**Course title:** Environmental Geochemistry

**Instructor:** Martial Taillefert, Yuanzhi Tang, Jennifer Glass, Ellery Ingall

**Text (required):** *Introduction to Geochemistry: Principles and Applications*, Kula C. Misra, Wiley and Blackwell, 2012.

**Reference text (optional):** *Aquatic Chemistry. Chemical equilibria and rates in natural waters* (3rd Edition), W. Stumm and J. J. Morgan, Wiley, 1996.

**Prerequisite:** Calculus II (MATH 1502) and Chemical Principles II (CHEM 1212K)

**Course Overview:** The objective of this course is to learn how chemical, biological, and geological processes control the distribution of chemicals in aquatic and soil environments. Geochemical processes are central to a variety of environmental issues, including the distribution of CO2 on Earth and the transformation and storage of inorganic and organic contaminants. Simultaneously, geochemical processes are involved in the transformation of natural species, including nutrients, carbon, and minerals. In this course, students will study the fundamental geochemical processes regulating the distribution of chemicals in environmental systems and learn how to predict the distribution of these species in aquatic systems and soils using an equilibrium approach.

**Evaluation:** homeworks (25%), 1 mid-term exam (25%), final exam (25%), and 1 term paper (25%).

**Course Outline:**

* **Introduction to Geochemistry**
* History of geochemistry and aqueous geochemistry
* The hydrological cycle
* Composition of natural waters
* **Chemical Thermodynamics and Kinetics**
* Principles of chemical thermodynamics
* Chemical potential and activity of solutions
* The equilibrium constant: temperature and pressure effects
* Kinetics vs. thermodynamics
* Rates, mechanisms, and elementary reactions
* **Acid and Bases**
* The strength of an acid or base
* pC-pH diagrams: pH as a master variable
* Buffer intensity and neutralizing capacity
* Production of acidity in the environment
* **The Carbonate System and pH in Natural Waters**
* Dissolved carbonate equilibrium in closed and open systems
* Atmosphere water interactions: Henry’s law
* Alkalinity changes: the effect of photosynthesis and respiration
* Equilibrium with solid carbonates
* **Metal Complexation in Aqueous Solutions**
* Natural and anthropogenic sources in aquatic systems
* Complexation by inorganic and organic ligands
* Calculating the speciation of metals in natural waters
* Metals as essential nutrients and toxic compounds for living organisms
* **Precipitation and Dissolution of Minerals**
* The solubility of minerals: clays, hydroxides, carbonates, sulfides
* The phase rule: components, phases, and degrees of freedom
* Kinetics of mineral dissolution: weathering
* **Oxidation and Reduction**
* Redox equilibria and the electron activity
* Electrode potential: the Nernst Equation
* pe-pH diagrams
* Redox conditions in natural waters: microbial vs. chemical influence
* **Reactions at the Mineral-Water Interface**
* Adsorption and adsorption isotherms
* Hydrous oxide surfaces: complexation by H+, OH-, cations and ligands
* Surface charge, the electrical double layer, and effect on equilibria
* Ion exchange reactions in natural waters

**Term paper**

A term paper will be required from each student in the class. This paper should be a critical review on a geochemical topic of interest to the student. The term paper should be typed in a standard word processor and be 10 pages in length (Font: Times 12; Lines: double-spaced) not including figures and references. It should contain an introduction that present the importance of the topic in geochemistry and outline the rest of the paper. The discussion on the topic should highlight the recent progresses made on the topic, include calculations relating to the topic using MINEQL+ or any other software (e.g., Matlab, PHREEQ-C), and should provide recommendations on the progresses that need to be made in the next decade. Topics should be approved by the instructor by week 5. A first draft of the paper is due at the end of week 12, and the final paper is due on the last day of class.

**Regulations and Honor Code**

We expect all students participating in the course to follow the honor code of Georgia Tech. Absences need to be excused prior the beginning of the class. E-mail is fine but the instructor reserves the right to ask for an official excuse. Homeworks must be turned in at the beginning of class on the designated dates. There will be a 10% deduction per day the home is turned late. Homeworks do not have to be typed in but are supposed to be neatly presented, ordered in a logical fashion, and include clear responses. Students are encouraged to work together on the homeworks, though each student will return their own answers to the problems. No plagiarism will be tolerated with homeworks, exams, or the written project.