Overview and Contact Information
The geology major offers students hands-on learning in the classroom, lab, and field. Intermediate and upper-level courses are relatively small and explore geologic materials, physical and biological processes, and earth history and change. We recommend strongly courses in the cognate sciences (biology, chemistry, and physics), as well as calculus and/or statistics.

Contact Information
Michelle Markley, Chair
Debra LaBonte, Academic Department Coordinator
304 Clapp Laboratory
413-538-2278
https://www.mtholyoke.edu/acad/geology

Learning Goals
Students majoring or minoring in geology learn about the dynamic processes and history that shaped our planet and provide us with the resources and natural environments on which we rely. This is a fascinating field of study that also prepares one for outstanding employment opportunities. Our courses are designed to achieve the following learning goals:

- Develop observational and quantitative skills appropriate for field, laboratory, analytical, and modeling methods of geoscience inquiry.
- Develop sophisticated and nuanced reasoning skills to evaluate multiple working hypotheses, integrate earth science data gathered at different spatial and temporal scales, and critically assess data, ideas, and methods from the published literature.
- Become an effective communicator, able to ask interesting questions, collaborate with peers, and engage thoughtfully and respectfully in discussion; to write about scientific observations and interpretations using appropriate vocabulary and style; and to orally and graphically present data, ideas, and methods from your own research and from published literature.
- We encourage geology majors to be informed about ideas and methods within the cognate sciences of biology, chemistry, physics, and math and statistics.
- Geology majors will understand the importance of earth processes and materials in shaping the history and future of humanity.

Faculty
This area of study is administered by the Department of Geology and Geography:
Steven Dunn, Professor of Geology
Girma Kebbede, Professor of Geography
Michelle Markley, Professor of Geology
Mark McMenamin, Professor of Geology
Thomas Millette, Director of the Geo-Processing Lab; Professor of Geography

Requirements for the Major
A minimum of 38 credits:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL-123</td>
<td>Methods in Earth Science</td>
<td>2</td>
</tr>
<tr>
<td>GEOL-201</td>
<td>Rocks and Minerals</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-202</td>
<td>History of Earth</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-203</td>
<td>The Earth’s Surface</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-224</td>
<td>Sedimentary Geology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-322</td>
<td>Igneous and Metamorphic Petrology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-333</td>
<td>Structural Geology and Orogenesis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4 additional credits in geology at any level</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4 additional credits in geology at the 200 level or above</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-150 (or 4 credits of Advanced Placement Chemistry)</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Total Credits 38

Additional Specifications
- Geography, environmental studies, astronomy, and other geology courses in the Five Colleges and from abroad may also apply toward the major as electives or, in some cases, as substitutes for required courses.
- A summer field course may also count for 4-6 credits in geology.
- No more than 4 credits of independent study (GEOL-295 or GEOL-395) may be counted toward the major.

Requirements for the Minor
A minimum of 22 credits:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL-103</td>
<td>Oceanography</td>
<td>4</td>
</tr>
<tr>
<td>GEOL-107</td>
<td>Environmental Geology</td>
<td></td>
</tr>
<tr>
<td>GEOL-109</td>
<td>History of Life</td>
<td></td>
</tr>
<tr>
<td>GEOL-131</td>
<td>Introduction to Hydrology: A Data Perspective</td>
<td></td>
</tr>
<tr>
<td>GEOL-123</td>
<td>Methods in Earth Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 credits at the 200 level or above</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4 additional credits at the 300 level</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Credits 22

Teacher Licensure
Students interested in pursuing licensure in the field of earth and space science can create a special earth science major and combine this course work with a minor in education. For specific course requirements for licensure in earth and space science within the field of geology (and related disciplines), please consult your advisor or the chair of the geology and geography department. Further information about
the minor in education (http://catalog.mtholyoke.edu/areas-study/psychology-education/#minortext) and the Teacher Licensure program (http://catalog.mtholyoke.edu/areas-study/psychology-education/#teacherlicensuretext) is available in other sections of the catalog, and consult Sarah Frenette of the psychology and education department.

Licensure also requires a formal application as well as passing scores on the Massachusetts Test of Educator Licensure (MTEL) in both the literacy component and the subject matter component. Copies of the test objectives for the MTEL are available in the Department of Psychology and Education.

Additional information about the Licensure Program, including application materials, can be found on the Teacher Licensure Program website (https://www.mtholyoke.edu/acad/teach/).

## Course Offerings

### GEOL-103 Oceanography
**Spring. Credits: 4**
Because more than seventy percent of our planet is covered by oceans, the study of marine systems is crucial to our understanding of Earth History and life on the planet. We will examine chemical, physical, geological, and biological processes in the oceans at a variety of scales in time and space. We will explore how the Earth’s oceans formed, how they provided the foundations for life, and how they continue to affect weather and climate, stabilize global chemical cycles, erode coastlines and provide access to resources. We will conclude the semester with a discussion of the human impact on the ocean environment including sea level rise, acidification, coral bleaching and over-fishing.

*Applies to requirement(s): Math Sciences*

*A. Werner*

**Advisory: Potential Environmental Studies and Geology majors should consider taking GEOL-123 concurrently with this course.**

### GEOL-107 Environmental Geology
**Fall. Credits: 4**
The only planet known to sustain life, Earth provides all the resources that sustain us, yet at the same time it can be an unpredictable and sometimes dangerous home. Floods, earthquakes, volcanic eruptions, and other natural processes challenge our ingenuity, while we also contend with self-induced problems such as pollution, desertification, and even global climate change. This course examines earth processes, how these affect our lives, and how we can best live with and sustain our environment. May be taken for 200-level credit with permission of instructor.

*Applies to requirement(s): Math Sciences*

*S. Dunn*

**Advisory: Potential Environmental Studies and Geology majors should consider taking GEOL-123.**

### GEOL-108 Precious Drops: The Geology of Groundwater and Fossil Fuels
**Not Scheduled for This Year. Credits: 4**
Are we running out of drinking water? Is fracking safe? When is peak oil? This course is a basic geology course that focuses on two earth materials we use every day: fresh water and fossil fuels. We cover where groundwater is found and why, the depletion and contamination of groundwater, and some major aquifers. We will also explore the formation, worldwide distribution, and extraction of coal, oil, and natural gas. This course introduces students to physical and historical geology, focusing particularly on plate tectonics and sedimentary basins, with attention to current events and illustrations from around the world.

*Applies to requirement(s): Math Sciences*

*M. Markley*

**Advisory: Potential Environmental Studies and Geology majors should consider taking GEOL-123 concurrently with this course.**

### GEOL-109 History of Life
**Not Scheduled for This Year. Credits: 4**
Life forms have inhabited the surface of our planet for most of its history. Earth, as a result, has a strange geology unlike that of any other known planet. In this course we will examine the interrelations between life processes and Earth’s crust and atmosphere, and how these relationships interact to generate the geology of the planet. By means of hands-on analysis of rocks and fossils, we will study the origin and evolution of life, the diversification of complex life forms, the appearance of large predators, and the causes and consequences of oxygenation of the atmosphere.

*Applies to requirement(s): Math Sciences*

*M. McMenamin*

**Advisory: Potential Environmental Studies and Geology majors should consider taking GEOL-123 concurrently with this course.**

### GEOL-116 Art in Paleontology
**Spring. Credits: 4**
Paleontological art brings ancient organisms back to life. In this course we will consider the role that "PaleoArt" itself plays as a mode of scientific discovery. Beginning with an analysis of the pioneering paleoart of Charles R. Knight, we will examine how paleoartists have uncovered key information about prehistoric life well in advance of its recognition by the scientific community. In a collaborative class project, we will identify the best and most representative works for a possible display somewhere on campus. For individual final class projects, students may choose between a research paper and presentation, and their own paleontological artwork in any visual medium. For the latter, students will be able to utilize resources of the Fimbel Maker and Innovation Lab.

*Applies to requirement(s): Math Sciences*

*Other Attribute(s): Speaking-Intensive, Writing-Intensive*

*M. McMenamin*

### GEOL-123 Methods in Earth Science
**Not Scheduled for This Year. Credits: 2**
This course provides a hands-on introduction to earth science and methods in geology. Students will learn the fundamental tools of the trade and explore local geology. Interactive laboratory work will include projects on groundwater contamination, landfill siting, geologic hazards, and earth materials. Students will also develop skills in reading topographic and geologic maps.

*Applies to requirement(s): Meets No Distribution Requirement*

*The department*

**Advisory: This is an excellent stand-alone introduction to the geosciences, and also works very well if taken concurrently with any 100-level geology course.**
GEOL-126 The Cambrian Explosion
Fall. Credits: 4
The origin of animals was arguably the most important event in earth history. In this course we will review the history of earth, learn basic geology, and then examine the problem of the origin of animals by studying Mount Holyoke College’s superb and unique collection of Proterozoic and Cambrian fossils. The emergence of animals has been called the Cambrian explosion. We will examine what this means for our understanding of evolution as we evaluate hypotheses proposed to explain the relatively sudden appearance of more than half of known animal phyla during the Cambrian event.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive, Writing-Intensive
M. McMenamin

GEOL-131 Introduction to Hydrology: A Data Perspective
Not Scheduled for This Year. Credits: 4
Understanding hydrology (the distribution and movement of water at the earth’s surface) is critical for resource management and climate modeling. With an eye toward these applications, we will use observational data to explore the components of the water cycle (precipitation, evapotranspiration, soil moisture, and streamflow) and the physical processes that govern them. Lectures and hands-on computer exercises are aimed at students with interests in earth and environmental science or data science. No previous experience is necessary. Students will receive an introduction to statistics, computer programming, data visualization techniques, and available environmental data sources.
Applies to requirement(s): Math Sciences
The department

GEOL-133 Mass Extinction, Dinosaurs and Ecological Recovery
Spring. Credits: 4
Beginning in Precambrian time over a half billion years ago, mass extinctions have periodically decimated earth’s biota and left the biosphere in ruins. For example, both the Permo-Triassic and the End-Cretaceous mass extinctions reshaped life on earth and initiated new geological eras. In this course we will examine why mass extinctions occur and study the ways in which the biosphere recovers from mass extinction events. We will also evaluate the claim that we humans are causing a mass extinction and examine proposals regarding the steps we might take to hasten biospheric recovery.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive, Writing-Intensive
M. McMenamin
Prereq: Any one course in biology, chemistry, environmental studies, geology, or physics.

GEOL-137 Dinosaurs
Fall. Credits: 4
The first dinosaur fossils to be recognized in North America, footprints of the creatures, were found in South Hadley. The very first dinosaur species described by a woman researcher, and one of the most ancient dinosaur species in the United States (Podokesaurus holyokensis), was discovered close to the Mount Holyoke campus. In this course we will learn the main types of non-avian dinosaurs, compare them to other ancient and modern vertebrates, assess their relationship to birds, debate their physiology (cold-blooded or warm blooded?), examine the ecology of the world they inhabited, and by means of field work, rock drilling and excavation, resume the search for a new specimen of Podokesaurus. To complete the final project, students will select a dinosaur species and study its geological age, geographic distribution, environmental preferences, ecological roles, feeding and reproductive strategies, and body form as they review the history of attempts to reconstruct their adopted dinosaur.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive
M. McMenamin

GEOL-141 Making the Past: Geosciences in the Makerspace
Not Scheduled for This Year. Credits: 4
The great German paleontologist Dolf Seilacher once remarked that "drawing enforces careful observation." As a consequence, Seilacher drew all of the illustrations for his influential scientific publications. Taking Seilacher’s insight into three dimensions, in this course we will utilize Mount Holyoke’s Makerspace to reconstruct ancient organisms. Studies have shown that well-crafted reconstructions of ancient creatures contribute substantially to improved scientific interpretation of their functional morphology, behavior and paleoecological role(s). We will use Makerspace resources, Pixologic’s Sculptris, 3D printing and other tools to improve our understanding of the morphologies and activities of ancient organisms, while gleaning information derived from the rock record to analyze their ancient morphologies and behaviors.
Applies to requirement(s): Math Sciences
M. McMenamin

GEOL-201 Rocks and Minerals
Fall. Credits: 4
In this course you will learn to recognize the common rock-forming minerals and principal rock types, and to understand their origins, properties, associations, and geological significance. Observational skills and hand sample identification will be emphasized in lab.
Applies to requirement(s): Math Sciences
S. Dunn
Coreq: GEOL-201L.
Advisory: Students must have either a one-year high school earth science class or any 100- or 200-level geology course or GEOG-107.
GEOL-202 History of Earth
Spring. Credits: 4
This course explores the evolution and interaction of life, rocks, oceans, and air during the past 4 billion years of earth history. Some topics covered are: the geologic time scale, significant events in earth history, ice ages and greenhouse atmospheres, continental drift, extinctions and radiations of flora and fauna, the geology of the anthropocene, and absolute and relative dating of rocks. Oral presentations and writing assignments focus on the design and testing of earth science hypotheses, critical analysis of recently published research on earth history, and proposal writing.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive, Writing-Intensive
M. Markley
Prereq: One 100-level Geology course.

GEOL-203 The Earth's Surface
Fall. Credits: 4
The surface of the Earth is a history book of past environmental change. Every hill and valley, every erosional feature and every deposit is the result of processes acting at the Earth's surface. In this course we study these processes (e.g. glaciers, rivers, slopes, coastlines, and regions, frozen ground, cave formation, soil development and groundwater) to understand how they work and to understand the resulting landforms and deposits. With this understanding we can then observe different landforms and deposits and infer past processes (i.e. environments of deposition). Field work and trips allow students to explore first-hand the processes that have created and modified the Earth's surface.
Applies to requirement(s): Math Sciences
A. Werner
Prereq: One 100-level Geology course. Coreq: GEOL-203L.

GEOL-210 Plate Tectonics
Not Scheduled for This Year. Credits: 4
Plate tectonic theory explains the origins of volcanoes and earthquakes, continental drift, and the locations of mountain belts and oceans. This course focuses on the geometry of plate tectonics. Topics include mid-ocean ridge systems, transform faults, subduction zones, relative plate motion, earthquake analysis, triple point junctions, and stereographic projection. Work includes individual research projects on active plate boundaries.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive, Writing-Intensive
M. Markley
Prereq: Any 100-level Geology course.
Advisory: Comfort with geometry and trigonometry required.

GEOL-211 Uranium
Spring. Credits: 4
From the A-bomb to zircon, uranium has revolutionized humanity's destructive potential and wisdom about time. Uranium is the planet's heaviest naturally occurring element, and it transforms by both radioactive decay and nuclear fission. This course uses computer modeling to explore these two transformations and what we make of them, specifically: the age of the earth, high-precision dating of recent geologic and climate events, nuclear power, nuclear weapons, and radiation and health. Writing and reading assignments focus on science communication for a general audience.
Applies to requirement(s): Math Sciences
M. Markley
Prereq: One course in Chemistry, Geology, Math, or Statistics.

GEOL-224 Sedimentary Geology
Not Scheduled for This Year. Credits: 4
Sedimentary rocks provide us with repositories of fresh water, hydrocarbons, and other critical raw materials, as well as geological evidence for the history of planet earth. This course will introduce students to the study of sedimentary rocks and their environments of deposition, with a focus on the varied processes of sediment accumulation. We will employ the principles of stratigraphic analysis and correlation to interpret ancient environments, paleoclimate, and paleogeography, and use these tools to probe the characteristics of sedimentary basins. Field trips will introduce a variety of analytical techniques used to study sedimentary rocks.
Applies to requirement(s): Math Sciences
M. McMenamin
Prereq: Any one course in biology, chemistry, environmental studies, geology, or physics.

GEOL-227 Groundwater Geology
Not Scheduled for This Year. Credits: 4
The demand for and the contamination of groundwater resources are major environmental concerns. To better understand the dynamics of the groundwater system, we will cover topics including the hydrologic cycle, surface and subsurface hydrology, groundwater resource evaluation, and groundwater contamination.
Applies to requirement(s): Math Sciences
A. Werner
Prereq: One Geology course or ENVST-200. Coreq: GEOL-227L.

GEOL-240 Geological Resources and the Environment
Not Scheduled for This Year. Credits: 4
This course surveys the geology and exploitation of important mineral deposits and energy resources. We will discuss factors that govern the economics of their production and the environmental implications of their extraction and use.
Applies to requirement(s): Math Sciences
S. Dunn

GEOL-295 Independent Study
Fall and Spring. Credits: 1 - 4
The department
Instructor permission required.

GEOL-322 Igneous and Metamorphic Petrology
Not Scheduled for This Year. Credits: 4
This course covers mineralogical and chemical compositions, classification, genesis, and mode of occurrence of igneous and metamorphic rocks, including relationships between rock-forming processes and global plate tectonics; labs involve the study of representative rock suites in hand specimen and thin section, introduction to analytical techniques and in-depth coverage of mineral optics.
Applies to requirement(s): Math Sciences
S. Dunn
Prereq: GEOL-201 and CHEM-150. CHEM-150 may be taken concurrently. Coreq: GEOL-322L.
GEOL-326 Seminar: Global Climate Change
Not Scheduled for This Year. Credits: 4
Earth's dynamic climate system is rapidly changing. This course will introduce you to the science behind climate change predictions as they apply to past, present, and future changes in our earth's climate. We will also discuss how, over the course of time, we adapted to these changing conditions with a specific focus on water resources and natural disasters, including floods, droughts, and hurricanes that have been predicted to intensify in response to ongoing climate change.
Applies to requirement(s): Meets No Distribution Requirement
The department
Prereq: One Geology or Environmental Studies course at the 200-level.

GEOL-333 Structural Geology and Orogenesis
Fall. Credits: 4
This course covers the basic techniques of field geology and structural analysis. Lectures concentrate on field techniques, stress, strain, faulting, folding, rock strength, deformation mechanisms, and multidisciplinary approaches to mountain building (orogenesis). Many labs are field trips that involve data collection. Weekly writing assignments focus on presenting original research and distinguishing between observations and interpretations.
Applies to requirement(s): Math Sciences
M. Markley
Prereq: GEOL-123 and GEOL-201. GEOL-201 may be taken concurrently. Coreq: GEOL-333L.

GEOL-342 Seminar in Geology
Seminars offer directed study and discussion of one or more selected topics in geology. Topics vary from year to year. Consult the department for information about future seminars.

GEOL-342DV Seminar in Geology: 'Death Valley Field Course'
Spring. Credits: 4
This seminar will cover selected topics on the geology of Death Valley region, California. We will meet for two hours per week up until spring break, then embark on a nine-day field trip to Death Valley National Park, March 2021. A participation fee is required. Students will be responsible for researching particular topics and presenting a final report.
Applies to requirement(s): Meets No Distribution Requirement
S. Dunn
Instructor permission required.
Prereq: Two geology courses.

GEOL-342HY Seminar in Geology: 'Geology and Hydrology Underfoot'
Not Scheduled for This Year. Credits: 4
To avoid the worst of climate change we must wean ourselves from fossil fuels and develop and use more sustainable methods of heating and cooling. Is it possible to replace our central heating plant with heat from earth? What are the rocks that underlie campus and how does ground water move through them? In this course we will learn about the geology of the Connecticut Valley to better understand the geology under our campus. Using borehole geophysical and temperature data collected from a deep well on campus, we will correlate the borehole stratigraphy with the regional valley stratigraphy and we will assess the hydrology and geothermal potential of the geology beneath campus.
Applies to requirement(s): Math Sciences
M. Markley, A. Werner
Prereq: One of the following: GEOL-201, GEOL-202, GEOL-203, GEOL-224, GEOL-247, ENVST-200. Coreq: GEOL-342HYL.

GEOL-342PE Seminar in Geology: 'Plastics in the Environment'
Not Scheduled for This Year. Credits: 4
Plastics are a part of everyday life. They are inexpensive, lightweight, last forever, and are accumulating in the environment. Macro-plastics are killing whales and micro-plastics are ingested by plankton. Studies have found micro-plastics in remote areas of the planet and in rainwater indicating wide-scale atmospheric transport and deposition. This seminar is aimed at understanding plastics as a material, how they are used, the ways they enter the environment, the ecological and health impacts and potential solutions to the problem. There will be weekly readings with faculty or student-led discussions. A term paper on a plastics topic of your choice will culminate the course.
Applies to requirement(s): Math Sciences
Other Attribute(s): Speaking-Intensive, Writing-Intensive
A. Werner
Prereq: 8 credits in the sciences.

GEOL-343 Applied Environmental Geology
Not Scheduled for This Year. Credits: 4
This field-based course focuses on assessing the environmental impact of applied road salt in two local hill towns. Each week we will leave campus to collect snow and water samples along the main road corridors for subsequent lab analysis. Because this course is all about road salt and snow we will brave the coldest and snowiest conditions to collect our samples. Each student will pursue their own independent research project but will work collaboratively with other students in the class.
Crosslisted as: ENVST-343
Applies to requirement(s): Math Sciences
Other Attribute(s): Community-Based Learning
A. Werner
Prereq: GEOG-203 or ENVST-200. Coreq: GEOL-343L.
Advisory: Warm clothes and a good attitude are the main prerequisites for this course.

GEOL-395 Independent Study
Fall and Spring. Credits: 1 - 8
The department
Instructor permission required.

GEOL-399 Getting Ahead in Geology and Geography
Not Scheduled for This Year. Credits: 1
This course provides mentoring for geology and geography majors as they pursue internships, summer jobs, independent research, graduate study, and careers. Experiences include: resume and communication workshops; self-reflection and sharing opportunities for students returning from internships, work experiences, and semesters abroad; guidance on preparing for, selecting, and applying to graduate school; and unconditional support for career exploration.
Crosslisted as: GEOG-399
Applies to requirement(s): Meets No Distribution Requirement
M. Markley
Restrictions: This course is limited to Geography and Geology majors and minors
Notes: Repeatable. Credit/no credit grading. Course meets on Fridays after Earth Adventures.