



## **Geochemistry of Natural Waters – GEOL4405 (N1, QD)**

Fall Semester 2023

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Office hours: Office hours: Friday 10.45AM -12:45PM and by appointment;

Meeting Time: MWF 9:40-10:30; Credits: 3, Pre-requisites: one 2000-level natural science course from, CEE, CHEM, CS, ENSC, GEOG, GEOL, NR, PSS.

### ***Welcome!***

Welcome to the Geochemistry of Natural Waters Course! We live on the blue planet which is  $\frac{3}{4}$  covered by water and 100% of all living organisms require some form of water to survive. It's simple, no water- No life. Yet freshwater demand already exceeds supply in certain areas of this planet and water is becoming the "new oil".

Following the hydrological cycle and the architecture of the Earth surface we explore how the geochemistry of water is impacted by processes in the atmosphere, biosphere, pedosphere (soil) all the way down to groundwater, where water interacts with the lithosphere. This is an interdisciplinary course, and we will draw from concepts from various fields in Earth and environmental sciences including geology, mineralogy, geochemistry, soil sciences, ecology and hydrology. We will apply specific principles in chemistry (process) and explore how these might have implications at larger temporal and spatial scales (pattern).

We will use data from the US Geological Survey and Critical Zone Observatories (CZO) where hands on conceptual and quantitative approaches help you to understand the geochemistry of natural waters in a comprehensive way. We will practice with real datasets and formulate and test hypotheses about the source of water constituents and processes that control water chemistry in the system now often termed the Critical Zone (CZ).

By spanning so many disciplines and approaches across scales, everybody will likely be outside of their comfort zone for some of the time in this course. It is actually very important for scientists to develop healthy strategies to work within this discomfort and take responsibility for developing individual and team skills. You will encounter some of it in this course and will have a chance to reflect on experiences.

*We will work with these main course goals:*

**Course Goal #1 - Knowledge:** Apply the knowledge of solute sources and geochemical reactions (acid-base, redox) to interpret processes controlling the composition of natural waters.

**Course Goal #2 - Understanding:** Apply your process understanding to interpret excel spreadsheet analysis of geochemical data (e.g. time-series and correlation plots).

**Course Goal #3 - Synthesis:** Demonstrate the ability to synthesize processes that impact water geochemistry with concept sketches and/or descriptions.

**Course Goal #4 - Communication:** Engage a peer audience to effectively communicate the importance of scientific findings as a group.

**Course Goal #5 - Responsibility:** Demonstrate the ability to reflect on own role in a scientific group, take responsibility and contribute to a positive work environment for all.

**Completing this course fulfills the following general education requirements:**

N1: Natural Science (without lab):

1. Demonstrate familiarity with scientific thought, observation, analysis, experimentation, and formal hypothesis testing in relation to the general field or topic of the course.
2. As appropriate to the level and field of the course, make informed judgments about scientific information and arguments related to the natural world.
3. As appropriate to the level and field of the course, use appropriate theories and models to predict change in natural systems over time.

QD: Quantitative and Data Literacy requirement:

- Present data in a variety of ways, including analytical, graphical, and tabular.
- Interpret data, solve problems, and draw conclusions from data presented in a variety of ways, including analytical, graphical, and tabular, and communicate the thought processes involved.
- Evaluate data-rich information and determine whether the resulting conclusions make logical sense or support a given argument within the context provided.

**Assessment:**

- **Quizzes (Course Goal 1-2):** assesses knowledge and understanding in open-book quizzes. You will use data and tools we practiced in class, and you will have the option to take make-up quizzes for most items if you choose to do so. Note: I encourage peer-to-peer mentoring and it is fine to work in study groups, but you need to hand in your own work, and you need to have understood what you are submitting. Submitting somebody else's answer is plagiarism.
- **Concept sketches (Course Goal 3):** assesses your ability to synthesize and clarify interrelations between CZ layers, disciplines, processes, and patterns. We will practice sketches in class, and you will hand in sketches for each of the main modules.
- **Presentation (Course Goal 4):** assesses your science communication skills during an oral group presentation of a scientific paper that covers the current class theme (rain, soil, etc). We will use a rolling rubric, which means that we will amend the rubric with additional items as the semester proceeds.
- **Written reflection and observation in class (Course Goal 5):** considers the extent to which you take responsibility for (and reflect on) your own role in science in general and this course specifically.

**Grading:** We will use a modified version of specs (specifics) grading, which means you know what you need to do in order to receive a specific grade. This approach gives you agency but also responsibility. For example, to receive an A you need a "pass" on 90% of all knowledge questions over the course of the semester. If in quiz 1 you only get a pass on 5 out of 10 questions (50%), do yourself a favor, study and retake the quiz. One-time make-up options will be available for knowledge, understanding and synthesis assessment. Below the requirement bundles for different grades, you will find rubrics for each category in the appendix.

	Category	A	B	C
<b>Quizzes &amp; sketches</b> <i>One retake option available for each</i>	<b>Knowledge questions</b>	Pass on ≥ 90%	Pass on ≥ 80%	Pass on ≥ 70%
	<i>and</i>			
	<b>Understanding questions</b>	Pass on ≥ 90%	Pass on ≥ 80%	Pass on ≥ 70%
	<i>and</i>			
	<b>Synthesis essays/ concept sketches</b>	Pass on 4/5	Pass on 3/5	Pass on 2/5
<i>and</i>				

<b>Communication</b> <i>No retakes</i>	<b>Group presentation</b>	Pass on all basic and 4 progress requirements	Pass on 4 basic and 1 progress requirements	Pass on 3 basic requirements
<b>Responsibility</b>	<b>Reflection</b>	Pass	Pass	No Pass
	<i>The following can move a grade up or down and/or add a "+" (or "-" if not observed).</i>			
	<b>Submissions*</b>	≤ 1 item is late	≤ 3 items are late	> 3 items late
	<b>Learning</b>	<ul style="list-style-type: none"> <li>• Always present* and fully engaged**</li> <li>• Catches up on missed class without making work for others.</li> <li>• Explores and applies learning strategies</li> <li>• Communicates issues early and effectively</li> <li>• Is resourceful, uses resources appropriately</li> </ul>		
	<b>Awareness</b>	<ul style="list-style-type: none"> <li>• Learns from mistakes</li> <li>• Takes feedback constructively</li> <li>• Offers feedback mindfully and constructively</li> <li>• Manages boundaries effectively (own and others)</li> </ul>		

See the full rubric (grades A-F) in the appendix.

**\* Exceptions for presence:**

- **Emergency:** an emergency is **serious, outside of your control and unexpected**. Note that most things that feel like an emergency might be unexpected, but not outside your control. For example, a computer breakdown 5 minutes before a quiz is due is entirely preventable by submitting work often and early. In other words, bad planning is not an emergency.
- **University business:** you are excused from class if you attend a research conference or are on official University business (team competitions etc). Please inform me early.

**\*\*Fully engaged:**

- **Contribute:** you find ways to contribute, by for example, helping others, contributing content during discussions, being active in group work or similar.
- **Refrain from** doing other work in class (emailing, texting, web browsing etc.), distract others (excessive chatting, goofing around) or produce work for others by coming unprepared to class.

**Further Reading:** there is no required book for this course, however, the following books may be helpful:

“Global Environment: Water, Air and Geochemical Cycles” by Berner and Berner;

“Soil and Water Chemistry, an Integrative Approach” by Essington.

“Environmental and Low temperature Geochemistry” by Pete Ryan;

**Schedule (subject to changes):**

Over the course of the semester, we will move through the Critical Zone (CZ), i.e. the system from tops of the tree canopy to the actively cycle ground water and investigate how water composition changes. Note that we typically have a shift in timing due to presentation schedules, a sick day, snow days etc. Please refer to communication on Brightspace for planned activities.

Week	Topics	Example activities
<i>Introduction</i>		
1	The Critical Zone: concept, patterns & processes	Lateral thinking, concept sketches
<i>Atmospheric inputs</i>		

2	acid rain, pH	Origin of rain, excess concentrations, presentations
3	ionic strength, charge balance	Rainwater data work
4	activity, strong and weak acids	Calculating pH
<i>Shallow subsurface</i>		
5	hydration vs. hydrolysis	Aluminum concept sketch
6	speciation	Geochemical models
7	soil respiration, alkalinity	pCO <sub>2</sub> calculations in soil water
8	organic matter	Recognizing organic constituents
<i>Deep subsurface</i>		
9	Mineral soil and organic matter	
10	Weathering and deep soil water	Weathering reactions, calculating tau values
11	Ground water composition	Redox dynamics
<i>Surface waters</i>		
12	Flow paths vs. in-stream processes	double paradox, working with stream data
13	<i>Thanksgiving recess</i>	
14	Watershed and permafrost	Case studies in Alaska
15	Watershed processes	Case studies, hydrologic vs biogeochemical controls

**Rules: WHAT'S OK AND WHAT'S NOT OK**

**ACADEMIC HONESTY AND PLAGIARISM** – Academic honesty is expected of all students. The University of Vermont has a very strict policy concerning academic honesty and plagiarism. Please see the statement on academic honesty <http://www.uvm.edu/~uvmppg/ppg/student/acadintegrity.pdf>. Plagiarism constitutes a violation of Academic Honesty and warrants failure on an assignment and/or failure in the course. The consequences of plagiarism or cheating range from a score of zero on the assignment or exam, to failing the class with an XF and filing a complaint with the University's Coordinator for Academic Honesty which can result in expulsion from UVM.

**What's OK:** it's ok and even expected that you work together and help each other with work in lecture and labs. For individual assignments it is OK to ask a friend, tutor, or group member to help you, however, you have to compile your own work based on this understanding.

**What's not OK:** Delivering any work without having understood it brings you into a potential danger zone: it is not ok to simply copy an answer, writing or quizzes. Plagiarism includes copying part or all of a fellow student's report, copying from original references, texts, or websites without proper citations etc.

**RESPECT** – It is of utmost importance to maintain a respectful environment in class, and this includes online environments. We expect this from all of you as you should expect this from us. You are here to learn, and we are here to help you learn with mutual respect.

**What's OK:** it's OK to arrive late if you have any unforeseeable events. It's OK to miss class for any reason that is out of your control (e.g. sickness) BUT I expect you to make up for it. This means complete all assigned reading, online content and contact your group for additional materials, spend some time with this BEFORE you contact me with questions.

It's OK to disagree with each other and ask for clarification. It's OK to feel frustrated when things don't go well.

**What's not OK:** It is not OK to disrupt class. It is not OK to expect a private tutoring session from me if you missed class for any reason. Before you contact me or come to office hours you should complete all assigned reading, watching, check in with your group as appropriate and spend some time thinking about the materials. I will be happy to address any remaining issues. It is not OK to blame, shame or insult anybody e.g., when you disagree. It is not OK to work out your frustration on others.

**COPYRIGHT ON TEACHING AND CURRICULA MATERIALS** – It is the University's policy that teaching and curricular materials (including but not limited to classroom lectures, class notes, exams, handouts, and presentations) are the property of the instructor.

**What's OK:** you can and will use all class materials for your own learning.

**What's not OK:** electronic recording and/or transmission of classes or class notes is prohibited without the express written permission from me. Such permission is to be considered unique to the needs of an individual student (e.g., ADA compliance), and not a license for permanent retention or electronic dissemination to others. For more

information, please see the UVM policy on Intellectual Property, sections 2.1.3 and 2.4.1. In short, do not share any class materials.

**EMAIL** – email is an important way of communicating; at the same time, it is not uncommon for faculty members to receive more than a 100 emails per day and emails can get lost.

**What's OK:** please contact me with any questions on the lecture or lab part that you cannot solve by yourself; I will answer you within a few business days. If you want an appropriate answer to your particular question, it is important to be precise in your wording. Also, please note that I will not answer emails during afterhours or weekends.

**What's not OK:** please do not contact me with questions you could have googled or ask content questions before you completed the assigned reading/watching. Please don't count on last minute help during afterhours when an assignment is due, you might not get an answer in time. Please use a respectful tone when writing me. For me it is OK to address me by my first name but note that this varies by instructor, and you should ask if you are unsure. It is not uncommon that faculty are addressed with "Yo", "Dude" etc, which is not acceptable.

**SICK?** – We still are dealing with COVID...

**What's OK:** If sick and potentially infectious (COVID, Flu, etc.), please do not come to class and let me know by email. After getting over a cold, consider wearing a mask for some time as a courtesy to others.

**What's not OK:** please do not come sick to class. It used to be considered "heroic" to push through and come to work/class feverish, coughing and sniffing. But all you do is prolong your recovery and get others sick. Take care of yourself and of others by staying home.

**RELIGIOUS HOLIDAYS** – We endorse observation of religious holidays!

**What's OK:** by the end of the second full week of classes submit in writing your documented religious holiday schedule for the semester to us. Plan ahead and make you're your group knows if you will miss group work. Students who miss work for the purpose of religious observance will be allowed to make up this work. Please avoid informing us post-hoc (after the fact).

#### **OTHER INFORMATION and POLICIES:**

In keeping with university policy, any student with a documented disability interested in utilizing ADA accommodations should contact Student Accessibility Services (SAS), the office of Disability Services on campus for students. SAS works with students and faculty in an interactive process to explore reasonable and appropriate accommodations, which are communicated to faculty in an accommodation letter. All students are strongly recommended to discuss with their faculty the accommodations they plan to use in each course. Faculty who receives Letters of Accommodation with Disability Related Flexible accommodation will need to fill out the Disability Related Flexibility Agreement. Any questions from faculty or students on the agreement should be directed to the SAS specialist who is indicated on the letter.

#### **Contact SAS:**

A170 Living/Learning Center;

802-656-7753

[access@uvm.edu](mailto:access@uvm.edu)

[www.uvm.edu/access](http://www.uvm.edu/access)

**A credit hour is now formally defined**, for Title IV aid purposes, as an amount of work that reasonably approximates not less than: (a) one hour of classroom or direct faculty instruction and a minimum of two hours of out of class student work each week for approximately fifteen weeks for a semester or (b) at least an equivalent amount of work as required in (a) for other academic activities such as laboratory work, internships, practica, studio work, or other academic work leading to the award of credit hours.

#### **Alcohol and Cannabis Statement:**

The Division of Student Affairs has offered the following statement on alcohol and cannabis use that faculty may choose to include, or modify for inclusion, in their syllabus or Blackboard site:

Statement on Alcohol and Cannabis in the Academic Environment

As a faculty member, I want you to get the most you can out of this course. You play a crucial role in your education and in your readiness to learn and fully engage with the course material. It is important to note that alcohol and

cannabis have no place in an academic environment. They can seriously impair your ability to learn and retain information not only in the moment you may be using, but up to 48 hours or more afterwards. In addition, alcohol and cannabis can:

- Cause issues with attention, memory and concentration
- Negatively impact the quality of how information is processed and ultimately stored
- Affect sleep patterns, which interferes with long-term memory formation

It is my expectation that you will do everything you can to optimize your learning and to fully participate in this course.

**Teaching and Learning Style:** Students learning style and instructors teaching style do not always match but there are ways to help each other. A good start is to assess *your* own learning style and to find out 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.

## Appendix:

### Assessment rubrics:

<b>Knowledge</b>	
<b>Pass</b>	<b>Fail</b>
answer is factually correct	answer is factually incorrect.

*Note: knowledge questions will be automatically graded, but the Brightspace system might not always correctly grade answers, especially if there is a rounding issue or a typo in short answer questions. If you suspect this to be the issue, please let me know. However, if the answer is just wrong, you have the option to take a make-up quiz.*

<b>Understanding</b>	
<b>Pass</b>	<b>Fail*</b>
<ul style="list-style-type: none"> <li>• Addresses the question, offers relevant answers.</li> </ul> and <ul style="list-style-type: none"> <li>• Demonstrates an accurate and complete understanding of the subject matter and the question.</li> </ul> and <ul style="list-style-type: none"> <li>• Demonstrates a clear understanding of meaning of results.</li> </ul> and if applicable <ul style="list-style-type: none"> <li>• Backs answers or conclusions with data examples and/or arguments.</li> </ul>	<ul style="list-style-type: none"> <li>• Does not address the question, or states no relevant answers.</li> </ul> and/or <ul style="list-style-type: none"> <li>• Indicates misconceptions, does not demonstrate accurate understanding of the subject matter and the question.</li> </ul> And/or <ul style="list-style-type: none"> <li>• Indicates lack understanding of meaning of results.</li> </ul> And if applicable <ul style="list-style-type: none"> <li>• Does not back answers or conclusions with data examples and/or arguments.</li> </ul>

*Note: you have the option to take a make-up quiz for understanding questions as well. Please consider that these type of questions are mostly hand-graded, so please put effort into it if you want a good grade. In other words, please do not make me hand-grade a make-up quiz if you do not plan to put in the work.*

<b>Synthesis: Concept sketches and descriptions</b>	
<b>Pass</b>	<b>Fail</b>

<p><u>Complete:</u> All essential concepts, processes and relationships are shown and</p> <p><u>Correct:</u> All essential concepts, processes and relationships are correctly portrayed - no conceptual errors or evidence of misunderstanding and</p> <p><u>Clear:</u> Sketch is detailed, clearly drawn and labeled effectively</p>	<p><u>Incomplete:</u> More than 1 essential concept, process or relationship is missing and/or</p> <p><u>Incorrect:</u> Conceptual error or evidence of misunderstanding in <b>any</b> concepts, processes and relationships and/or</p> <p><u>Unclear:</u> Sketch lacks detail, not clearly drawn and/or not labeled effectively</p>
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*Note: artistic ability is not an assessment criterion, and you are not at a disadvantage if you are not good at drawing, sketching etc. In fact, elaborate artwork can sometimes make it harder for the reader to understand a concept sketch. However, pay attention to how you use space effectively for sketching and labelling.*

**Communication: Paper presentations nuts and bolts:**

- The presentation should be 12-15 minutes long with 5 minutes Q&A and feedback.
- Use power point or google slides, bring the presentation on a thumb drive, google or have your computer with you (with an adapter).
- Come a few minutes early to get your presentation uploaded on the classroom media system
- Rule of thumb: you'll need ~1 minute/per slide, don't exceed 20 slides
- Give enough background so that class can follow
- Present the main points of the paper
- Don't overcrowd the slides, especially avoid too much text
- Use plenty of visualizations and avoid data tables (or highlight aspects of a data table)
- You also should anticipate general questions from the audience and prepare for them. We will not expect you to know everything, but you should be able to define abbreviations, explain main underlying principles of presented work and have answers to questions like: why does this matter? Is this important for other areas, systems, countries as well? Where is the study situated? If it is an older paper, anticipate questions on what has changed since.

**Grading:** We will use an evolving rubric for our presentation grades, this means that we will continuously amend the "base requirements" listed in our presentation rubric below with "progress requirements". Attending each other's presentations and feedback is important in order to prepare your presentation with these additional requirements in mind.

A = meets 4 progress & all base expectations categories, B = meets 4 base expectations categories, C = meets base expectation in 3 categories, D = meets base expectations in 2 categories, F = below, no show, late cancellation (except emergencies).

Class presentation requirements			
Category	Progress expectations	Base expectations	Below expectations*
Presenter		<ul style="list-style-type: none"> <li>• Pays attention to audience</li> <li>• Knows presentation well</li> </ul>	<ul style="list-style-type: none"> <li>• Ignores audience</li> <li>• Unprepared: does not seem to know presentation well</li> </ul>
Content		<ul style="list-style-type: none"> <li>• Content is accurate</li> <li>• Content is applicable to class</li> </ul>	<ul style="list-style-type: none"> <li>• Content misconception</li> </ul>

Flow		<ul style="list-style-type: none"> <li>Information is presented in a logical order</li> <li>Transitions between slides/presenters are smooth</li> <li>Presenter keeps allotted time</li> </ul>	<ul style="list-style-type: none"> <li>Jumpy presentation and transitions</li> <li>Presentation too short or too long</li> </ul>
Slides		<ul style="list-style-type: none"> <li>Put care into slides</li> <li>Slides are not overcrowded</li> <li>Amount of text is limited and font is large</li> </ul>	<ul style="list-style-type: none"> <li>Sloppy slides</li> <li>Crowded slides</li> <li>Mostly text</li> <li>Small text</li> </ul>
Discussion		<ul style="list-style-type: none"> <li>Presenters have subject knowledge</li> <li>Answers are thoughtful and concise</li> </ul>	<ul style="list-style-type: none"> <li>Presenter did not understand subject.</li> </ul>

*\*Not meeting the base expectations typically happens when students forget about the presentation or start working on it too late. This often leads to jumpy presentations, use of badly recycled materials, sloppy slides and on top of it all can cause you a great deal of anxiety. Issues in the “flow” category often are additionally a result of team issues (somebody not pulling their weight, conflict etc). To prevent this, start early and consider making a team contract. Example [https://capstone.unst.pdx.edu/sites/default/files/Group%20Work%20Contract%2C%20Gloria%20Totten\\_0.doc](https://capstone.unst.pdx.edu/sites/default/files/Group%20Work%20Contract%2C%20Gloria%20Totten_0.doc).*

**Class:** During the presentation it is best to make notes for questions to ask later. The trick to having a good question is to think about it during the presentation, not only at the end. If you’re especially nervous about public speaking, make yourself ask one question per month, its good practice! Because we will amend the rubric as we go, pay attention to the presentation and feedback, and be prepared to give (and take) feedback constructively.

**Feedback:** Feedback from the class is important and requires as much skill as presenting. We will discuss how to give feedback and amend the list below, but these are the basics for you to consider:

**You are ready to offer feedback** when

- You know that you are imperfect and worthy, just like the presenter
- You are aware of power dynamics, implicit bias, and stereotypes
- You have something to contribute to our collective learning

**Your feedback might be valuable** when

- Your feedback is specific, constructive and task oriented
- Your feedback is worded with your experience in mind (“...I could not see the writing on the table, consider increasing the font”).

**Fear of public speaking?** If you struggle with anxiety around public speaking, please contact me at the beginning of the semester. We have lots of ways of working with it (e.g. present from your seat, present virtually, use a video instead of a ppt etc.) and can discuss.

Reflection	
Pass	Fail
<ul style="list-style-type: none"> <li>Critically reflects on all aspect of the reflection prompts thoughtfully, with depth and care.</li> <li>Shows awareness of own role in situations</li> <li>Uses examples of specific situations or contexts</li> </ul>	<ul style="list-style-type: none"> <li>Does not address the prompt, offers surfcial answer to reflection prompts or</li> <li>No indication of self-awareness. or</li> <li>Response is vague, lacks examples or specifics</li> </ul>



Rubric for lower grades. Since you have the possibility to retake quizzes or resubmit items within a given time-frame, you have the agency to improve your grade throughout the course.

	<b>Category</b>	<b>D</b>	<b>F</b>
<b>Quizzes</b>	<b>Knowledge questions</b>	Pass on 60%	Pass on 50%
	<i>and</i>		
	<b>Understanding questions</b>	Pass on 60%	Pass on 50%
	<i>and</i>		
	<b>Synthesis essays/ concept sketches</b>	Pass on 40%	Pass on 20%
<b>Communication</b>	<i>and</i>		
	<b>Group presentation</b>	Pass on 2 basic requirements	Pass on less than 2 basic requirements
<b>Responsibility</b>	<b>Reflection</b>	No Pass	No Pass
	<b>Submissions</b>	4 items late	missing items and more than 4 late items
	<i>The following metrics can move a grade up or down and/or add a "+" (or "-" if not observed).</i>		
	<b>Learning</b>	<ul style="list-style-type: none"> <li>- Always present and fully engaged**</li> <li>- Catches up on missed class without making work for others.</li> <li>- Explores and applies learning strategies</li> <li>- Communicates issues early and effectively</li> <li>- Is resourceful, uses resources appropriately</li> </ul>	
	<b>Awareness</b>	<ul style="list-style-type: none"> <li>- Learns from mistakes</li> <li>- Takes feedback constructively</li> <li>- Offers feedback mindfully and constructively</li> <li>- Manages boundaries effectively (own and others)</li> </ul>	