314 or equivalent. Reviews current research on landslides and slope stability, including landslide types and processes, landslide triggering mechanisms, soil and rock slope stability, soil and rock slope failure modes, landslide hazard analysis. Offered alternate years.

572 SURFACE WATER HYDROLOGY (4)

Prereq: permission of instructor. Components of the hydrologic cycle and their interaction, including precipitation, infiltration, evapotranspiration, and runoff, and their effect on a water balance in a watershed.

573 GROUND WATER HYDROLOGY (4)

Prereq: permission of instructor. Introduction to the geologic and hydrologic factors controlling the occurrence and movement of subsurface water. Applications in well hydraulics and groundwater site investigations.

574 GROUND WATER CONTAMINATION (3)

Prereq: GEOL 573 or permission of instructor. Introduction to the principles of some of the important physical, chemical, and biological processes that govern the transport, persistence, and/or degradation of pollutants in saturated and unsaturated groundwater systems.

576 SURFACE WATER QUALITY MODELING AND ANALYSIS (3)

Prereq: graduate status in the sciences and computer literacy, e.g., competency in the use of MathCAD. Application of mass balance concepts to determining water quality concentrations in completely mixed streams. Reaction kinetics are introduced and applied to perturbations caused by impulse loads, step loads, exponential loading, and periodic inputs.

595 SEMINAR IN CONTEMPORARY GEOLOGY PROBLEMS (2)

Prereq: graduate status in department. Seminar and weekend field trips introduce geology graduate students to research problems. S/U grading. Repeatable to a maximum of 6 credits.

690 THESIS (2-15)

Thesis research, repeatable up to 15 credits.



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