# Geochemistry

## Degrees Offered
- Professional Masters in Environmental Geochemistry
- Master of Science (Geochemistry)
- Doctor of Philosophy (Geochemistry)

## Program Description
The Graduate Program in Geochemistry is an interdisciplinary program with the mission to educate students whose interests lie at the intersection of the geological and chemical sciences. The Geochemistry Program consists of two subprograms, administering two M.S. and Ph.D. degree tracks and one Professional Master's (non-thesis) degree program. The Geochemistry (GC) degree track pertains to the history and evolution of the Earth and its features, including but not limited to the chemical evolution of the crust and mantle, geochemistry of energy and mineral resources, aqueous geochemistry and fluid-rock/fluid-mineral interactions and chemical mineralogy. The Environmental Biogeochemistry (EBGC) degree track pertains to the coupled chemical and biological processes of Earth’s biosphere, and the changes in these processes caused by human activities.

## Master of Science and Doctor of Philosophy

### 1. Geochemistry degree track

#### Prerequisites
Each entering student will have an entrance interview with members of the Geochemistry subprogram faculty. Since entering students may not be proficient in both areas, a placement examination in geology and/or chemistry may be required upon the discretion of the interviewing faculty. If a placement examination is given, the results may be used to establish deficiency requirements. Credit toward a graduate degree will not be granted for courses taken to fulfill deficiencies.

#### Requirements
The Master of Science (Geochemistry degree track) requires a minimum of 36 semester hours including:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Course work</td>
<td>24.0</td>
</tr>
<tr>
<td>Research credits</td>
<td>12.0</td>
</tr>
<tr>
<td>Total Semester Hrs</td>
<td>36.0</td>
</tr>
</tbody>
</table>

To ensure breadth of background, the course of study for the Master of Science (Geochemistry degree track) must include:

- CHGC503 INTRODUCTION TO GEOCHEMISTRY 3.0
- CHGC504 METHODS IN GEOCHEMISTRY 2.0

Master of Science (Geochemistry) students select three of the following (3.0):

- CHGC509 INTRODUCTION TO AQUEOUS GEOCHEMISTRY 3.0
- GEOL513 HYDROTHERMAL GEOCHEMISTRY 3.0
- GEOL535 LITHO ORE FORMING PROCESSES 3.0

### Master of Science (Geochemistry) degree track
Students must also complete an appropriate thesis, based upon original research they have conducted. A thesis proposal and course of study must be approved by the student's thesis committee before the student begins substantial work on the thesis research.

### Doctor of Philosophy (Geochemistry degree track)

The Doctor of Philosophy (Geochemistry degree track) program will require a minimum of 72 credit hours beyond the Bachelor degree with a minimum of 40 course credit hours.

Students who enter the PhD program with a thesis-based Master's degree may transfer up to 36 semester hours in recognition of the course work and research completed for that degree. At the discretion of the student's Thesis Committee, up to 24 semester hours of previous graduate-level course work (at CSM or elsewhere) can be applied towards the course requirement of the Doctor of Philosophy (Geochemistry degree track) program.

Doctor of Philosophy (Geochemistry degree track) students must take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHGC503 INTRODUCTION TO GEOCHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC504 METHODS IN GEOCHEMISTRY</td>
<td>2.0</td>
</tr>
<tr>
<td>CHGC514 GEOCHEMISTRY THERMODYNAMICS AND KINETICS</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Students must also select two of the following (3.0):

- CHGC509 INTRODUCTION TO AQUEOUS GEOCHEMISTRY 3.0
- GEOL513 HYDROTHERMAL GEOCHEMISTRY 3.0
- GEOL535 LITHO ORE FORMING PROCESSES 3.0
- GEGN586 NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS 3.0
- GEOL512 MINERALOGY AND CRYSTAL CHEMISTRY 3.0
- GEOL540 ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY 3.0

In addition, all students must complete at least one laboratory course selected from the following (2.0):

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEGN530 CLAY CHARACTERIZATION</td>
<td>2.0</td>
</tr>
<tr>
<td>GEOL523 REFLECTED LIGHT AND ELECTRON MICROSCOPY</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Doctor of Philosophy (Geochemistry degree track) students must also complete an appropriate thesis, based upon original research they have conducted. A thesis proposal and course of study must be approved by the student's thesis committee before the student begins substantial work on the thesis research.

Master of Science (Geochemistry degree track) will be expected to give one public seminar on their research and Doctor of Philosophy (Geochemistry degree track) students are required to give at least one public seminar in addition to their thesis defense presentation.

2. Environmental Biogeochemistry (EBGC) degree track

Prerequisites

A candidate for an M.S. or Ph.D. in the EBGC degree track should have an undergraduate science or engineering degree with coursework including multivariable calculus, two semesters each of physics and chemistry, and one semester each of biology and earth science.

Applicants who do not fulfill these requirements may still be admitted, but will need to undergo an entrance interview to establish deficiency requirements. Credit toward a graduate degree will not be given for undergraduate courses taken to fulfill deficiencies.

Requirements

Required Curriculum: A thesis proposal and thesis are required for all M.S. and Ph.D. degrees in the EBGC degree track. M.S. thesis advisors (or at least one co-advisor) must be members of the EBGC subprogram. Ph.D. thesis committees must have a total of at least four members. Ph.D. advisors (or at least one of two co-advisors) and one additional committee member must be members of the EBGC subprogram. M.S. students will be expected to give one public seminar on their research; Ph.D. students are required to give at least one in addition to their thesis defense presentation.

In addition, both M.S. and Ph.D. students in the EBGC degree track must complete the following coursework:

1. Two required classes:
   - CHGC503 INTRODUCTION TO GEOCHEMISTRY 3.0
   - CHGC504 METHODS IN GEOCHEMISTRY 2.0

2. One chemistry-focused class, chosen from the following list:
   - CEEN550 PRINCIPLES OF ENVIRONMENTAL CHEMISTRY 3.0
   - CHGC509 INTRODUCTION TO AQUEOUS GEOCHEMISTRY 3.0
   - CEEN551 ENVIRONMENTAL ORGANIC CHEMISTRY 3.0

3. One biology-focused class chosen from the following list:
   - CEEN560 MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT 3.0
   - CEEN562 ENVIRONMENTAL GEOMICROBIOLOGY 3.0

4. One earth science-focused class chosen from the following list:
   - GEGN586 NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS 3.0
   - (New class) Earth Surface Geochemistry

5. One class focusing on analytical methods in environmental/biogeochemistry chosen from several available, including:
   - GEGN530 CLAY CHARACTERIZATION 2.0

   Total credits required for M.S.: 36
   Total credits required for Ph.D.: 72 (at least 18 of coursework)

The student's thesis committee may specify additional course requirements and makes final decisions regarding transfer credits.

Comprehensive Examination

Doctor of Philosophy (Geochemistry) students in both degree tracks must take a comprehensive examination. It is expected that this exam will be completed within three years of matriculation or after the bulk of course work is finished, whichever occurs earlier. This examination will be administered by the student's thesis committee and will consist of an oral and a written examination, administered in a format to be determined by the thesis committee. Two negative votes in the thesis committee constitute failure of the examination.

In case of failure of the comprehensive examination, a re-examination may be given upon the recommendation of the thesis committee and approval of the Dean of Graduate Studies. Only one re-examination may be given.

Tuition

The Master of Science (Geochemistry) and Doctor of Philosophy (Geochemistry) programs have been admitted to the Western Regional Graduate Program. This entity recognizes the Geochemistry Program as unique in the region. Designation of the Geochemistry Program by Western Regional Graduate program allows residents of western states to enroll in the program at Colorado resident tuition rates. Eligible states include Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah, Washington and Wyoming.

Professional Masters in Environmental Geochemistry

Introduction

The Professional Masters in Environmental Geochemistry program is intended to provide:

1. an opportunity for CSM undergraduates to obtain, as part of a fifth year of study, a Master in addition to the Bachelor degree; and
2. additional education for working professionals in the area of geochemistry as it applies to problems relating to the environment.

This is a non-thesis Master degree program administered by the Environmental Biogeochemistry subprogram of the Geochemistry program, and may be completed as part of a combined degree program by individuals already matriculated as undergraduate students at CSM, or by individuals already holding undergraduate or advanced degrees and who are interested in a graduate program that does not have the traditional research requirement. The program consists primarily of coursework in geochemistry and allied fields with an emphasis on environmental applications. No research is required though the program does allow for independent study, professional development, internship, and cooperative experience.
Application

Undergraduate students at CSM must declare an interest during their third year to allow for planning of coursework that will apply towards the program. These students must have an overall GPA of at least 3.0. Students majoring in other departments besides the Department of Geology and Geological Engineering and the Department of Chemistry and Geochemistry may want to decide on the combined degree program option earlier to be sure prerequisites are satisfied. Applicants other than CSM undergraduates who are applying for this non-thesis Master degree program must follow the same procedures that all prospective graduate students follow. However, the requirement of the general GRE may be waived.

Prerequisites

Each entering student will have an entrance interview with members of the Geochemistry faculty. Each department recognizes that entering students may not be proficient in both areas. A placement examination in geology and/or chemistry may be required upon the discretion of the interviewing faculty. If a placement examination is given, the results may be used to establish deficiency requirements. Credit toward a graduate degree will not be granted for courses taken to fulfill deficiencies.

Requirements

A minimum of 30 credit hours are required, with an overall GPA of at least 3.0. The overall course requirements will depend on the background of the individual, but may be tailored to professional objectives.

A 10 credit-hour core program consists of:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>GEGN466</td>
<td>GROUNDWATER ENGINEERING</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC503</td>
<td>INTRODUCTION TO GEOCHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC509</td>
<td>INTRODUCTION TO AQUEOUS GEOCHEMISTRY</td>
<td>3.0</td>
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</tbody>
</table>

Total Semester Hrs: 9.0

In addition, 14 credit hours must be selected from the list below, representing the following core areas: geochemical methods, geographic information system, geological data analysis, groundwater engineering or modeling, hydrothermal geochemistry, isotope geochemistry, physical chemistry, microbiology, mineralogy, organic geochemistry, and thermodynamics. This selection of courses must include at least one laboratory course.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEN560</td>
<td>MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC504</td>
<td>METHODS IN GEOCHEMISTRY</td>
<td>2.0</td>
</tr>
<tr>
<td>CHGC555</td>
<td>ENVIRONMENTAL ORGANIC CHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGN503</td>
<td>ADV PHYSICAL CHEMISTRY I</td>
<td>4.0</td>
</tr>
<tr>
<td>GEGN532</td>
<td>GEOLOGICAL DATA ANALYSIS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN575</td>
<td>APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN581</td>
<td>ANALYTICAL HYDROLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN583</td>
<td>MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN586</td>
<td>NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEOL540</td>
<td>ISOPOE GEOCHEMISTRY AND GEOCHRONOLOGY</td>
<td>3.0</td>
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Laboratory courses:

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<thead>
<tr>
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<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHGC503</td>
<td>INTRODUCTION TO GEOCHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC504</td>
<td>METHODS IN GEOCHEMISTRY</td>
<td>2.0</td>
</tr>
<tr>
<td>CHGC505</td>
<td>INTRODUCTION TO ENVIRONMENTAL CHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC506</td>
<td>WATER ANALYSIS LABORATORY</td>
<td>2.0</td>
</tr>
<tr>
<td>CHGC509</td>
<td>INTRODUCTION TO AQUEOUS GEOCHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC511</td>
<td>GEOCHEMISTRY OF IGNEOUS ROCKS</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC527</td>
<td>ORGANIC GEOCHEMISTRY OF FOSSIL FUELS AND ORE DEPOSITS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN586</td>
<td>NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC555</td>
<td>ENVIRONMENTAL ORGANIC CHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CHGC563</td>
<td>ENVIRONMENTAL MICROBIOLOGY</td>
<td>2.0</td>
</tr>
<tr>
<td>CHGC564</td>
<td>BIOGEOCHEMISTRY AND GEOMICROBIOLOGY</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Professors

Linda A. Figueroa, Civil and Environmental Engineering
Wendy J. Harrison, Geology and Geological Engineering
John McCray, Civil and Environmental Engineering
James F. Ranville, Chemistry
John R. Spear, Civil and Environmental Engineering
Bettina M. Voelker, Chemistry
Richard F. Wendlandt, Geology and Geological Engineering

Associate Professors

Christopher P. Higgins, Civil and Environmental Engineering
Thomas Monecke, Geology and Geological Engineering
Jonathan O. Sharp, Civil and Environmental Engineering

Assistant Professors

Alexander Gysi, Geology and Geological Engineering
Alexis Navarre-Sitchler, Geology and Geological Engineering
Professors Emeriti
John B. Curtis, Geology and Geological Engineering
Donald L. Macalady, Chemistry and Geochemistry
Patrick MacCarthy, Chemistry and Geochemistry
Samuel B. Romberger, Geology and Geological Engineering
Thomas R. Wildeman, Chemistry and Geochemistry

Associate Professors Emeriti
L. Graham Closs, Geology and Geological Engineering
E. Craig Simmons, Chemistry and Geochemistry