Georgia Institute of Technology
School of Earth and Atmospheric Sciences

Course title:	Mineral Surface Geochemistry
Course number:	EAS 4803/8803-YT
Term:	Spring 2018
Credit hours:	3
Time & location:	T/Th 12:00-1:15 pm, Clough Commons 272

Instructor: Prof. Yuanzhi Tang
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Office hours: T/Th 2 – 3pm, or by appointment (email only)

Overview

Fundamental principles concerning mineral surface properties, element distribution at the mineral-water interface, and analytical techniques relevant to interfacial reactions.

Course Description

Chemical reactions occurring at the mineral-fluid interfaces are ubiquitous on Earth and other planets. They control the transport and distribution of a wide range of nutrients, carbon, metal, and organic and inorganic contaminants. In this course, we will learn the fundamental principles concerning mineral surface properties, element distribution in aqueous solutions and at the mineral-water interface, as well as a range of analytical techniques that are relevant to these interfacial reactions. We will also host guest lectures on selected topics and tour user facilities (if schedule allows).

Learning Outcome

Upon completion of this course, students will be able to:

- Describe the main minerals that are important in environmental systems
- Become familiar with the basics of crystal chemistry
- Understand the fundamental principles of mineral surface structure
- Understand the principles controlling metal ion interaction at mineral-water interfaces
- Get exposure to the roles of microorganisms in controlling mineral formation and dissolution
- Get exposure to a range of analytical techniques relevant to interface reactions
- Develop skills that are necessary for scientific discussion and for the analysis of current scientific literature

Recommended Textbook

There are no assigned textbooks for the course. Course material will be based on class notes, handouts, and assigned readings. It is recommended that everyone has access to mineralogy and aqueous geochemistry textbooks. The following books are recommended:

- Cornelis Klein & Barbara Dutrow.2007. The manual of mineral science. 23th Edition. Wiley.
- Donald Langmuir. 1997. Aqueous environmental geochemistry. Prentice Hall.

Below are a few additional useful reference books:

- Werner Stumm and James J. Morgan. 1996. Aquatic chemistry: Chemical equilibria and rates in natural waters. Wiley.
    - Hard copy and online access available at GT library
- Kurt Konhauser. 2007. Introduction to Geomicrobiology. Blackwell Publishing.
- Garrison Sposito. 2004. The surface chemistry of natural particles. Oxford.

- Susan Brantley, James Kubicki, Art White. 2007. Kinetics of water-rock interaction. Springer.

Evaluation and Grading
Those with final grades between 90-100% are guaranteed an A; 80-89.9% are guaranteed at least a B; 70-79.9% are guaranteed at least a C; 60-69.9% are guaranteed at least a D; anyone earning a course grade less than 60 will receive an F. Grade cutoffs might be lowered but not raised.

- **Attendance and participation (5%).** If you miss 6 classes, you will not pass.
- **Assignments and projects (55%).** Besides regular homeworks, there will also be an assignment on instrumental proposal. Because we will cover a range of analytical techniques, the students will pick an instrument that is relevant for their background and/or research, and write a 2-page proposal that describes the research needs, experimental set up, and expected outcomes. More detailed instructions will be given in class.
- **Midterm (20%).** Graduate students will be required to answer extra questions.
- **Term paper (15%) and presentation (5%).** This paper should be a critical review on a topic of interest to the student and is relevant to chemical processes occurring at mineral-fluid interfaces. The term paper should be typed in a standard word processor and be 10-12 pages in length. It should contain an introduction that presents the importance of the topic in geochemistry or environmental science and outlines the rest of the paper. The discussion on the topic should highlight the recent progress made on the topic, and should provide recommendations for research progress that needs to be made in the future. Students will also deliver a final presentation on their term paper topic at the end of class. More details on the term paper topic selection and format will be discussed in class.

Late policy
All material handed in late will be deducted 10% per day.

Academic Integrity
Academic dishonesty will not be tolerated. This includes cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code. Plagiarism includes reproducing the words of others without both the use of quotation marks and citation. Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at www.honor.gatech.edu.

Learning Accommodations
If needed, we will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the Office of Disability Services (http://disabilityservices.gatech.edu).

SLS affiliation
This course is part of Georgia Tech's Serve-Learn-Sustain (SLS) initiative, uniting classroom learning with community action. SLS works with all six colleges to offer courses and programs connecting sustainability and community engagement with real-world partners and projects, allowing students to use their disciplinary expertise related to science and technology to help "create sustainable communities" where humans and nature flourish, now and in the future, in Georgia, the U.S., and around the globe. More information about SLS can be found at www.serve-learn-sustain.gatech.edu. Visit the website to sign up for the SLS Email List, view the full list of affiliated courses, and find links to Facebook, Instagram and Twitter.

Tentative topics

- Coordination chemistry, chemical bonding
- Principles of crystal chemistry
- Common minerals (e.g. carbonates, phosphates, silicates, metal oxides)
- Mineral surface structure and properties
- Interactions at mineral-fluid interface: dissolution/precipitation, substitution, adsorption, redox reaction
- Role of mineral-fluid interactions on controlling contaminant/nutrient fate and transport, chemical weathering, and biomineralization
- Analytical techniques for mineral-water interface studies

Tentative class schedule (Spring 2018)

Week	Date	Lecture	Deadlines	Reading*
1	1/9	Introduction and overview		
	1/11	**Basics of crystal chemistry:** - Bonding, coordination, closest packing		Klein Ch3, Ch4 (p66-68), Shannon 1976
2	1/16	No class		
	1/18	- Pauling's rules, unit cell		Klein Ch4 (p68-83), Ch6
3	1/23	- Point symmetry - Translational symmetry, Bravais Lattices	HW #1	Klein Ch6 (109-129) Klein Ch7 (p143-164)
	1/25	- Space groups, crystal systems, crystallographic axes, Miller indices		Klein Ch7 (164-168) Klein Ch6 (p129-134)
4	1/30	- Substitution **Minerals:** - Silicates (classification, tectosilicates)	HW #1 due	Klein Ch5 (p96-99) Klein Ch18 (p434-438, 467-482)
	2/1	- Silicates (phyllosilicates, clay minerals) - Metal oxides (Fe, Mn oxides)	HW #2	Klein Ch18 (p456-467) Klein Ch16 (p368-375)
5	2/6	**Techniques:** XRD (guest lecture)		Klein Ch14 (p308-321)
	2/8	**Minerals:** Carbonates, phosphates, sulfates		Klein Ch17 (p399-403, 406)
6	2/13	**Aquatic ions**	HW #2 due	Langmuir Ch3 (p82-99, 112-114)
	2/15	**Mineral surface properties:** - Surface structure, surface charge **Reactions at mineral-fluid interface:** - Adsorption	HW #3	Langmuir Ch10 (p343-353) Langmuir Ch10 (p353-371)
7	2/20	- Sorption isotherm - Electric double layer		Langmuir Ch10 (p353-371) Maurice Ch6 (p153-157)
	2/22	- Surface complexation models - Case study	HW #3 due	Maurice Ch6 (p155-163) Arai 2001, Elzinga 2009
8	2/27	Homework and midterm review		
	3/1	**Midterm**		
9	3/6	**Techniques:** Synchrotron X-ray techniques	HW #5	
	3/8	**Reactions at mineral-fluid interface:** - Mineral dissolution, chemical weathering		Langmuir Ch7 Optional: Brantley Ch5
10	3/13	- Precipitation and nucleation		Stumm Ch6, Rimer 2010
	3/15	**Techniques:** - SEM/TEM (guest lecture)		Maurice Ch4
11	3/20	Spring break, no class		
	3/22	Spring break, no class		
12	3/27	- AFM, XPS, vibrational spectroscopy	HW #4	Maurice Ch4
	3/29	- NMR (guest lecture)		
13	4/3	**Reactions at mineral-fluid interface:** - Oxidation-reduction	Term paper topic due	Langmuir Ch11 MIsra Ch8
	4/5	- Nanoparticles (guest lecture)	HW #4 due	Maurice Ch13
14	4/10	**Microbe-mineral interactions:** - Biosorption - Bioweathering		Maurice Ch12 Optional: Konhauser Ch3 Optional: Konhauser Ch5
	4/12	- Biomineralization	HW #5 due	Maurice Ch12 Optional: Konhauser Ch4
15	4/17	Term paper presentations	Presentation due	
	4/19	Term paper presentations		
16	4/24	Term paper presentations	Term paper due	

***Note:**

- Klein (Cornelis Klein & Barbara Dutrow. 2007. The manual of mineral science. 23th Edition. Wiley)
- Langmuir (Donald Langmuir. 1997. Aqueous Environmental Geochemistry. Prentice Hall)
- Maurice (Patricia Maurice. 2009. Environmental Surfaces and Interfaces from the Nanoscale to the Global Scale. Wiley)
- Stumm (Werner Stumm. 1992. Chemistry of the Solid-Water Interface. Wiley)
- Konhauser (Kurt Konhauser. 2007. Introduction to Geomicrobiology. Blackwell Publishing)