Geology

Degrees Offered

• Master of Science
• Doctor of Philosophy

Nature of the Program

The graduate program in geology provides study opportunities in the following areas:

• Hydrogeology and environmental geology with strengths in ground water flow and modeling; aqueous, contaminant and isotope geochemistry; mine reclamation; and floods and debris flows
• Basin analysis and sedimentary geology with strengths in seismic modeling, basin structures, deposition analysis, sequence stratigraphy, biostratigraphy, diagenesis, and plate tectonics
• Energy geology and geophysics with strengths in the exploration and development of oil, gas, and coal; and environmental impacts of fossil fuel usages
• Paleobiology and paleontology with strengths in macroevolution, paleoecology, and phylogenetics, particularly in relation to arthropods and mass extinctions
• Igneous petrology and volcanology with strengths in arc magmatism and the emplacement of lava flows and pyroclastic currents
• Computational and geochemical analysis

Tracks within the Masters Degree

The Research Track requires student to complete independent scholarly research culminating in a thesis. This track is intended for students interested in a more-traditional research-based graduate degree.

The Professional Studies Track requires students to complete a Professional Development credits/tasks in place of thesis-based research. This track is intended for students looking to obtain additional knowledge and skills for their professional careers in Energy Geology or Environmental Geology.

FACULTY

CHAIR
• Timothy Carr - Ph.D. (Univ. of Wisconsin-Madison)

ASSOCIATE CHAIR FOR GEOLOGY
• Jaime Toro - Ph.D. (Stanford Univ.)

PROFESSORS
• Timothy Carr - Ph.D. (Univ. of Wisconsin-Madison)
  Sedimentology, Petroleum Geology
• Kathleen Benison - Ph.D. (Univ. of Kansas)
  Sedimentology, Stratigraphy, Evaporites
• Dengliang Gao - Ph.D. (Duke Univ.)
  Geophysics, Petroleum
• Jaime Toro - Ph.D. (Stanford Univ.)
  Structural Geology, Tectonics, Energy
• Dorothy Vesper - Ph.D. (Penn State Univ.)
  Geochemistry, karst, hydrogeochemistry
• Timothy Warner - Ph.D. (Purdue Univ.)
  Remote Sensing

ASSOCIATE PROFESSORS
• Shikha Sharma - Ph.D. (Univ. of Lucknow, India)
  Isotope Geochemistry, Biogeochemistry, Energy
• Amy Weislogel - Ph.D. (Stanford Univ.)
  Stratigraphy, Sedimentology, Energy
ASSISTANT PROFESSORS

- Graham Andrews - Ph.D. (Univ. of Leicester)  
  Igneous Petrology
- James Lamsdell - Ph.D. (Univ. of Kansas)  
  Paleobiology, Paleoecology, Macroevolution
- Chris Russinello - Ph.D. (Univ. of Delaware)  
  Hydrogeology, coastal processes

TEACHING ASSOCIATE PROFESSOR

- Joseph Lebold - Ph.D. (West Virginia Univ.)  
  Earth Science Education, Stratigraphy, Paleoecology

PROFESSORS EMERITI

- Robert Behling - Ph.D. (Ohio State Univ.)
- Alan Donaldson - Ph.D. (Pennsylvania State Univ.)
- Joe Donovan - Ph.D. (Penn State)
- Thomas Kammer - Ph.D. (Indiana Univ.)
- J Steven Kite - Ph.D. (Univ. of Wisconsin-Madison)
- Henry Rauch - Ph.D. (Pennsylvania State Univ.)
- John (Jack) Renton - Ph.D. (West Virginia Univ.)
- Robert Shumaker - Ph.D. (Cornell Univ.)
- Richard Smosna - Ph.D. (Univ. of Illinois)
- Thomas Wilson - Ph.D. (West Virginia Univ.)

Admissions

PROCEDURES AND PREREQUISITES

Applicants seeking admission and financial support for the fall semester should apply by February 1. For spring semester, apply by October 1.

GRADUATE ADMISSION REQUIREMENTS FOR ALL GRADUATE PROGRAMS

- Transcripts from all universities attended
- An undergraduate GPA of 3.0 or higher
- Scores of the Graduate Record Examination
- A minimum of two letters of reference (3 preferred)
- Statement of goals. MS applicants must identify their intended Track (Research or Professional Studies)
- International students must fulfill the English Language Proficiency requirements of WVU (https://graduateadmissions.wvu.edu/information-for/international-students).

ADDITIONAL ADMISSION REQUIREMENTS FOR THE MASTERS PROGRAM WITH A PROFESSIONAL STUDIES TRACK

- B.A. or B.S. degree in a STEM or relevant field that includes course work in general physics, chemistry, and calculus. Completed coursework in geology is preferred

ADDITIONAL ADMISSION REQUIREMENTS FOR THE MASTERS PROGRAM WITH A RESEARCH TRACK

Students seeking admission to the M.S. program with a Research Track must complete the equivalents of the geology and allied science and mathematics courses required for the B.S. in Geology at WVU:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 284</td>
<td>Mineralogy</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 285</td>
<td>Introductory Petrology</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 311</td>
<td>Stratigraphy and Sedimentation</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 341</td>
<td>Structural Geology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 404</td>
<td>Geology Field Camp</td>
<td>6</td>
</tr>
<tr>
<td>MATH 155</td>
<td>Calculus 1</td>
<td>4</td>
</tr>
<tr>
<td>MATH 156</td>
<td>Calculus 2</td>
<td>4</td>
</tr>
</tbody>
</table>

At least 4 courses for the following 3 subject areas:
Similar courses from other universities or relevant experiences may be substituted if approved during admission review. A requirement may be waived by the committee if the student can demonstrate competence in that subject area.

Master of Science

Degree Requirements

- **Completed Plan of Study**
- **Credit Hours:** Students are required to complete a minimum of 32 graduate credit hours at the 400, 500 or 600 level
- **Grade Point Average:** Students must earn minimum overall GPA of a 3.0 and a minimum GPA of 3.0 in coursework applied to their graduate program.
- **Degree Requirements:**
  - Complete a plan of study
  - Complete 24 formal (graded) course credit-hours
  - At least 15 of the 24-required formal course credits taken from GEOL and GEOG
  - Courses outside of GEOL and GEOG to be approved by the student's advisor unless they are on the approved list of outside courses
- **Completion Requirements:** students must select a completion track for a total of 8 credits. Available tracks are the
  - Research track: students must complete a Master's thesis including:
    - Thesis Proposal Defense
    - Thesis Defense
  - Professional studies track: students have the option of completing an internship, completing a project with a faculty member, taking the ASBOG Fundamental exam (first step in professional licensure), additional coursework, or a combination of these options.

CURRICULUM REQUIREMENTS

**Core Requirements**

- Any GEOL courses at the 400, 500 or 600 level*

**Electives**

- Select three courses from the list below:
  - Any additional GEOL courses at the 400, 500 or 600 level**
  - AEM 401 Environmental Microbiology
  - AGRN 417 Soil Genesis and Classification
  - AGRN 455 Reclamation of Disturbed Soils
  - AGRN 552 Pedology
  - ENVP 460 Environmental Impact Assessment
  - ENVP 515 Hazardous Waste Training
  - ENVP 555 Environmental Sampling and Analysis
  - FHYD 444 Watershed Management
  - FHYD 644 Watershed Management & Landuse Hydrology
  - PNGE 632 Reservoir Simulation and Modeling
  - PNGE 735 Advanced Formation Evaluation
  - RESM 444 Advanced GIS for Natural Resource Management
  - RESM 441 Introduction Geographic Information Systems Natural Science
  - RESM 480 Environmental Regulation
  - RESM 540 Geospatial Modeling
  - RESM 545 Spatial Hydrology and Watershed Analysis
  - STAT 511 Statistical Methods 1

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*Any GEOL courses at the 400, 500 or 600 level*

**Any additional GEOL courses at the 400, 500 or 600 level**
**GRADUATION TRACK**

Select one track:

**Research Track:**
- GEOL 697 Research
- GEOL 699 Graduate Colloquium

**Professional Studies Track:**

Core Courses:

Select one option or a combination of options below:
- GEOL 682 Masters: Professional Studies Track Cohort Seminar (taken first semester in program)
- GEOL 699 Graduate Colloquium

**Internship:**
- GEOL 681 Grad Internship in Geology

**Project:**
- GEOL 680 Masters Project Research

**Professional Licensure:**
- Any GEOL course(s) at the 400, 500 or 600 level

Total Hours: 32

* no more than 40% of courses may be at the 400 level (WVU requirement)

** Except GEOL 594, 680, 681, 694, 697.

**Doctor of Philosophy**

**Degree Requirements**

- **Credit Hours:** Students are required to complete a minimum number of nine credit hours of formal coursework at the 400, 500, 600 or 700 level. Additionally, students will complete a minimum of 10 additional credits in research, colloquium, and seminar.

- **Grade Point Average:** Students must maintain a minimum GPA of 3.0 overall and in the major.

**Curriculum Requirements**

**Core Courses:**
- GEOL 699 Graduate Colloquium (1 credit, taken twice)
- GEOL 697 Research (at least 6 credits)
- GEOL 799 Graduate Colloquium (1 credit, taken twice)

**Formal Coursework**

Graduate coursework at the 400, 500, 600 or 700 level

Total Hours: 19

* Excludes GEOL 600, 697, 698, 700, 797, and 798. Courses will be selected in consultation with an advisor.

**Degree Progress - Masters**

- Students whose GPA falls below 3.0 will be put on probation for one semester. If they remain below 3.0 for a second semester, they are dismissed from the program.
- Withdrawing from classes is only permitted with the permission of the student's advisor or the Geology Graduate Program Committee.
- Students must complete annual progress reports (see graduate handbook for details)
- For students completing the Research track, deadlines are below: (for January starting students)
  a. Proposal defense:
• Target date: May 1-Year 2 (August 1-Year 2);
• Probation date: August 1-Year 1 (December 1-Year 1);
• Funding termination date: May 1-Year 2 (August 1-Year 2)

b. Thesis defense:
• Target date: May 1-Year 2 (August 1-Year 2);
• Probation date: May 1-Year 2 (August 1-Year 2)

Degree Progress - Ph.D.

• Students whose GPA falls below 3.0 will be put on probation for one semester. If they remain below 3.0 for a second semester, they are dismissed from the program.
• Withdrawing from classes is only permitted with the permission of the student's advisor or the Geology Graduate Program Committee.
• Students must complete annual progress reports (see graduate handbook for details).
• Deadlines are below: (for January starting students)

a. Preliminary Exam:
• Target date: May 1-Year 1 (December 1-Year 1);
• Dismissal date (re-takes only): August 1-Year 1 (December 1-Year 2)

b. Proposal/Comprehensive (Candidacy) Exam:
• Target date: May 1-Year 2 (December 1-Year 2);
• Probation date: December 1-Year 3 (May 1-Year 3):
• Funding termination date: May 1-Year 3 (December 1-Year 3)

c. Dissertation Defense
• Target date: May-Year 4 (December-Year 4)

Major Learning Outcomes

GEOLOGY

Students obtaining a masters in Geology with a Research Track will be able to:

• Communicate geologic concepts orally and in writing
• Apply research skills to analyze geologic questions
• Propose, produce and defend original research in their field of study
• Explain geologic principles as they relate to their area of research

Students obtaining a masters in Geology with a Professional Studies Track will be able to:

• Communicate geologic concepts orally and in writing
• Demonstrate knowledge in either energy geology or environmental geology
• Apply geological knowledge and methods to (1) find, develop and produce energy resources particularly natural gas, natural gas liquids and oil; OR, (2) to assess environmental issues

Students obtaining a doctorate in geology degree will be able to:

• Communicate geologic concepts orally and in writing
• Apply research skills to analyze geologic questions
• Propose, produce and defend original research of publishable quality
• Explain geologic principles as they relate to their area of research
• Effectively communicate the state of knowledge in their research area
• Identify research questions in geology
• Critique and assess peer-reviewed literature
COURSES

GEOL 510. Computer Aided Subsurface Interpretations. 3 Hours.
PR: GEOL 311 and GEOL 341. Develop subsurface interpretations from integrated geological, geophysical and engineering databases in a computer workstation environment. Construct maps and 3D visualizations of subsurface structure, seismic horizons, layer properties, etc., for prospect location and subsurface assessment.

GEOL 511A. Sedimentary Geology in Ireland - Travel. 1 Hour.
Travel portion of GEOL 511. See GEOL 511 for description.

GEOL 522. Surficial and Glacial Geology. 3 Hours.
PR: GEOL 321 or GEOG 321 or consent. Analysis of late Cenozoic landscapes, especially those caused by glaciers or otherwise influenced by global climate change. Required weekend field trips at student’s expense. (Also listed as GEOG 522.)

GEOL 525. Problems in Geomorphology. 4 Hours.

GEOL 543. Tectonics. 3 Hours.
PR: GEOL 341 and GEOL 311; undergraduates need Consent. Investigation of patterns and processes of large-scale deformation mechanisms that shape the earth. Focuses on the structural evolution and modeling process of various plate boundaries.

GEOL 556. 3-D Seismic Visualization. 3 Hours.
This course focuses on the application of 3-D seismic data visualization and interpretation technologies to the characterization of subsurface structure, facies, and reservoirs, with particular reference to hydrocarbon exploration and CO2 sequestration.

GEOL 558. Seismic Attribute. 3 Hours.
PR: GEOL 341 and GEOL 311 and MATH 155. The effective seismic attribute technologies and attribute interpretation workflows, their application to the characterization of subsurface structures, facies, and reservoir properties, with particular reference to hydrocarbon exploration and CO2 sequestration.

GEOL 562. Quantitative Hydrogeology. 3 Hours.
PR: MATH 156 or GEOL 351 and GEOL 463 or Consent. Mathematical and computer analysis of groundwater flow, aquifer systems, radial-flow solutions; well/aquifer test methods; superposition, boundaries; dispersive/advective transport.

GEOL 564. Environmental Hydrogeology. 4 Hours.
PR: GEOL 101 and GEOL 102 and GEOL 463 and (PR or CONC: GEOL 562). Seminar reviewing groundwater occurrence, flow, quality, and exploration in various geologic terrains; groundwater pollution and dewatering; and groundwater technology. Includes topical literature review.

GEOL 575. Imperial Barrel Competition. 3 Hours.
The students will participate in the Imperial Barrel Award competition sponsored by the American Association of Petroleum Geologists (AAPG). They will evaluate a real-world petroleum basin using industry seismic and well data and will make a presentation to a panel of professional judges recommending an exploration strategy. Travel to the regional and national AAPG meeting may be required.

GEOL 579. Applied Petroleum Geoscience. 3 Hours.
Students work in teams to conduct integrated characterization of a petroleum reservoir, develop numerical simulation, consider technical options, perform economic analyses and make a final report to the company/organization.

GEOL 580. Organic Contaminant Geochemistry. 3 Hours.
This course focuses on fundamental chemical properties and structures of organic contaminants that control their functionality, fate, and transport in the environment. Natural organic matter and inorganic phases are discussed relative to contaminant mobility.

GEOL 585. Optical Mineralogy and Petrology. 3 Hours.
PR: GEOL 285. Introduction to the optical properties of minerals and the use of the petrographic microscope. Interpretation of sedimentary, igneous, and metamorphic rocks based on microscopic examination of thin sections. (Offered alternate years.)

GEOL 586. Advanced Isotope Geochemistry. 3 Hours.
PR: GEOL 486. Advance the understanding of isotopic systems by comprehensive discussion of selected research publications. Laboratory exercises will provide hands-on training in stable isotope measurement techniques. Study topics will focus on use of isotopes to address research questions in variety of fields, including geology, biology, forensics, environmental sciences and energy.

GEOL 588. Aqueous Geochemistry. 3 Hours.
PR: GEOL 101 and CHEM 112 or CHEM 116, or Consent. Review of basic chemical principles as they apply to aqueous geochemical environments. Properties of water and the types, sources, and controls of the common and environmentally significant chemical species dissolved in water.

GEOL 591. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

GEOL 593. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

GEOL 594. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.
GEOL 610. Advanced Stratigraphy. 3 Hours.

GEOL 615. Advanced Stratigraphic Methods. 3 Hours.
Advanced discussion of stratigraphic correlation techniques, including sequence stratigraphy, to analyze deposition of clastic and carbonate sediments, with emphasis on assessing porosity development in sandstones and limestones, organic matter deposition, and flow of fluids, such as water, gas and oil, through rock.

GEOL 616. Advanced Sedimentation. 4 Hours.
PR: GEOL 311 or Consent. Origin of sedimentary rocks; principles involved in interpretation of ancient geography, climates, animals, and plants. Emphasis on detrital sediments and rocks.

GEOL 621. Advanced Fluvial Geomorphology. 4 Hours.
PR: GEOL 321 or GEOG 321 or Consent. Analysis of stream processes, landforms, deposits, including paleohydrology and Appalachian surficial geology. (Required weekend field trips at student's expense; also listed as GEOG 521.).

GEOL 632. Paleocology. 3 Hours.
PR: GEOL 331 and GEOL 311 or Consent. Methods of paleoecologic analysis in sedimentary geology. Topics include trace fossil analysis, shell biogeochemistry, community paleoecology, biofacies analysis of basins, and Precambrian paleoecology.

GEOL 642. Advanced Structural Geology. 3 Hours.
PR: GEOL 341. Theoretical and observational aspects of the development of geological structures. Problems ranging from the microstructural to the orogenic scale will be addressed.

GEOL 645. Basin Analysis. 3 Hours.
PR: GEOL 341 and GEOL 311 or equivalent. The origin, development, and distribution of basins and the structure found within basins throughout the world are studied. The techniques used for investigating basin evolution are emphasized. The effects of basin processes on the occurrence of energy resources are addressed.

GEOL 655. Remote Sensing Principles. 3 Hours.
Mapping of earth features using aerial and satellite-borne sensors, image enhancement, geo-referencing, and classification. (Also listed as GEOG 655.).

GEOL 659. Quantitative Methods in Geoscience. 3 Hours.
PR: STAT 312 or STAT 511 or Consent. Brief review and introduction to multivariate quantitative techniques as applied to geology and geography.

GEOL 665. Groundwater Modeling. 4 Hours.
PR: GEOL 562 or Consent. Theory and application of groundwater flow modeling, focusing on MODFLOW; numerical methods; discretization and boundaries; parameterization and calibration; problems and case histories.

GEOL 666. Karst Geology. 3 Hours.
PR: Consent. Review of karst terrain hydrogeology and geomorphology, emphasizing origins and nature of caves, sinkholes and other karst landforms, environmental problems of karst, and its water and mineral/petroleum resources.

GEOL 680. Masters Project Research. 1-5 Hours.
Planning and presentation of a professional project, including proposal, work plan execution, and project report. Status reports and timeline planning. Must be taken in two consecutive semesters, totaling to 6 credits.

GEOL 681. Grad Internship in Geology. 1-6 Hours.
PR: Be enrolled in the Geology MS with a Professional Studies AOE and consent. To obtain practical work experience in a professional setting while obtaining skills and knowledge as a geologist.

GEOL 682. Masters: Professional Studies Track Cohort Seminar. 1 Hour.
PR: Registered students in the Geology MS: Professional Studies Track. This seminar will provide graduate students with the information, tools and resources needed to succeed in the Masters of Geology Professional Studies Track.

GEOL 690. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of geology. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It also provides a mechanism for students not on assistantships to gain teaching experience. (Grading will be P/F.).

GEOL 691. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

GEOL 692. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

GEOL 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

GEOL 694. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

GEOL 695. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.
GEOL 697. Research. 1-15 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U.).

GEOL 698. Thesis or Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision during the writing of student reports (698), or dissertations (798). Grading is normal.

GEOL 699. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking course work credit, but who wish to meet residence requirements, use the University facilities and participate in its academic and cultural programs. NOTE: Graduate students not actively involved in course work or research or enrolled, through enrollment in his/her departments Graduate Colloquium, to consult with graduate faculty, participate in both formal and informal academic activities sponsored by his/her program and retain all of the rights and privileges of duly enrolled students. Grading is P/F; colloquium credit may not be counted against credit requirements for master's programs.

GEOL 755. Advanced Remote Sensing. 3 Hours.
PR: GEOG 655 or GEOL 655 or consent. Collection, processing and classification of remotely sensed data, including optical, thermal, radar, and topographic information. (2 hour lecture, 1 hour laboratory.) (Also listed as GEOG 755.).

GEOL 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of geology. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be P/F.).

GEOL 791. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

GEOL 794. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

GEOL 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

GEOL 796. Graduate Seminar. 1 Hour.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

GEOL 798. Thesis or Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision during the writing of student reports (698), or dissertations (798). Grading is normal.

GEOL 799. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use of the University's facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department's 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is P/F; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

GEOL 930. Professional Development. 1-6 Hours.
Professional development courses provide skill renewal or enhancement in a professional field or content area (e.g., education, community health, geology). These tuition-waived continuing education courses are graded on a pass/fail grading scale and do not apply as graduate credit toward a degree program.

GEOL P101. . 3 Hours.
GEOL P102. . 1 Hour.
GEOL P103. . 3 Hours.
GEOL P104. . 1 Hour.
GEOL P105. . 3 Hours.