Introduction to Cave Geology

GEOL 0289-01
Fall, 2023

Lectures: T/Th 9:30-10:45 AM
Bureau 111A

Instructor

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Teaching Assistant

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Course overview: This course is an introduction to the spectacular and complex world of caves. Most caves result from the dissolution of soluble bedrock such as limestone or gypsum, and are part of a larger landscape known as karst. Karst is characterized by large solutional features such as sinkholes, sinking streams, enclosed depressions, towers, pinnacles, and caves. The way that water moves through these cavernous areas, and the unique hazards they present, have important implications for the 25% of the world's population that either live on or get their drinking water from karst. Caves are windows into the subsurface through which we can access and study the chemical, physical, and biological processes that sculpt these breathtaking landscapes and underground worlds.

In this course, we will explore how caves form, their importance to humans, and the fragile and rare ecosystems that they contain, with emphasis on caves as interactive microcosms that cross-cut diverse scientific disciplines. This class will introduce students to the geology of soluble rocks, carbonate chemistry, karst hydrology, speleothem climate records, geomicrobiology, and the possibility and astrobiological significance of planetary caves.

Place in curriculum: This course is an elective for most undergraduate degrees offered in the Earth and Environmental Science Department.

Course learning outcomes: Upon successful completion of this course, students will be able to:

- Describe different types of caves and how they form

- Explain the chemical and hydrological processes responsible for limestone caves
- Describe karst, and the geology and defining features of karst landscapes
- Explain the chemical and physical processes behind the formation of different speleothems
- Describe how information on past climates can be recorded in stalagmites, and the advantages and challenges of speleothem as environmental recorders
- Describe the formation and major types of volcanic caves
- Recognize or explain the development of sinkholes and other hazards of karst
- Describe the energy resources for micro- and macroorganisms in caves, and the different ways in which living organisms use cave environments
- Explain and apply certain introductory geologic concepts such as relative versus absolute dating, stratigraphic principles, rock types, and geologic vocabulary
- Recognize or explain the relevance of caves for astrobiology and planetary geology
- Interpret and synthesize material from the primary literature in class discussions and assignments
- Effectively communicate scientific information on cave science to different audiences

Program learning outcomes: Learning outcomes for undergraduate and graduate degrees in Earth and Environmental Science: https://nmt.edu/academics/ees/Outcomes.php

Prerequisites: There are no prerequisites for this course, other than an interest in the Earth and environmental sciences.

Mode of instruction: In-person most days, although we may have some remote presentation to accommodate fieldwork schedules and guest speakers.

Field trips: We will have two or three weekend field trips during the course to caves. These may require up to 2 miles of hiking. Details will be provided in lecture.

Course website: Canvas course website, http://learn.nmt.edu

Readings:

Required texts:

- *Cave Geology*, by Arthur Palmer (2007, Cave Books ISBN 978-0-939748-66-2, https://cavebooks.com/book_review1.html#geology). *Cave Geology* is the main text for this course, and is an excellent and readable introductory text for students interested in cave and karst science. The book is available for purchase at the NMT Bookstore and New Mexico Bureau of Geology bookstore, and a copy has been placed on reserve at the Skeen Library.

Other required readings: Additional readings will be taken from the scientific literature or other sources. Electronic versions will be made available through the course webpage.

Grading: For this course, I am using a philosophy of assessment called "specifications grading," which has been shown to reduce some of the negative impacts of grades on the learning process. Students are provided a guide to the work required to achieve a particular grade. Grades are directly tied to learning objectives through satisfactory achievement of assignments, often with

opportunities to revise the assignments to achieve a satisfactory score. If you're curious to learn more about this grading philosophy, see *Specifications Grading* by Linda Nilson (2015), or short pieces such as those by Johanesen et al. 2022 (https://doi.org/10.1130/abs/2022AM-382375) or Bayraktar 2020 (https://higheredpraxis.substack.com/p/tip-specs-grading).

Grades will be assigned based on the following criteria:

		Earn C	**Earn B**	**Earn A**
Field trips and trip reports	Participate in at least	1	2	2
Final project	Earn a score of at least	M*	M	E
Sciworthy assignment	Earn a score of at least	M*	M	E
Exams (out of 4 total)	Meets expectations for at least	2	3	3 (E on 1)
Homeworks (out of 3 total)	Meets expectations for at least	3	3	3 (E on 1)
Learning reflections and participation inventories	Complete at least	1	2	3
Final presentation			M	M
Attemdance and participation	Maximum *unexcused* absenses	6	4	2

**Students may earn a grade of C with a score of M or better on either the final project or the Sciworthy activity*

Scoring system

For most assignments, grades will be assigned based on the following categories:

- Excellent (E): Complete understanding of the material is evident, and errors are trivial.
- Meets Expectations (M): Complete understanding of the material is evident without the need for further revision. May include some errors that warrant revisions but are covered by comments.
- Needs Revision (R): Limited understanding of the material is evident. Exhibits many errors or one or more major errors that necessitate revision.
- Not Completed (N): Not completed to a degree where understanding is evident or can be assessed.

Different assignments or projects may use a specific rubric or have different criteria for achieving a score of R, M, or E. For points-based assignments and exams, a score of M is usually ≥75% of possible points, and E is usually ≥90% of points. Assignment-specific details will be provided in class.

Resubmitting substandard or incomplete work: Problem sets, reports, and other assignments that do not meet expectations (score of M or better) may be resubmitted within a week of receiving your score. This does not apply to scheduled exams or the final project, but for those items, there will be alternative makeup opportunities (including the option of taking another exam), as well as opportunities to prepare in advance including practice exams, review sessions, and rough draft submissions.

+/- letter grade criteria

- A grade of B+ would mean achieving B criteria, but meeting A criteria in at least 2 categories; likewise for C+ versus C.

- A grade of B- would mean achieving B criteria in all except one category; likewise for A- versus A and C- versus C.

D/F grades: These grades indicate that most leaning objectives were not met, and therefore a fundamental breakdown of expectations. A grade of D represents a meaningful but unsuccessful attempt at earning a C or above. An "F" represents a lack of evidence of meaningful progress.

Late work: You have the option to turn in three assignments up to one week late. You might think of this as having three "tokens" that allow you a free pass to submit late work. Otherwise, no credit will be given for late assignments.

No extra credit is available outside of designated assignments. We will look over any exam or homework questions you think are not graded correctly and adjust your score as appropriate, but we will otherwise not negotiate your final grade. If you are having trouble in class for academic or any other reasons and are concerned about your grade, please see me early on so we can discuss how you can improve your understanding and performance.

Exams: We will have multiple exams that will cover lecture and reading material.

Problem sets and activities: Homework will take the form of problem sets (for example, calculating carbonate saturation and applying it to cave patterns) as well as other activities, such as an article summary of a recent paper related to cave and karst science.

Fieldtrip reports: You will be asked to prepare a short report following each of the fieldtrips. These will be relatively short and are intended you help you reflect on what you learned in the field, and to tie your observations to lecture topics.

Final project: One of the main deliverables for the semester will be a final project that is due at the end of the semester. Details will be provided in class.

To help you succeed with your final project and all other writing-heavy assignments, ***you are encouraged to take advantage of the resources available at the Writing and Communication Lab***, which offers qualified tutors for graduate and undergraduate students to improve writing skills (https://www.nmt.edu/academics/class/center.php).

Presentations: At the end of the term, you will give a short presentation on your final project. Presentations will last 5-10 minutes, and details will be discussed in class. Breaking down a complex topic into a brief presentation that is appropriate and easily digestible for your target audience is a tall order, but one that is important for your success as a scientist, whether you are talking to a scientific peer, neighbor, state senator, or funding agency representative.

Participation and Attendance: Everyone is expected to attend class and participate in discussions, field trips, and other activities. See the grading criteria for the number of *unexcused* absences allowed for the semester. We will make reasonable accommodations for medical absences and for students that contact us in advance about unavoidable absences, including for students that are unable to attend for COVID-19-related reasons. This includes COVID-19 and

other illnesses; please consult NMT's COVID-19 information page (https://www.nmt.edu/covid19/) for up-to-date guidelines.

Tracking participation: You will be asked to track and reflect on your participation through periodic "participation inventories," typically as part of your learning reflections (see below).

Reflections: Assessing your own learning process (metacognition) is a critical skill for lifelong learners. Three times over the course of the semester, you will be asked to reflect on your learning journey in this course. Details will be provided during the semester.

NMT Policies and Resources

Academic Honesty: New Mexico Tech's Academic Honesty Policy for undergraduate and graduate students is found in the catalog, which can be found at: https://www.nmt.edu/registrar/catalogs.php/. Further information about academic honesty can be found on the Associate Vice President for Academic Affairs website: https://www.nmt.edu/academicaffairs/avpaa/academic_honesty.php
You are responsible for knowing, understanding, and following this policy.

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Student Resources: Wondering where to go for help? Please see the offices below or visit the "Where NMT Students Should Go for Help" website.

Student Success: New Mexico Tech offers numerous peer tutoring services for students who are struggling in their courses, or who just wish to receive friendly advice, including the Office of Student Learning (Skeen Library, https://www.nmt.edu/osl/), Math Helproom (https://www.nmt.edu/academics/math/ugrad/mathhelproom.php), the Writing and Communication Lab (Skeen Library, https://www.nmt.edu/academics/class/center.php), and numerous department-run centers. These services are free of charge to students! Students may also consult the Dean for Student Success Initiatives, Elaine Debrine Howell (Fidel, rm. 237; 575-835-5208; elaine.debrinehowell@nmt.edu) or may receive emails from her if they are struggling in class.

Reasonable Accommodations: New Mexico Tech is committed to protecting the rights of individuals with disabilities and providing access and full participation in the educational experience. Students with disabilities who require reasonable accommodations are invited to make their needs known to the Office for Student Access Services (SAS) as soon as possible. Accommodations are not retroactive and may take some time to implement. The

process for requesting accommodations can be found at their website https://nmt.edu/ds/for_students.php

You can contact SAS in person at the Fidel Center Room 245, call 575-835-6209, email access@nmt.edu or book through the link on our website.

Counseling Services: The Counseling Center is very excited to announce that Tech has partnered up with the Virtual Care Group (VCG), to offer free supplemental healthcare services to our degree-seeking students. This virtual healthcare includes unlimited Tele-medical and unlimited Tele-therapy/counseling sessions available 24/7, as well as life coaching. Both in-person sessions on campus and this virtual healthcare are available for those degree-seeking students currently enrolled for Fall classes. Download The Virtual Care Group app from your app store. For questions about the platform, please email VCG's Care Team at care@virtualcaregroup.com. For more information on services at NMT, please call 835-6619, email counseling@nmt.edu or check out our website at https://www.nmt.edu/cds/.

Respect Statement: New Mexico Tech supports freedom of expression within the parameters of a respectful learning environment. As stated in the *New Mexico Tech Guide to Conduct and Citizenship* (Student Handbook): "New Mexico Tech's primary purpose is education, which includes teaching, research, discussion, learning, and service. An atmosphere of free and open inquiry is essential to the pursuit of education. Tech seeks to protect academic freedom and build on individual responsibility to create and maintain an academic atmosphere that is a purposeful, just, open, disciplined, and caring community."

Title IX Reporting: Sexual misconduct, sexual violence, and other forms of sexual misconduct and gender-based discrimination are contrary to the University's mission and core values, violate university policies, and may also violate state and federal law (Title IX). Faculty members are considered "Responsible Employees" and are required to report incidents of these prohibited behaviors. Any such reports should be directed to Tech's Title IX Coordinator (Dr. Peter Phaiah, 238 Fidel Student Center, 575-835-5953 (O), 575-322-0001 (C), titleixcoordinator@nmt.edu) or reports can be filed online to Tech's Title IX & Sexual Misconduct Report. Please visit Tech's Title IX Website (www.nmt.edu/titleix) for additional information and resources.

Land Acknowledgement: We acknowledge that the New Mexico Institute of Mining and Technology campus stands on the unceded ancestral lands of the Pueblo and Apache peoples. These lands were taken by Congress in the Indian land Cession 689 on October 1, 1886, and the people forcibly moved to reservations. These injustices were accomplished under false white-supremacist ideologies such as manifest destiny and the doctrine of discovery. As visitors to these lands we appreciate their millennia of stewardship to the land, water, animals and plants, and the opportunity to live and learn here. Please visit https://indianpueblo.org/new-mexicos-19-pueblos/ to learn more about these Native nations, their cultures, and sovereignty.

Language on New Mexico Tech policies from https://www.nmt.edu/academicaffairs/policies.php, and courtesy of Dr. Steve Simpson.

Language on learning reflections, tracking participation, and some grading topics courtesy of Dr. Katherine Mattaini, Roger Williams University, and Dr. David Clark, Grand Valley State University.
Land acknowledgement text courtesy of Anne Gray, Chris ChoGlueck, Michael Schaefer, and the EES Diversity, Equity, and Inclusion (DEI) committee.

ERTH 289: Introduction to Cave Geology

Fall 2023, T/Th 9:30-10:45 AM, Bureau 111A

Course schedule

Palmer is the textbook (*Cave Geology* by Art Palmer)

Lecture materials and readings may be subject to change as the semester progresses

Week 1: Introductory week

T	15 Aug	Course introduction	
Th	17 Aug	Overview of cave types; karst landscapes and features	
Readings		Palmer Ch. 1-3	

Week 2: Solution caves

T	22 Aug	Geology of karst rocks; start limestone dissolution	
Th	24 Aug	*No class*	
Readings		Palmer Ch. 3-5 (focus most on Ch. 5)	

Fieldtrip: Robinson's Cave, Saturday Aug. 26

Week 3: Solution caves

T	29 Aug	Limestone dissolution	
Th	31 Aug	Case study: Flank margin caves	
Readings		Palmer Ch. 5, 8	

Week 4: Solution caves; speleothems

T	5 Sep	Case study: Sulfuric acid caves	Homework 1 due
Th	7 Sep	Speleothem formation; carbonate dissolution and precipitation revisited	
Readings		Palmer Ch. 8, 10	

Week 5: Speleothems

T	12 Sep	Speleothems continued; Case study: Cave pearls	
Th	14 Sep	***Exam 1***	
Readings		Palmer Ch. 10	

Week 6: Speleothems as climate archives

T	19 Sep	Speleothem paleoclimate	
Th	21 Sep	Speleothem paleoclimate	***Sciworthy assignment***
Readings		Palmer Ch. 10, 13	

Week 7: Karst landscapes

T	26 Sep	Karst hydrology and landscape evolution	
Th	28 Sep	Case study: Sinkholes	***Sciworthy topic due 9/29***
Readings		Palmer Ch. 2, 15	

Fieldtrip: karst rocks and paleokarst features, Saturday Sep. 30 (details TBA)

Week 8: Other caves

T	3 Oct	Lava tubes and volcanic caves	Homework 2 due
Th	5 Oct	Volcanic caves continued; ice caves and other pseudokarst features	
Readings		Palmer Ch. 11	

Week 9: Other caves

T	10 Oct	***Exam 2***	
Th	12 Oct	TBA	
Readings		Palmer Ch. 2	

Week 10: TBA

T	17 Oct	*No class - GSA week*	
Th	19 Oct	TBA	***Sciworthy assignment due 10/20***
Readings			

Week 11: TBA

T	24 Oct	TBA	
Th	26 Oct	TBA	***Final project topic due***
Readings			

Week 12: Energy and life in caves

T	31 Oct	Energy and life in caves	
Th	2 Nov	Case study: Chemosynthesis and sulfuric acid caves	
Readings		Palmer p. 164-165; Jones and Northup (2021)	

Week 13: Energy and life in caves; start astrobiology

T	7 Nov	Trogloxenes, troglophiles, and troglobites	Homework 3 due
Th	9 Nov	Planetary caves and astrobiology	
Readings		Palmer p. 164-165; Titus et al. (2021)	***Final project draft due 11/10***

Week 14: Planetary caves

T	14 Nov	Case study: Martian lava tubes	
Th	16 Nov	***Exam 3***	
Readings			

Possible weekend fieldtrip, 18-19 Nov: Details TBA

Week 15: Thanksgiving break

--------- Thanksgiving break, Nov 20-24 ----------

Week 16: Planetary caves and class presentations

T	28 Nov	Finish planetary caves; class presentations	
Th	30 Nov	Finish planetary caves; class presentations	
Readings			***Final project due 12/1***

Final exam (will be scheduled between 12/2/2023-12/8/2023)