Environmental Geochemistry GEOL135



- Fall Semester 2019
- Instructor: Dr. Julia Perdrial, Office: 213C; Tel: (802) 656 0665;
- Email:Julia.perdrial@uvm.edu
- Office hours: W 10:30-11:30 and by appointment;
- Meeting Time: Lecture MWF 10:50-11:40; Lab W 2:20 – 5:20PM
- One mandatory full-day field trip on a Saturday in September
- Credits: 4, Pre/co-requisites: CHEM 31, 32.

Welcome to Environmental Geochemistry!

Environmental Geochemistry is a (happy) marriage of the fields of geology and chemistry applied on environmental issues. In this hands on lecture and lab course we will use a mix of lecture, reading and group work to get to the heart of some of the most pressing environmental issues we face today. Environmental science happens outside and can be best approached by going where the questions are. We therefore will have a mandatory day-long field trip at the beginning of the semester where you will collect samples for your project. The other lab meeting times you will spend in an actual environmental biogeochemistry and mineralogy lab where you will receive training in lab methods and learn how to accurately and safely work on your research project. You may also spend some time in the computer lab where you will use your own data to practice data analysis, generate meaningful visualizations and work on your presentation. Additionally we will practice science communication using hands on approaches.

General goal of this course:

- At the end of this course you will be able to apply geochemical concepts to explain selected environmental issues.
- You will learn to collect data to test hypotheses on a selected environmental issue (your lab project). You will also be able to perform selected geochemical analyses in the lab and collect analytical data independently and safely.
- You will be able to communicate your lab project effectively to a non-science audience.

Lectures: We will use lecture class meeting times to investigate the geochemistry behind important environmental issues. Only once we have an understanding of the complex dynamics behind an environmental issue we can act. For example, around 30 years ago tree health began to decline in the NE and fish in streams and lakes died. Only by understanding the link between atmospheric composition, rain water pH and ecosystem function we could address the issue by limiting emissions of nitrogen and sulfur oxides. We will use a mix of lecture, reading and group work to get to the heart of some of the most pressing environmental issues we face today.

Science communication: scientists are notoriously bad at communicating science, which is one of the reasons why the general public sometimes think scientists disagree on environmental issues such as climate change. We

will therefore work on science communication using a variety of hands on improvisation exercises. You will be able to showcase your communication skills in a brief group video on climate change.

Labs: You will conduct your own research on one of the projects described at the end of the syllabus. We will have one mandatory day-long fieldtrip at the beginning of the semester on a Saturday where you will collect samples for your project. Because our field sites are a 90 minutes drive away from campus the normal lab meeting times are not a good option. One long day field trip will count for several lab meeting times, which means that you will have some Wednesday afternoons off. The other times you will spend in an actual environmental biogeochemistry and mineralogy lab (XRD lab).

Book: Please get a copy of Environmental and Low Temperature Geochemistry (by Peter Ryan), I will provide the first two chapters via blackboard until your copies arrive.

Learning assessment:

Lectures: 60%

- You will have the option of choosing between frequent quizzes or two exams (we'll vote at the beginning of the semester, 30%)
- You will complete homework problem sets (20%).
- Group work and communication (10%).

Labs: 40%

- You will be evaluated using the rubric in the appendix of the syllabus. Note that this assessment will vary with your academic level. I will take the trajectory of your performance into account, which means that I do not expect a "great" level at the beginning but a clear progress towards it. Note: "great"=A, "solid"=B, "not enough"=C or less in the rubric (20%).
- You will also receive a group grade for your lab project presentation towards the end of the semester. As a group you can choose how you want to present your research: You could prepare either a poster or you could prepare a talk. You will receive more information when the time comes (20%).

Teaching and Learning Style:

It's always helpful to know about your own learning style and know what you can do to support your own learning. Please take the "Index of Learning Styles Questionnaire" following this link:
http://www.engr.ncsu.edu/learningstyles/ilsweb.html
The results are for yourself only, but this very simple test will help you to better understand your learning (and probably my teaching).

Important to do:

- Complete the following online lab safety trainings this week (by 09/09/2017): http://www.uvm.edu/safety/lab/safetytraining 1)Chemical Safety in the Laboratory, 2)Laboratory Ventilation and Chemical Fume Hoods 3) Laboratory Chemical Waste Disposal and 4) Laboratory Safety Roles and Responsibilities.
- You will also receive classroom trainings in lab safety on 09/05. If you miss this training for some reason you need to make up for it on your own time, check the webpage above for info.
- **In the lab:** You will receive training in all procedures by myself and graduate researchers. Please take organized notes during training sessions, you will not be able to remember everything. Bring your notes each time you come to the lab. Please also see the info in Appendix E.
- Peer reviewed publications: You will also read peer reviewed publications ("papers") for your lab projects. Important resources to search for papers are the library (Howe Library--> databases --> Academic search premier), science direct (http://www.sciencedirect.com/) or google scholar. Its a good idea to use several searches to get a complete picture.

- Adhere to the Code of Academic Integrity (no plagiarism, fabrication, collusion, and cheating). Deliberate offense against the code will be forwarded to the Center for Student Ethics and Standards (see http://www.uvm.edu/~uvmppg/ppg/student/acadintegrity.pdf for more information).
- If you are sick and have to labs contact me ASAP, please note that most labs (except computer labs) cannot be repeated! This is especially true for the fieldtrip.

My pet peeves:
For some reason if find the following very annoying, please do your best to avoid it.
1) I cannot stand folks checking or answering texts or emails in my class. I do want to allow the use of phones and computers in my class, because it might help you with the course work. But PLEASE don't try to use your phones or laptops for private stuff.
2) Please turn in your work in time, I hate decreasing grades for late work but have to do it. I sometimes hear from students that they would just need another day or two to make a "good" homework "great". However, consider that everything could be better if we just had more time. The grade takes the amount of time you have into account. Exception: If you have struggled with deadlines in the past and found yourself procrastinating please come and talk to me within the first two weeks of classes. We can work with some additional strategies to help you manage deadlines.

Student learning accommodations:

- Any student with a documented disability interested in utilizing accommodations should contact ACCESS, the office of Disability Services on campus.
  ACCESS works with you to create reasonable and appropriate accommodations via an accommodation letter to their professors as early as possible each semester.
  Contact ACCESS: A170 Living/Learning Center - 802-656-7753 - access@uvm.edu.

Approximate Schedule (subject to changes):

Week 1:
Lecture: Introduction: What is Geochemistry? Surficial and Environmental Mineralogy
Lab: Formation of teams, literature review
Week 2:
Lecture: Surficial and Environmental Mineralogy
Lab: Lab safety trainings
Week 3:
Lecture: Surficial and Environmental Mineralogy
Lab: training group 4 & 5
Week 4:
Lecture: Organic compounds in the Environment
Lab: training group 1 & 2
Week 5:
Lecture: Organic compounds in the Environment
Lab: training group 3
Week 6:
Lecture: Aqueous systems
Lab: most likely week for fieldwork
Week 7:
Lecture: Aqueous systems, solubility, weathering
Lab: Analysis group 4 & 5
Week 8:

Lecture: Aqueous systems, solubility, weathering
Lab: Analysis group 1, 2 & 3

Week 9:

Lecture: Carbon cycle
Lab: Analysis group 4 & 5

Week 10:

Lecture: Biogeochemical cycles and eutrophication
Lab: Analysis group 1, 2 & 3

Week 11:

Lecture: Global atmosphere
Lab: Data and interpretation

Week 12:

Lecture: Global atmosphere
Lab: Data and interpretation

Week 13:

Lecture: Stable isotopes and climate
Lab: presentations

Week 14 Thanksgiving

Week 15:

Lecture: Stable isotopes and climate
Lab: presentations

Week 16:

Wrap up

Appendix A: These are the assessment rubrics for exams, problem sets

	Problem sets	
Level of Achievement	**General Approach**	**Comprehension**
Exemplary **100% of points**	• Addresses the question. • States a relevant, justifiable answer. • Presents arguments in a logical order.	• Demonstrates an accurate and complete understanding of the question. • Backs conclusions with data and warrants. • Uses ideas, examples and/or arguments that support the answer.
Adequate **75% of points**	• Does not address the question explicitly, although does so tangentially. • States a relevant and justifiable answer. • Presents arguments in a logical order.	• Demonstrates accurate but only adequate understanding of question because does not back conclusions with warrants and data. • Uses idea to support the answer. • Less thorough than above
Needs Improvement **25-50% of points**	• Does not address the question. • States no relevant answers. • Indicates misconceptions. • Is not clearly or logically organized.	• Does not demonstrate accurate understanding of the question. • Does not provide evidence to support their answer to the question.

No Answer (0 pts)		

Appendix B: Example lab projects

Project 1:
Title: The evolution of (clay) mineralogy with depths and landscape position.
Why: Minerals, especially clays have huge implications on soil characteristics.
Field: You will use an auger to sample soils along hillslopes and in wetlands at up to 5 depths.
Lab: You will dry and sieve samples (maybe you also need to mill them) and then analyze them with X-ray diffraction. To identify specific clay minerals you will perform repeat analysis after saturation your samples with e.g. ethylene glycol (test to identify swelling clays). The type of

Project 2:
Title: Aggregate stability in soils
Why: Aggregates are typical means of stabilizing carbon in soils and preventing the generation of greenhouse gases.
Field: You will use an auger to sample soils along hillslopes and in wetlands at up to 5 depths.
Lab: You will mix small amounts of your soils with water and perform particle size analysis using the laser PS analyzer. You will then sonicate your samples to check if your particle size changes to test for aggregates. By comparing the data from different locations and depth you can make inferences on aggregate size and stability.

Project 3:
Title: Solutes in a wetland
Why: Wetlands represent very active environments where redox geochemistry can lead to the mobilization of (contaminant) metals.
Field: You will use an auger to sample soils in 2 wetlands (agricultural and forest) in at 3 locations each and in up to 5 depths.
Lab: You will dry your samples, grind them and analyze them using X-ray fluorescence. By comparing the data from different locations and depth you can investigate how variable the distribution of metals in these systems is.

Project 4:
Title: The difference between soil water and stream water carbon signature
Why: Carbon in streams is easily recycled and transferred into the greenhouse gas CO2, an important source are soils. Can we trace soil C into our streams?
Field: You will sample soil from near stream areas and take water samples.
Lab: You will mix your soil with water to extract the soil signature into the water, then you will separate water and soil and analyze the extract using the carbon analyzer and the fluorescence spectrometer. By comparing the data between soil and stream you can detect similarities and differences.

Project 5:
Title: Stream water organic matter signature in agricultural and forested settings
Why: Carbon in streams is easily recycled and transferred into the greenhouse gas CO2, an important source are soils. Where do we find more carbon, in our agricultural or forested stream? Which carbon is more readily transferred into CO2?
Field: You will sample stream waters at several locations in forested and agricultural settings.
Lab: You will filter and analyze your samples using the carbon analyzer and the fluorescence spectrometer. By comparing the data between the two field sites you can investigate similarities and differences.

Note, you can suggest your own project as long as it's within the scope of the course and feasible with our resources (Time, instrument availability etc).

APPENDIX C

Undergraduate research rubric

	Great	**Solid**	**Not enough**
Laboratory Safety	Knows and follows correct safety procedures in the laboratory; actively seeks training or information when necessary.	Knows and follows correct safety procedures in the laboratory after receiving training.	Needs to be reminded repeatedly to engage in safe laboratory procedures.
Knowledge	Independently seeks thorough knowledge of the background using peer reviewed literature research. Has motivation for project.	Has a developing knowledge of the background and motivation for project. Has some familiarity with scientific literature	Needs to be repeatedly reminded to improve knowledge of the background and does not have motivation for project. Has minimal familiarity with scientific literature
Technical skills	Practices and shows skill and care in technical procedures and instruments. Is able to consistently reproduce high quality results.	Practices to improve skill in technical procedures and instruments. Quality of results may be inconsistent	Does not display skill in technical procedures and instruments. Consistently fails to reproduce results.
Independence, time management, and planning	Works without close supervision; Actively manages time to push project forward; Manages project and produces results in a timely manner. Generates ideas. Seeks advice from mentors adequately	Sometimes requires supervision in the planning or executing of experiments. Does manage time and is usually efficient at completing experiments. Seeks advice	Unable to work without supervision; does not plan experiments or manage time. Inefficient at completing experiments in a timely manner. Does not seek advice or does so for information that is easily obtainable elsewhere
Collegiality and Collaboration	Works well with peers and supervisors; begins to mentor or train others; gives and takes constructive criticism well; respects differing backgrounds and points of view	Works well with supervisors; takes constructive criticism; respects differing backgrounds and points of view	Has conflict with coworkers and supervisors; does not apply constructive criticism for improvement of performance; does not respect differences

Record keeping	Keeps complete, organized, and legible records in project folder and data spreadsheets	Keeps complete records, but they may be disorganized or have legibility issues.	Does not keep complete records, or components are missing, inadequate, or have unexplained gaps

Appendix D

PERDRIAL Biogeochemistry Lab Rules *updated 12/10/2016*

Safety:

1. Everybody who works in this lab has to complete the online lab safety training:
    - - Chemical Safety in the Laboratory
    - - Laboratory Chemical Waste Disposal
    - - Laboratory Safety Roles and Responsibilities
    - - Laboratory Ventilation and Fume Hoods

They can be found at http://esf.uvm.edu/courses/

2. Complete the "Orientation/Training Checklist for New Laboratory Employees" to make sure you are ready to begin working in the lab. Copys are available in 301 or here: http://www.uvm.edu/safety/sites/default/files/uploads/documents/newemployeechecklist2013.pdf
3. Adhere to standard safety rules discussed in the training, particularly:
    - ALWAYS wear closed-toe shoes and clothes that cover legs. This is tricky in the summer time but you can bring a spare set of clothes/shoes and store in the grey cabinet.
    - When handling acids/ bases wear goggles, labcoat and gloves.
    - Don't work alone in the lab (except if approved by Julia or Nico).
    - Please label all vials, bottles vessels with the green or orange labels and use secondary containers.
    - Know what you are doing and plan ahead. If you don't, PLEASE ask.

Etiquette and cleanliness:

4. Don't create labware orphans: Take care of your own labware and label samples, vessels etc..
5. Please be a good parent to "orphaned" items such as dishes. It may not be yours but if you see a beaker etc sitting in the same spot for weeks, take care of it (wash it). Exception: item or content may be hazardous, ask Julia or Nico.
6. If you finish something let us know.
7. Be a good lab citizen: empty trash **before** its overflowing, refill labelling tape dispenser etc. Inquire about items that don't seem to belong to anybody, inform us (unsafe practices, issues with cleanliness etc).
8. If you break something, let me know. It's normal that stuff breaks in a lab but we need to know to be able to fix or replace it.

9. please clean up after yourself and wipe all lab surface daily. We have a mixed use lab with processes generating dirt and dust just beside experiments that need a clean environment and need to avoid cross contamination.
10. Please keep the hoods and sinks clean and empty the soil trap regularly (weekly to monthly).

11. Please remove boxes and don't store them in the area of the electric panel. When you have a box you need to get rid of, fold it and put it in front of the lab. The custodial team will take them away.

UVM Risk Management & Safety
Orientation/Training Checklist for New Laboratory Workers

Employee's Name:_____ Date checklist started:_____ completed: _____

Trainer (PI/Supervisor/Designated Trainer): _____

I. General (www.uvm.edu/safety)

- ☐ Review Safety Website (www.uvm.edu/safety).
- ☐ Complete all required safety trainings. (http://www.uvm.edu/safety/lab/safetytraining)
- ☐ Complete Safety tour inside and outside of the lab including fire extinguishers, fire alarms, egress & exits, & safety equipment (PPE, showers, eyewash, chemical spill kit, telephone, cylinder restraints, disinfectants, etc).
- ☐ Review emergency response procedures specific to each lab, reporting procedures for accidents and injuries, and emergency phone numbers. (http://www.uvm.edu/safety/lab/prepare-for-emergencies)
- ☐ Review lab-specific and building-specific safety features (e.g. close lab doors, evacuation map & meeting site, gas shut-offs).
- ☐ Review the contents of Laboratory Safety Notebook and the Monthly Self-Inspection Checklist.
  - ☐ Review the location of Safety Data Sheets (SDSs).

II. Chemical Safety (http://www.uvm.edu/safety/lab/chemical-safety)

- ☐ Review or complete chemical hazard assessments, including Chemical Use Planning Forms, for the chemicals you will be handling in the laboratory.
- ☐ Understand what controls are required to minimize potential exposure to chemicals and other hazards in this lab. (http://www.uvm.edu/safety/lab/identify-and-control-hazards)
  - ☐ Engineering Controls: Fume hoods, biosafety cabinets, glove boxes, Schlenk line, snorkel exhaust, etc.
  - ☐ Administrative Controls: Standard Operating Procedures and lab-specific protocols
  - ☐ Proper Personal Protective Equipment: Lab coat, gloves, eye and face protection, respirator*

  **Must complete a Request for Respirator Use form and receive approval and instruction before using a respirator.*
- ☐ Review procedures for operating equipment (e.g. power tools, autoclave, NMR, kilns, ovens, engineering controls). Do not operate unfamiliar equipment or materials without proper training and approval.
- ☐ Review proper labeling, segregation, and storage for all chemicals used in this lab.
- ☐ Review chemical waste procedures including labeling, storage, and disposal.

III. Biosafety and Bloodborne Pathogens (http://www.uvm.edu/safety/lab/biological-safety)

- ☐ Review and sign-off on all laboratory infectious agents Standard Operating Procedures (SOPs).
- ☐ Understand how to use the proper controls in order to minimize any potential biological exposure.
- ☐ Review biohazardous waste procedures including labeling, storage, and disposal, disinfection of liquid waste, proper set-up of aspiration flasks, and biohazard box disposal.
- ☐ All employees who work with human or primate blood, blood-products or other potentially infectious materials must:
  - ☐ be designated "at risk" with Infectious Materials Risk Designation Form,
  - ☐ be offered the Hepatitis B vaccine with the HBV Vaccination Consent/Dissent Form, and
  - ☐ review the UVM Exposure Control Plan. (http://www.uvm.edu/safety/lab/bloodborne-pathogens-0)

IV. Other Laboratory Hazards

- ☐ Receive and document necessary training for any highly hazardous material or process, including lasers, time sensitive chemicals, highly toxic or reactive chemicals, pressurized devices, etc).
- ☐ Review safe handling procedures for gas cylinders (how to check for leaks, proper restraining & transport, etc).
- ☐ Review safe operating and handling procedures for thermal hazards (e.g. Liquid Nitrogen, ovens, kilns, autoclaves, hot plates, Bunsen burners, etc).
- ☐ Review proper disposal procedures for other wastes including sharps, broken glass, uncontaminated lab waste, batteries, and light bulbs.

I understand that this checklist is intended as a safety-training guide for my laboratory; it may not be a comprehensive list of all the training I may need to be safe from the hazards in my specific laboratory.

Employee's Signature:_____ Date Completed:_____ Revised 05/16