

# GEOLOGICAL SCIENCES

## Undergraduate Program Information

A degree in geology leads to a wide variety of career choices. Students can access careers in the geosciences through one of three concentrations in the BS Geology degree. The first concentration is Geological Sciences. This is a traditional geology curriculum, in which students take geology classes, augmented with calculus, physics, and chemistry; this concentration leads to graduate study in the geosciences and careers in industry, academia, government, and policy. The second concentration is Earth and Environmental Systems. Students take geology classes, augmented with a variety of environmental, economic, and political classes; this concentration leads to careers in the environmental industry. The third concentration is Earth Science Education. Students take geology and education classes, and are certified to teach science at New Mexico middle and high schools after completing the BS and one year of graduate work in the College of Education.

Students earning the BS in Geology, any concentration, may also earn the Undergraduate Research Certificate in the Department of Geological Sciences. Completion of the Undergraduate Research Certificate includes completion of an undergraduate research project, participation in the department's undergraduate research meetings and one of the following:

1. a senior thesis;
2. a manuscript submitted for a publication; or
3. an oral or poster presentation at a national or regional meeting.

Undergraduate Research Certificates are presented at the department's annual awards ceremony.

### Graduate Program Information

The Department of Geological Sciences offers graduate study leading to the Master of Science degree in geology. The department offers excellent laboratory facilities for research in mineralogy, igneous petrology, geochemistry, stratigraphy, geochronology, and sedimentology. Available are a large, fully equipped rock preparation laboratory, mineral separation laboratory, plus computer, geochemical and petrographic labs. Major equipment includes a Gemini heavy mineral separation table, a class 1000 clean lab, Thermal Ionization Mass Spectrometry (TIMS) and Laser-Ablation Multi-Collector Inductively Coupled Plasma Mass Spectrometry (LA-MC-ICP-MS). The department maintains its own fleet of field vehicles. Also available are computing facilities that include an HP color plotter and GIS system. Financial support is available to graduate students in geology through teaching and research assistantships and scholarships. Inquiries regarding financial aid should be directed to the graduate advisor. Admission to the program is in accord with the general regulations of the Graduate School.

## Degrees for the Department

### Bachelor Degree(s)

- Geology (Earth and Environmental Sciences) - Bachelor of Science (<https://catalogs.nmsu.edu/nmsu/arts-sciences/geological-sciences/geology-earth-environmental-sciences-bachelor-science/>)
- Geology (Earth Science Education) - Bachelor of Science (<https://catalogs.nmsu.edu/nmsu/arts-sciences/geological-sciences/geology-earth-science-education-bachelor-science/>)

- Geology (Geological Sciences) - Bachelor of Science (<https://catalogs.nmsu.edu/nmsu/arts-sciences/geological-sciences/geology-geological-sciences-bachelor-science/>)

### Master Degree(s)

- Geology - Master of Science (<https://catalogs.nmsu.edu/nmsu/graduate-school/geology-master-science/>)

## Minors for the Department

- Geology - Undergraduate Minor (<https://catalogs.nmsu.edu/nmsu/arts-sciences/geological-sciences/geology-undergraduate-minor/>)

### Professor, Nancy J. McMillan, Department Head

**Professors** Amato, McMillan, Ramos; **Associate Professor** Hampton; **Assistant Professor** Thines **Adjunct Professors** K. Davis, J. Witcher; **Emeritus Faculty** Lawton, Mack

*N. J. McMillan, Department Head, Ph.D. (Southern Methodist)– igneous petrology, geochemistry; J. M. Amato, Ph.D. (Stanford)– structural geology, tectonics; F. C. Ramos, Ph.D. (California- Los Angeles)– isotope geochemistry, petrology; B.A. Hampton, Ph.D. (Purdue)- sedimentology, tectonics; J. Thines, Ph.D. (U. Iowa)- volcanology, mineralogy, petrology; T.F. Lawton, Ph.D. (Emeritus) (Arizona)- stratigraphy, basin analysis; G.H. Mack, Ph.D. (Emeritus) (Indiana-Bloomington)- sedimentary petrology, sedimentology.*

## Geology Courses

### GEOL 1110G. Physical Geology

#### 4 Credits (3+3P)

Physical Geology is an introduction to our dynamic Earth introducing students to the materials that make up Earth (rocks and minerals) and the processes that create and modify the features of our planet. The course will help students learn how mountains are formed, how volcanoes erupt, where earthquakes occur, and how water, wind, and ice can shape landscapes. Students will also develop a basic understanding of the ways humans have altered the planet including our impact on natural resources and global climate change.

#### Learning Outcomes

1. Recall, describe or explain geologic vocabulary.
2. Identify or explain aspects of the geologic time scale and compare the uses and limitations of relative and absolute dating.
3. Recognize or explain the evidence used to support the theory of plate tectonics. Describe or identify how plate tectonics is related to the structure and features of the Earth.
4. Describe the formation of, and describe, compare, and classify minerals.
5. Identify or describe the three main rock types, how each forms in the context of the rock cycle and what each indicates about its environment of formation.
6. Recognize or explain the fundamentals of surface and groundwater hydrology and discuss the impact of human activities on water quality and quantity.
7. Describe or discuss the processes that are responsible for specific geologic hazards (e.g., earthquakes, volcanic eruptions, mass movement, flooding, etc.).
8. Recognize or describe the geologic processes involved in the formation and concentration of geologic resources.

### GEOL 1150. Introduction to Rocks and Minerals

#### 3 Credits (2+3P)

This course is an introduction to the characteristics and the formation of the three main types of rocks, the rock-forming minerals, and important ore minerals. An outline of Plate Tectonics will give students the basis to understand how many of these rocks and minerals form. In laboratory exercises, students will gain practice in describing and identifying hand-specimens of the main types of rocks and minerals.

**Prerequisite(s)/Corequisite(s):** GEOL 1110G.

**Learning Outcomes**

1. The student Identify the main rock-forming minerals from each mineral group as demonstrated by scoring a total of 70% or more on the relevant laboratory exercise component. Studying minerals, the student will: Identify the main minerals in hand specimens; Describe the environments in which these minerals form; Identify the rock types in which these minerals are found.
2. The student will understand the structure, composition, and genesis of rocks by identifying the principal igneous, sedimentary, and metamorphic rocks, as demonstrated by scoring a total of 70% or more on the relevant laboratory exercise components.
3. Studying rocks, the student will: Define the principal igneous processes and features, identify the most common igneous rocks and their constituting minerals in hand specimens, and discuss their origin and interpretation; Describe the principles of sedimentary processes and features, identify the most common sedimentary rocks in hand specimens, and discuss their origin and interpretation; Describe the principles of metamorphic processes and features, identify the most common metamorphic rocks and constituting minerals in hand specimens, and discuss their origin and interpretation.

**GEOL 2996. Special Topics**

**1-3 Credits**

Specific subjects to be announced in the Schedule of Classes.

Community Colleges only. May be repeated for a maximum of 12 credits.

**Learning Outcomes**

1. Varies

**GEOL 305V. Fossils and the Evolution of Life**

**3 Credits (3)**

Examination of the fossil record within the context of geologic time.

Special emphasis on critical evaluation of possible terrestrial and extra-terrestrial causes for the evolution of plants and animals and for periods of mass extinction.

**GEOL 310. Mineralogy**

**3 Credits (2+3P)**

Crystallography and the physical and chemical aspects of minerals.

**Prerequisite(s):** GEOL 1110G and CHEM 1215G.

**GEOL 312. Mineralogy and Optics**

**3 Credits (2+3P)**

Principles of crystallography, optical mineralogy, and mineral chemistry as applied to the identification and characterization of rock-forming minerals. May be repeated up to 3 credits.

**Prerequisite(s):** GEOL 1110G and GEOL 1150.

**Learning Outcomes**

1. Students will understand how polarized light interacts with isotropic, uniaxial, and biaxial crystals.
2. Students will be able to recognize optical phenomena resulting from the interaction of polarized light with minerals.
3. Students will become proficient in the recognition of the major rock-forming minerals in thin section.
4. Students will recognize crystal faces according to the Miller Indices.

5. Students will be able to calculate the structural formula of any mineral.

**GEOL 320. Special Topics**

**1-3 Credits**

Specific subjects to be announced in the Schedule of Classes. May be repeated for a maximum of 12 credits.

**GEOL 335V. Earthquakes, Volcanoes, Hurricanes, and Floods: The Role of Natural Hazards in Civ Past and Present**

**3 Credits (3)**

This class will provide an introduction to geologic hazards and natural disasters, their effects on society and the attempts at preparation and mitigation for these events. Hazards to be covered include earthquakes, volcanic eruptions, floods, landslides, hurricanes, tsunamis and others.

**GEOL 353. Geomorphology**

**3 Credits (2+3P)**

Examination of the principal theories and concepts of landform creation; exploration of the roles of structure, processes, climate, and time in the formation of various types of landforms. Cross-listed with GEOG 553 and GEOG 353.

**Learning Outcomes**

1. Outline the basic history of geomorphic theory and research methods.
2. Describe the trends and probable causes of Cenozoic climate change and its links to basic landform processes.
3. Describe the main landform processes including weathering, soil formation, hillslope evolution and associated natural hazards, fluvial processes, arid land processes, glacial/interglacial climates and processes.
4. Integrate field observations into basic landscape evolution reconstructions.
5. Design and implement a fluvial system experiment and analyze the data.

**GEOL 360. General Geochemistry**

**3 Credits (3)**

The chemistry of the earth and its parts, with emphasis on geochemical systems and cycles, distribution of the elements, and mineral equilibria. Crosslisted with: CHEM 360

**Prerequisite(s):** CHEM 1215G or CHEM 1120G.

**GEOL 399. Igneous and Metamorphic Petrology**

**3 Credits (2+3P)**

Mineralogical composition, classification, and genesis of igneous and metamorphic rocks. May be repeated up to 3 credits.

**Prerequisite:** GEOL 312 for geology majors, GEOL 1150 for majors other than geology.

**Learning Outcomes**

1. Students will learn to identify minerals and rocks in hand sample and using the petrographic microscope. Students will be expected to score above 70% on a set of eight laboratory exercises and a laboratory final exam.
2. Students will learn to understand the environments, sources, and processes involved in generating igneous rocks and metamorphic rocks in a range of geologic/tectonic environments.
3. Students will learn to write within the field of geology using Geological Society of America format. A 6-10 page paper will be required and will be graded using the Ramos writing rubric. Revisions will also be required.
4. Students will learn to present in standard GSA format (12 minute oral presentations using Powerpoint). Presentation will be graded

using a rubric that evaluates presentation materials, presentation effectiveness, and presenter skills/behaviors related to their presentations.

#### **GEOL 401. Geology Colloquium**

##### **1 Credit (1)**

Presentations by visiting speakers and students. May be repeated up to 6 credits.

#### **GEOL 420. Stratigraphy and Sedimentology**

##### **3 Credits (2+3P)**

Identification and interpretation of sedimentary rocks with emphasis on classification, deposition, and stratal geometry. May be repeated up to 3 credits.

**Prerequisite:** GEOL 1150.

##### **Learning Outcomes**

1. Recognize patterns associated with physical and chemical weathering and erosion.
2. Identify and classify siliciclastic and chemical sedimentary rock and sediment.
3. Compare and contrast sedimentologic processes recorded in depositional, erosional, deformational, and biogenic sedimentary structures (i.e., facies).
4. Identify specific sedimentary facies associated with specific depositional environments.
5. Delineate between nonmarine, marginal marine, and deep marine environments.
6. Correlate stratigraphic successions and environments along strike and place in a tectonic and basin-scale context.

#### **GEOL 424. Soil Chemistry**

##### **3 Credits (3)**

Same as SOIL 424, CHEM 424.

#### **GEOL 441. Tutorial Geology**

##### **2 Credits (1+3P)**

Participation in teaching lower-division laboratories and conducting tutorial sessions. May be repeated for a total of 4 credits.

**Prerequisite:** junior or above standing and nomination by faculty.

#### **GEOL 442. Zuhl Collection Internship**

##### **1-3 Credits (3-9P)**

Applied experience with the NMSU Zuhl Collection, under supervision of the Zuhl Collection Director. Possible activities include developing displays, giving tours, developing outreach materials, etc. May be repeated up to 6 credits. Consent of Instructor required.

#### **GEOL 444. GIS for Geology**

##### **3 Credits (3)**

Tools-based introduction to using GIS software for solving problems in geology. Emphasis on effectively portraying and analyzing geologic maps. One required field trip. Crosslisted with: GEOG 544.

**Prerequisite(s):** GEOL 470.

#### **GEOL 449. The Geological Profession**

##### **1 Credit (1)**

Outcomes assessment exit exams. For graduating seniors only. May be repeated up to 1 credits.

**Prerequisite(s):** Graduating seniors only.

#### **GEOL 452. Geohydrology**

##### **4 Credits (3+2P)**

Origin, occurrence, and movement of fluids in porous media assessment of aquifer characteristics. Development and conservation of ground

water resources, design of well fields. May be repeated up to 4 credits. Crosslisted with: ENVS 452 and C E 452.

#### **GEOL 455. Undergraduate Research**

##### **1-3 Credits**

Geological research and field projects for the advanced student. May be repeated for a total of 6 credits. May be repeated up to 6 credits. Consent of Instructor required.

**Prerequisite(s):** Consent of instructor.

#### **GEOL 465. Isotope Geochemistry**

##### **3 Credits (3)**

Geochemistry of stable and radiogenic isotopes and its application to a wide range of problems in the earth and planetary sciences.

**Prerequisite(s):** CHEM 1225G, GEOL 360, GEOL 399.

#### **GEOL 470. Structural Geology**

##### **3 Credits (2+3P)**

Deformation of rocks of the earth. May be repeated up to 3 credits.

**Prerequisite:** GEOL 1150.

##### **Learning Outcomes**

1. Describe and analyze features in rocks produced by deformation, such as folds and faults.
2. Describe regional phases of structural geology and their relationship to plate tectonic processes.
3. Describe how understanding of deformational features informs plate tectonic models.
4. Describe how practical knowledge of structural geology is related to all fields of geology.

#### **GEOL 471. Volcanology**

##### **3 Credits (3)**

Identification and interpretation of volcanic deposits (including air fall, ash flow tuffs, surges, lava flows), with focus on how the characteristics of these deposits can reveal eruption styles and eruption dynamics. Other topics covered include: magma migration and storage, volcanic hazards, volcano monitoring and volcanoes and climate. Crosslisted with: GEOL 571.

**Prerequisite(s):** GEOL 399.

#### **GEOL 477. Special Problems**

##### **1-3 Credits**

Selected advanced topics of current interest or importance. May be repeated for a total of 6 credits.

**Prerequisite:** consent of instructor.

#### **GEOL 478. Petroleum Systems and Stratigraphy**

##### **3 Credits (2+3P)**

Sedimentation, stratigraphy, depositional environments, and tectonics in relation to the occurrences and exploration of hydrocarbons. Course includes two off-campus field trips. May be repeated up to 3 credits.

**Prerequisite(s):** GEOL 420.

#### **GEOL 480. Seminar**

##### **1-3 Credits**

Supervised study of a subject not covered by regular courses. For organized group meetings treating selected advanced topics. May be repeated for a maximum of 6 credits.

**Prerequisite:** consent of instructor.

#### **GEOL 482. Zuhl Collection Internship**

##### **1-3 Credits (1-3)**

Applied experience working with the Zuhl Collection of rocks, minerals, fossils, and petrified wood, supervised by the Director of the Zuhl Collection. Activities include tours, display development, research on aspects of the collection, and other work in the museum. May be

repeated up to 6 credits. Consent of Instructor required. Restricted to: GEOL majors.

**GEOL 490. Field Geology**

**3 Credits (9P)**

Mapping, instrumentation, and interpretation of geology in the field.

**Prerequisites:** either GEOL 420 and GEOL 470.

**GEOL 491. Tectonic Evolution of North America**

**3 Credits (3)**

Current ideas regarding the plate-tectonic evolution of North America from Archean through Holocene time, emphasizing the use of regional stratigraphy and structural geology to interpret mountain building, magmatism, and basin development.

**Prerequisites:** GEOL 1110G, GEOL 399, GEOL 420 and GEOL 470.

**GEOL 495. Geology Field Camp**

**4 Credits (12P)**

Three week intensive summer course. Geologic mapping in a site-based setting, emphasizing spatial relations, cross-section construction, and preparation of geologic reports. Prerequisite: GEOL 490

**GEOL 499. Senior Thesis**

**1-3 Credits**

Writing a formal paper describing original geologic research conducted under supervision of a faculty advisor. Restricted to majors.

**Prerequisite:** consent of instructor.

**GEOL 501. Geology Colloquium**

**1 Credit (1)**

Presentations by visiting speakers and graduate students.

**GEOL 520. Selected Topics**

**1-3 Credits (1-3)**

Selected topics in geology. Students must be in graduate standing to enroll. Consent of instructor required. May be repeated up to 99 credits.

**Learning Outcomes**

1. Varies

**GEOL 534. Tectonics of Sedimentary Basins**

**3 Credits (3)**

Origin of sedimentary basins with emphasis on subsidence mechanisms, geometry of basin fill, depositional systems and tectonic setting. Course includes two off-campus field trips. Restricted to: GEOL majors May be repeated up to 3 credits. Prerequisite: .

**Learning Outcomes**

1. To be able to recognize sedimentary basin types in geologic and geomorphic environments.
2. To understand these aspects of sedimentary basins: plate tectonic setting/context, basement to basins (continental vs. oceanic/transitional lithosphere), structure and structural vergence, sedimentologic and stratigraphic signatures in the rock record, depositional systems, and basin-scale provenance.

**GEOL 537. Topics in Volcanology**

**3 Credits (3)**

A seminar-style class exploring volcanic processes. Course topics vary by semester and include: magmatism and volcanism at different tectonic settings (subduction zones, intraplate) and plumbing systems and eruptions of volcanoes (calderas, monogenetic volcanoes).

**GEOL 544. GIS for Geology**

**3 Credits (3)**

Tools-based introduction to using GIS software for solving problems in geology. Emphasis on effectively portraying and analyzing geologic maps.

One required field trip. Taught with: GEOL 444. May be repeated up to 3 credits.

**Learning Outcomes**

1. A tools-based introduction to Geographic Information Systems software, specifically the ArcGIS package developed by ESRI.
2. Hands-on use of GIS software to make maps and analyze datasets that are commonly used by geoscientists.
3. Compiling and analyzing geologic mapping datasets collected from the field and from published literature.
4. Development of an awareness of how to find publicly accessible datasets and solutions to problems beyond the sample exercises presented in class.
5. Application of GIS to solve a problem.

**GEOL 558. Neotectonics**

**3 Credits (3)**

Recognition, measurement, and dating of deformation related to earthquakes in the Quaternary geologic record.

**GEOL 562. Analytical Geochemistry**

**3 Credits (3)**

Techniques used to determine the major element, trace element and isotopic composition of rocks and minerals and the determination of mineral structure.

**GEOL 565. Isotope Geochemistry**

**3 Credits (3)**

Trace element partitioning and isotope systematics applied to problems in petrology and ore genesis.

**GEOL 571. Volcanology**

**3 Credits (3)**

Identification and interpretation of volcanic deposits (including air fall, ash flow tuffs, surges, lava flows), with focus on how the characteristics of these deposits can reveal eruption styles and eruptions dynamics. Other topics covered include: magma migration and storage, volcanic hazards, volcano monitoring and volcanoes and climate. Crosslisted with: GEOL 471.

**GEOL 578. Petroleum Systems and Stratigraphy**

**3 Credits (2+3P)**

Sedimentation, stratigraphy, depositional environments and tectonics in relation to the occurrences and exploration of hydrocarbons. Course includes two off-campus field trips.

**GEOL 582. Plate Tectonics**

**3 Credits (3)**

Plate tectonics as a fundamental model for geological activity on a dynamic earth. Focuses on plate tectonic theory development and mechanisms, plus modern analogs of ancient processes.

**GEOL 585. Geochronology**

**3 Credits (3)**

The principles, analytical methods, and interpretation of the most common geochronologic methods.

**GEOL 598. Special Research Programs**

**1-3 Credits**

Investigations into contemporary geological problems. May be repeated for unlimited credit.

**Prerequisites:** graduate standing and consent of instructor.

**GEOL 599. Master's Thesis**

**15 Credits**

Thesis research. May be repeated up to 88 credits.

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