

Physics and Chemistry of the Earth (GLG 470) – Fall 2019

*School of Earth and Sustainability
College of Engineering, Forestry, and Natural Sciences*

Course Information

Instructors: Mary Reid (Mary.Reid@nau.edu) - Geology Annex, rm. 207
Ryan Porter (Ryan.Porter@nau.edu) – Geology, rm. 214

TA: Sarah Robinson

Time/Location: Lectures: 12:40 – 1:30 pm MW – Geology, rm. 223
Labs: 2:20 – 5:20 pm T – Geology, rm. 104

Office Hours: Porter: 1-4 pm W (or by appointment)
Reid: 3:30-5:30 pm T

Credits: 3 (two-hour lectures, three-hour lab per week)

Prerequisites: Upper division GLG Students

Description

In order to understand the structure, composition, and dynamic process within the Earths, scientists use geochemical and geophysical techniques to produce images of its interior. In this course we will present the principle geochemical and geophysical techniques used to study the solid Earth for the first part of the semester, and then work outwards, from core to crust, examining these features and how geophysics and geochemistry allows us to understand them.

Textbook

Required:

- W. M. White, Geochemistry, 2013. (~\$75)

Useful:

- R. J. Lillie, Whole Earth Geophysics, 1999. (out of print, but ~\$40 to rent)

Learning Objectives

Upon completion of this course students should be able to:

1. Summarize the basic theory behind common geophysical and geochemical techniques used to analyze the internal structure and composition of the Earth.
2. Identify the large-scale internal structure and composition of the Earth and explain how they are constrained using geochemical and geophysical techniques.

3. Describe dynamic processes within the Earth including convection in the core and mantle, plate boundary processes, and the long-term evolution of the Earth. Evaluate how these processes impact conditions at the Earth's surface and within its interior.
4. Compile, interpret, and evaluate geologic literature related to the chemistry and physics of the Earth.

Course Outline

There will be two in-class exams during the semester. In-class lectures will be supplemented by laboratories (often including a short lecture portion) that will involve you in activities related to data collection and interpretations. Labs will start on Sept. 3 (Tuesday). In addition to the labs, there will be problem sets distributed occasionally during the semester (due dates shown). A calendar with major due dates is located at: www.porterrc.com/glg470.

Wk.	Dates	Monday	Tuesday (Lab)	Wednesday
1	Aug 26, Aug 28	Introduction to Class	No lab.	Earth's Large-Scale Structure
2	Sept 2, 4	Labor Day Holiday	Lab 1: Elastic Constants	Introduction to seismology
3	Sept. 9, 11	Seismology Homework 1 Due: Seismic Basics	Lab 2: Refraction Seismology	Seismology
4	Sept. 16, 18	Potential Field: Gravity	Lab 3: Gravity & Isostasy	Gravity & Isostasy Homework 2 Due: Gravity
5	Sept. 23, 25	No Class: GSA Fall Meeting	No lab	Magnetics
6	Sept 30, Oct 2	Magnetics Homework 3 Due: Magnetics	Lab 4: Paleomagnetism	Exam 1
7	Oct 7, 9	No Class: GLG 340	No Lab: GLG 340	Bulk Chemistry
8	Oct 14, 16	Trace Elements Homework 4 Due: Chemistry Review	Lab 5: REE & Mantle	Trace Elements
9	Oct 21, 23	Isotopes Homework 5 Due: Mass Balance/Fractionation	Lab 6: Geochronology	Geochronology
10	Oct 28, Oct 30	Isotopes as Tracers Homework 6 Due: Trace elements Final Paper Topic Due	Lab 7: Condensing the Nebula	Meteorites/ Planetary Formation
11	Nov 4, 6	Core-mantle differentiation Homework 7 Due: Zircon dating	Lab 8: Chemistry of Earth & Core	Exam 2
12	Nov 11, 13	Veteran's Day Holiday	No Lab	No Class: GLG 340
13	Nov 18, 20	Crust-mantle differentiation	Lab 9: Origin of MORB	Mantle Geophysics Paper Draft Due 5:00 PM
14	Nov 25, 27	Paper Peer Review	Lab 10: Earthquakes	Lithosphere & Plate Tectonics

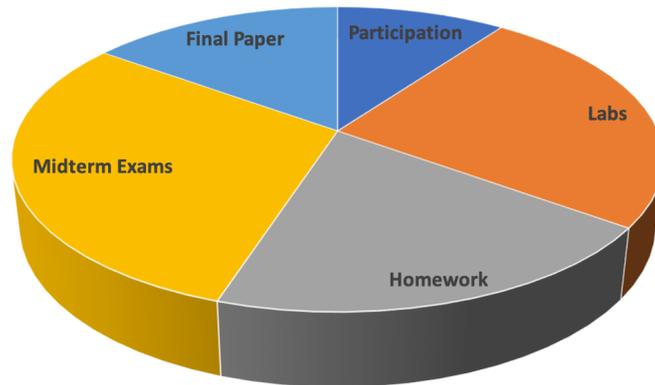
15	Dec 2, 4	Crustal Geophysics/Earthquakes	No lab.	Geochemistry of Crust Lab 11: Earthquakes
16		Final Paper Due (5:00 pm 12/9/19)		

Assessment of Student Learning Outcomes

Geophysics and geochemistry are practiced in a variety of ways and so multiple assessment tools will be utilized, as summarized here. The timeline for the homework exercises, exams, and the final project are given in the course schedule (above). Some adjustments to this schedule may be made as the semester evolves. It's your responsibility to be familiar with this schedule and to be aware of any changes that are announced. The online calendar will be updated if any schedule changes do occur.

Final Grades will be assigned based on the following:

- 10% Participation
- 25% Labs
- 20% Homework
- 30% Midterm Exams
- 15% Final Paper



Final letter grade will be no lower than the following: >90% A, 80-90% B, 70-80% C, 60-70% D, <60% F. Cutoffs *may* be adjusted to coincide with breaks in the class distribution. Grade challenges must be submitted in writing (except where minor) within one week of the return of a graded assignment. We will not assign a grade of "I" (incomplete) except in extreme circumstances that are beyond the student's control. It is against university policy for us to give you an "Incomplete" grade because you are dissatisfied with a final grade and hope to complete additional post-course work to improve your grade.

We encourage you to work together to understand the laboratory exercises and the lecture material. **All work submitted for grading, however, must be the final work of each individual student, and must show all working and sources of material where appropriate. Cheating on examinations or plagiarism* in exercises or any form of assignments will result in a score of zero for all students involved in these activities.** *Plagiarism is copying work from any other source (a book, journal, magazine, web site, another student or free or purchased materials, etc.) without clearly identifying the text/work that is copied by placing this text/work within

quotation marks, using a different font for the text/work, such as an italic font, or otherwise identifying the text/work, and giving the source of the text/work.

Participation: Participation in class, whether as questions, responses to questions, volunteered information, or contributions to discussions will help you learn, will make you more comfortable with geophysics and geochemistry and the scientific language associated with it, and will keep us from losing you in the lectures and labs. You are expected to attend every class and arrive on time. However, the participation contribution to the grade in this class will be based on more than this. The following “participatory” activities may be included this semester: in-class solo and group activities, brief (<1 hr) independent “take-home” activities to engage you in applying what you’re learning and to encourage reading, and short (including pop) quizzes based on reading and lecture material.

Exams: There will be two exams. You will take them after you have had a chance to gain a basic command of the application of geophysics and geochemistry to understanding Earth’s interior. These exams will allow us to assess your understanding of what you’ve learned and to help you identify any areas where you will want to become more competent in order to apply geophysical and geochemical information in the class and in your post-graduate career.

Final Project: The final project will give you an opportunity to integrate geologic, geophysical, and geochemical information in the context of a specific scientific problem. To accomplish this, you will produce a research paper. Major deadlines for this project are outlined in the course schedule. More details on the topic, requirements and grading of this project will be given later in the course.

Registrar Deadlines: The deadline to Add/Drop (without W) is 9/5/19; the deadline for Withdrawal (with W) is 11/2/19.

Course Policies

- Retests/makeup tests will only be given with prior approval.
- Students are expected to attend every class and actively participate.
- Late work will not be accepted unless prior arrangements are made.
- Academic dishonesty, in any form, will not be tolerated.

University Policies

- The University policies on Safe Working and Learning Environment, Students with Disabilities, Institutional Review Board, and Academic Integrity policies can be found at: <https://in.nau.edu/academic-affairs/academic-integrity/>, <https://in.nau.edu/disability-resources/>, and <https://nau.edu/university-policy-library/safe-working-and-learning/>
- NAU has an Emergency Textbook Loan Program. Eligible students can apply for assistance with acquisition of textbooks for the semester. More information at: <https://in.nau.edu/dean-of-students/emergency-textbook-loan-program/>

Student Support

The Student Learning Centers, TRIO Outreach programs, and Educational Support Services main office are back in the University Union, second floor. Specific room locations are below:

Student Learning Center

- Tutoring-room 201
- Transfer and Commuter Connections office/lounge-room 247
- Peer Jacks lounge and staff-room 201

TRIO Outreach Programs

- Educational Talent Search (ETS)/Educational Opportunity Center (EOC)/Nizhoni-room 241
- Upward Bound and Upward Bound Math Science-room 201

Educational Support Services

- Main office – room 260

NAU POLICY STATEMENTS

ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full academic integrity policy available at <https://policy.nau.edu/policy/policy.aspx?num=100601>.

COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (Academic Credit Policy 2-224), for every unit of credit, a student should expect, on average, to do a minimum of three hours of work per week, including but not limited to class time, preparation, homework, and studying.

DISRUPTIVE BEHAVIOR

Membership in NAU's academic community entails a special obligation to maintain class environments that are conducive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not breach the peace, interfere with normal class activities, or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's disruptive behavior policy at <https://nau.edu/university-policy-library/disruptive-behavior>.

NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. Due to potentially unethical consequences, certain

consensual amorous or sexual relationships between faculty and students are also prohibited. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's Safe Working and Learning Environment (SWALE) policy. EAO also assists with religious accommodations. For additional information about SWALE or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or via the EAO website at <https://nau.edu/equity-and-access>.

TITLE IX

Title IX is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a "Title IX Coordinator" to monitor the institution's compliance with this important civil rights law. NAU's Title IX Coordinator is Pamela Heinonen, Director of the Equity and Access Office located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3312 (TTY: 928-523-1006), by fax at 928-523-9977, or by email at pamela.heinonen@nau.edu. In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student resources, including how to request immediate help or confidential support following an act of sexual violence, is available at <http://nau.edu/equity-and-access/title-ix>.

ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), 928-523-6906 (TTY), 928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at <https://nau.edu/disability-resources/student-eligibility-process> or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at <https://nau.edu/research/compliance/research-integrity>.

MISCONDUCT IN RESEARCH

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University's Research Integrity Officer, Dr. David Faguy, who can be reached at david.faguy@nau.edu or 928-523-6117. More information about Misconduct in Research is available at <https://nau.edu/university-policy-library/misconduct-in-research>.

SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.