

# EARTH SCIENCE

## THE WIESS SCHOOL OF NATURAL SCIENCES

### CHAIR

Alan Levander

### PROFESSORS

John B. Anderson

André W. Droxler

Richard G. Gordon

Dale S. Sawyer

### ASSOCIATE PROFESSORS

Gerald R. Dickens

Adrian Lenardic

Andreas Lutgge

Julia Morgan

Colin A. Zelt

### ASSISTANT PROFESSORS

Rajdeep Dasgupta

Brandon Dugan

Helge Gonnerman

Cin-Ty Lee

Caroline Masiello

Fenglin Niu

### ADJUNCT PROFESSORS

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Juan Antonio Simo

John C. Van Wagoner

Fred M. Weaver

### ADJUNCT ASSOCIATE PROFESSOR

Vitor Abreu

David L. Olgaard

### ADJUNCT ASSISTANT PROFESSORS

Alan D. Brandon

Patrick J. McGovern

Christian A. Noll

Stephanie S. Shipp

Julia S. Wellner

Yitian Xiao

### EARTH SCIENCE RESEARCH

#### SCIENTISTS

Rolf Arvidson

Glen Snyder

### EARTH SCIENCE LECTURERS

Vitor Abreu

Stephen H. Danbom

Alison T. Henning

W.C. Rusty Riese

### EARTH SCIENCE POSTDOCTORAL

#### RESEARCH ASSOCIATES

William Hockaday

Tobias Hoeink

Peter Luffi

Meghan Miller

Bing Shen

### EARTH SCIENCE JOINT APPOINTMENTS

#### (WITH CHEMISTRY)

Andreas Lutgge

## ESCI DEGREES OFFERED: BA, BS, MS, PHD

All undergraduate majors in earth science take a 4-course core sequence, typically in the sophomore and junior years, on earth processes, materials, observations, and history. Majors also take a course in geological field techniques and introductory courses in mathematics, chemistry, and in many cases, physics and biology.

The selection of upper-division courses and additional science courses depends on which major, BA or BS, and, for the BS major, which of 5 tracks are chosen by the student: geology, geochemistry, geophysics, environmental earth science, or a track designed by the student subject to the approval of the department undergraduate advisor. The program of study typically includes experience with analytical equipment, computer systems, and fieldwork.

The BS in earth science degree should be chosen by students planning a career or further study in earth science or a related field. The BA in earth science degree has fewer requirements and might be a good choice for students planning a career or further study to which earth science is incidental.

**DEGREE REQUIREMENTS FOR BS IN EARTH SCIENCE**

For general university requirements, see Graduation Requirements (pages 16–19).

BS majors also must complete the “Additional Requirements” for one track (described below).

***The following courses are required for all tracks:***

MATH 101/102 *Single Variable Calculus I and II*  
 CHEM 121/122 or 151/152 *General Chemistry I and II with lab*  
 PHYS 101/102 or 111/112 *Introductory Physics I and II with lab*

ESCI 321 *Earth System Evolution and Cycles*  
 ESCI 322 *Earth Chemistry and Materials*  
 ESCI 323 *Earth Structure and Deformation with lab*  
 ESCI 324 *Earth's Interior*  
 ESCI 334 *Geological and Geophysical Techniques*

**ADDITIONAL REQUIREMENTS FOR THE GEOLOGY TRACK**

***The following courses are required:***

MATH 211 *Ordinary Differential Equations and Linear Algebra*  
 ESCI 390 *Geology Field Camp*  
 ESCI 442 *Exploration Geophysics I*

***Choose one of the following courses:***

COMP 110 *Computation in Natural Science*  
 CAAM 210 *Introduction to Engineering Computation*  
 COMP 210 *Principles of Computing and Programming*

***Choose one of the following courses:***

ESCI 412 *Advanced Petrology*  
 ESCI 430 *Principles of Trace-Element and Isotope Geochemistry*

***Choose one of the following courses:***

ESCI 427 *Sequence Stratigraphy*  
 ESCI 521 *Seminar in Applied Micropaleontology*

***Choose one of the following courses:***

ESCI 504 *Siliciclastic Depositional Systems*  
 ESCI 506 *Carbonate Depositional Systems*  
 ESCI 421 *Paleoceanography*

***Choose one of the following courses:***

ESCI 418 *Quantitative Hydrogeology*  
 ESCI 463 *Advanced Structural Geology*  
 ESCI 428 *Geologic Interpretation of Reflection Seismic Profiles*  
 ESCI 464 *Global Tectonics*

**ADDITIONAL REQUIREMENTS FOR THE GEOCHEMISTRY TRACK**

***The following courses are required:***

BIOS 201 *Introductory Biology I*  
 ESCI 390 *Geology Field Camp* or  
 ESCI 391 *Earth Science Field Experience*

***Choose 9 hours from the following:***

ESCI 340 *Global Biogeochemical Cycles*  
 ESCI 412 *Advanced Petrology*  
 ESCI 421 *Paleoceanography*  
 ESCI 425 *Organic Geochemistry*  
 ESCI 458 *Thermodynamics/Kinetics for Geoscientists*  
 ESCI 203 *Biogeochemistry*

ESCI 430 *Principles of Trace-Element and Isotope Geochemistry*

***Choose 8 hours from the following:***

All upper division ESCI courses  
 CEVE 401 *Introduction to Environmental Chemistry*  
 CEVE 403 *Principles of Environmental Engineering*  
 CEVE 434 *Chemical Transport and Fate in the Environment*  
 CEVE 532 *Physical-Chemical Processes in Environmental Engineering*  
 CEVE 534 *Transport Phenomena and Environmental Modeling*

CEVE 550 *Environmental Organic Chemistry*  
 BIOS 202 *Introductory Biology*  
 BIOS 211 *Introductory Lab Module in Biological Science*  
 CHEM 211/212 *Organic Chemistry*  
 CHEM 311/312 *Physical Chemistry*  
 CHEM 415 *Chemical Kinetics and Dynamics*  
 CHEM 495 *Transition Metal Chemistry*

MATH 211 *Ordinary Differential Equations and Linear Algebra*  
 MATH 212 *Multivariable Calculus*  
 COMP 110 *Computation Science and Engineering*  
 CAAM 210 *Introduction to Engineering Computation*  
 COMP 210 *Introduction to Principles of Scientific Computing*

## ADDITIONAL REQUIREMENTS FOR THE GEOPHYSICS TRACK

### **The following courses are required:**

MATH 211 *Ordinary Differential Equations and Linear Algebra*  
 MATH 212 *Multivariable Calculus*  
 PHYS 201 *Waves and Optics*  
 PHYS 231 *Elementary Physics Lab II*  
 ESCI 390 *Geology Field Camp* or  
 ESCI 391 *Earth Science Field Experience*

### **Choose one of the following courses:**

COMP 110 *Computation in Natural Science*  
 CAAM 210 *Introduction to Engineering Computation*  
 COMP 210 *Principles of Computing and Programming*

### **Choose 6 hours from the following:**

ESCI 418 *Quantitative Hydrogeology*  
 ESCI 440 *Geophysical Data Analysis: Digital Signal Processing*

ESCI 441 *Geophysical Data Analysis: Inverse Theory*  
 ESCI 442 *Exploration Geophysics I*  
 ESCI 444 *Exploration Geophysics II*  
 ESCI 450 *Remote Sensing*  
 ESCI 454 *Geographic Information Science*  
 ESCI 461 *Seismology I*  
 ESCI 462 *Tectonophysics*  
 ESCI 464 *Global Tectonics*  
 ESCI 532 *Advanced Global Tectonics*  
 ESCI 542 *Seismology II*

### **Choose 6 hours from the immediately preceding or following lists:**

Any 3- or 4-hour course in ESCI with a number between 411 and 475, except for research and special studies

Any 300- or 400-level MATH, CAAM, or PHYS class  
 CHEM 311 *Physical Chemistry*

## ADDITIONAL REQUIREMENTS FOR THE ENVIRONMENTAL EARTH SCIENCE TRACK

### **The following courses are required:**

MATH 211 *Ordinary Differential Equations and Linear Algebra*  
 BIOS 201 *Introductory Biology I*

### **Choose one of the following courses:**

COMP 110 *Computation in Natural Science*  
 CAAM 210 *Introduction to Engineering Computation*  
 COMP 210 *Principles of Computing and Programming*

### **Choose 11 hours from the following, including at least two courses in ESCI:**

ESCI 340 *Global Biogeochemical Cycles*

ESCI 418 *Quantitative Hydrogeology*  
 ESCI 425 *Organic Geochemistry*  
 ESCI 451 *Analysis of Environmental Data*  
 ESCI 353 *Environmental Geochemistry*  
 ESCI 442 *Exploration Geophysics*  
 ESCI 454 *Geographic Information Science*  
 ESCI 463 *Advanced Structural Geology I*  
 ESCI 504 *Clastics*  
 ESCI 506 *Carbonates*  
 ESCI 568 *Paleoclimates and Human Response*  
 CEVE 306 *Global Environmental Law and Sustainable Development*

CEVE 434 *Chemical Transport and Fate in the Environment*

CEVE 412 *Hydrogeology and Watershed Analysis*

CEVE 401 *Environmental Chemistry*

CHEM 211 *Organic Chemistry*

CHEM 311 *Physical Chemistry*

CHEM 360 *Inorganic Chemistry*

PHYS 201 *Waves and Optics*

PHYS 231 *Elementary Physics Lab II*

BIOS 202 *Introductory Biology II*

### ADDITIONAL REQUIREMENTS FOR THE SELF-DESIGNED TRACK

The department recognizes the interdisciplinary nature of modern earth science and the opportunity for students to specialize in nontraditional and emerging fields. Therefore, students can design their own specialty track, normally in close consultation with 1 faculty member and followed by approval from the department's undergraduate advisor. In addition to required earth science courses and related courses, these tracks will generally comprise 12 additional hours that target a coherent theme from an approved list of 300- or higher-level courses, from inside or outside the department. Interested students are expected to submit a statement of rationale by the beginning of their 3rd year.

#### **Choose 9 hours from the following:**

BIOS 201 *Introductory Biology I*

COMP 110 *Computation in Natural Science*

CAAM 210 *Introduction to Engineering Computation*

COMP 210 *Principles of Computing and Programming*

CHEM 311/312 *Physical Chemistry I and II*

MATH 211 *Ordinary Differential Equations and Linear Algebra*

MATH 212 *Multivariable Calculus*

PHYS 201 *Waves and Optics*

PHYS 203 *Atmosphere, Weather, and Climate*

ESCI 390 *Geology Field Camp* or

ESCI 391 *Earth Science Field Experience*

**Choose 12 hours of additional courses numbered 300 or higher targeting a coherent theme selected with approval of the department undergraduate advisor.**

### DEGREE REQUIREMENTS FOR BA IN EARTH SCIENCE

For general university requirements, see Graduation Requirements (pages 16–19).

#### **The following courses are required:**

MATH 101/102 *Single Variable Calculus I and II*

CHEM 121/122 or 151/152 *General Chemistry I and II with lab*

ESCI 321 *Earth System Evolution and Cycles*

ESCI 322 *Earth Chemistry and Materials*

ESCI 323 *Earth Structure and Deformation with lab*

ESCI 324 *Earth's Interior*

ESCI 334 *Geological and Geophysical Techniques*

MATH 211 *Differential Equations*

PHYS 101/102 or 125/126 *Introductory Physics*

COMP 110 *Computation in Natural Science* or CAAM 210 *Introduction to Engineering Computation* or COMP 210 *Principles of Computing and Programming*

**Choose 4 upper division ESCI courses, approved by the department undergraduate advisor.**

**Choose 6 hours in science and engineering (including ESCI) courses at the 200 level or above approved by the department undergraduate advisor.**

#### **Choose 6 hours from the following:**

BIOL 201/202 *Introductory Biology I and II*

BIOL 211, 213 *Biology Lab Modules*

## UNDERGRADUATE INDEPENDENT RESEARCH

The department encourages, but does not require, earth science undergraduate majors to pursue independent supervised research in ESCI 481 *Research in Earth Science*. See also Honors Programs (page 28).

## DEGREE REQUIREMENTS FOR MS AND PHD IN EARTH SCIENCE

All incoming students should have a strong background in physics, chemistry, and mathematics and should have, or should acquire, a broad grounding in fundamental earth science. The department encourages applications from well-qualified students with degrees in the other sciences and mathematics. For general university requirements, see Graduate Degrees (pages 61–62). The requirements for the MS and PhD in earth science are similar, but the PhD demands a significantly higher level of knowledge, research skills, and scholarly independence. Most students need at least 2 years beyond the bachelor's degree to complete the MS and at least 2 years beyond the MS degree for the PhD.

Candidates determine, with their major professor and thesis committee, a course of study following the *Guidelines for Advanced Degrees in the Department of Earth Science* distributed to all incoming students. For both degrees, candidates must:

- Complete 20 semester hours of course work at the 400 level and above (or other approved courses), not including research hours
- Pass a written preliminary exam
- Maintain a grade point average of 3.00 (B) or better
- Prepare a written thesis
- Produce a publishable thesis that represents an original contribution to science
- Defend the research and conclusions of the thesis in an oral examination

Students of exceptional ability with a bachelor's degree and department approval may work directly toward the PhD, in which case the course of study is equivalent to that required for both degrees; performance on the examinations and the thesis, however, should be at the level required for the PhD. Because the graduate programs require full-time study and close interaction with faculty and fellow students, the department discourages students from holding full (or nearly full) time jobs outside the university. Outside employment must be approved by the chair.

**See ESCI in the Courses of Instruction section.**