GEOCHEMISTRY OF NATURAL WATERS: 370

Instructor, Bereket Haileab
Office Mudd 162
Tuesday: 10:10 –11:55 AM
Thursday: 10:10 –11:55 AM
Laboratory: Tuesday 1:00–5:00 PM
Office hours: Wednesday 9:00 AM-12:00 PM

This course will explore: principles of geochemistry, applications of chemical thermodynamics to geologic problems, minerals solubility's, stability diagrams, chemical aspects of sedimentary rocks, geochemical tracers, radiogenic isotopes and principles of stable isotope fractionation.

Textbook (required)
The Geochemistry of natural waters; by James I. Drever, 3rd Edition

Recommended textbooks:
Geochemistry, An Introduction, Francis Albarede
Geochemistry; by Richardson and McSween
Aquatic chemistry; by Stumm and Morgan
Chemical equilibrium in the Earth; by Brocker and Oversby
Tracers in the Sea; by Brocker and Peng
Aqueous Environmental Geochemistry, by Donald Langmuir
Stable Isotope Geochemistry, by Hoefs
Applied Chemical Hydrogeology, by Alan E. Kehew

Grading:

Homework	10%
Class participation	30%
Midterm take home exam	20%
Term paper	40%

Term paper
Instead of final exam you will write a term paper on some aspect of geochemistry of natural waters. Topic will be selected during the first week of classes You have to collect samples, analyze them and report your findings in a scientific format. It will require careful and thorough literature search and research. The term paper will not be due until the last day of classes (June 1), but I have established several interim deadlines to ensure you don't end up trying to do the whole thing at the very end of the term.

Lecture days: Days

March 29	Hydrologic cycle
March 31	Using Stable Isotopes/Ann Zawistoski (librarian) will visit class (11:00-12:00)
April 5	Using Stable Isotopes Continued
April 7	Using Stable Isotopes Continued
April 12	The Carbonate Systems and pH Control
April 14	The Carbonate Systems and pH Control
April 19	Prof. Yang Wang
April 21	Clays Minerals and the environment continued
April 26	Clays Minerals and the environment
April 28	Field trip to the University of Utah
May 3	Field trip to the University of Utah
May 5	Reading and discussion of selected papers by visiting professors (see last page for your assignment for which papers you are responsible)
May 10	Prof. Emi Ito
May 12	Prof. David Fox
May 17	Reading and discussion of selected papers by visiting professor (see last page for your assignment for which papers you are responsible)
May 19	GSA meeting in Minneapolis
May 24	Prof. Kevin Theissen
May 26	Professor Larry Edwards
May 31	Final Project Presentation

Laboratory:

March 29	Field trip to Cannon River, Cannon River Wilderness Park
April 5	IC and AAS introduction and water analysis
April 12	XRD, XRF
April 19	Preparing sampling for Utah/Florida
April 26	Field trip to Utah
May 3	Final Project
May 10	Final Project
May 17	Final Project
May 24	Final Project
May 31	Final Project presentation

1. Water

- Water
  - Origin of water
  - Natural Isotope of Hydrogen and Oxygen
  - Physical properties of water
  - Global Water Reservoirs and Fluxes
- Hydrologic Cycle, Residence time
- Chemistry of natural waters
  - Chemistry of Rainwater
  - Chemistry of Rivers
  - Chemistry of Lakes
  - Chemistry of Sea Water
  - Chemistry of Unnatural waters: Pollution
  - Chemistry of Groundwater
  - Groundwater as a Resource and Groundwater Contamination
  - Controls of the Composition of Subsurface-waters
- Nonmeteoric Types of Water
- Precipitation Chemistry and Acid Rain
- The pH of rain due to Atmospheric Carbon Dioxide
  - The General composition of Precipitation
  - Acid rain
  - Trace elements in Rain
  - The importance of Defining Background water quality
- The Human factor
  - Irrigation
  - Wetland Drainage
  - Ground cover damage
  - Deforestation
  - Interbasin Diversion
  - Streamflow Management
  - Land Use Changes
  -

Reading: Chapter 1 (James I. Derver) and handout

2. Using Stable Isotopes:

- BASIC CONCEPTS
  - Atomic structure, Periodic Table of the Elements & Structure of the Atomic Nucleus
  - Stable and Radioactive Isotopes
  - What is isotope?
  - Isotope effects
  - Isotope fractionation
  - Equilibrium fractionation
  - Isotopic composition:
  - Fractionation factor and its relation to temperature
  - Isotope standards
  - Kinetic fractionation
  - Variation of isotopic composition with chemical composition and crystal structure
  - Isotopes of interest
- STABLE ISOTOPES IN NATURAL WATERS
  - Meteoric water: (oxygen and hydrogen isotopic composition of meteoric water, Rayleigh fractionation, Meteoric water line)
  - Groundwater, River and lake water
  - Stable isotopes as hydrological tracers (groundwater recharge, mixing & flow path)
  - Application of isotopes to study salinization
  - Application of isotopes to study lake and reservoir's water budget
  - Isotopes in ice cores and paleoclimate
  - Sea water
  - Isotope fractionation between water and vapor as a function of salt content
  - Application of isotopes to study the origin of deep ocean waters
  - Isotope composition of the paleo-ocean water
- ISOTOPE GEOTHERMOMETER
  - Isotope exchange reaction
  - Determination of isotope fractionation factor (theoretical calculation and experimental determination)
  - Paleothermometry
- Oxygen and hydrogen in isotope in Lithosphere
- ISOTOPE IN PLANTS AND SOILS
  - Isotope fractionation during photosynthesis
  - Isotope and diet
  - Isotope in tree rings as paleoclimate indicators
  - Isotope in soil organic matter, soil CO2 & soil carbonates as ecological & climatic indicators
  - Tracing the source of nitrate in groundwater
  - Tracing the source in SO2 in the atmosphere
- LABORATORY: METHODS IN STABLE ISOTOPE ANALYSES
  - Preparation of various samples for Isotope analysis
  - Stable Isotope ration mass spectrometer

Reading: Chapter 14, (James I. Derver), and Handout

4. Chemical Equilibrium, Rate and Natural Systems:

- Thermodynamics
  - Systems at Equilibrium: Thermodynamics
  - Measure of Spontaneity, K*eq*
  - Measure of disequilibrium
  - Activity-concentration relationships
- Transport advection and diffusion

Reading: Chapter 2, (James I. Derver) and handout

5. The Carbonate System and pH control:

- Carbonic Acid System
- Alkalinity and Titration Curves
  - Alkalinity Titration
  - Gran Plots
- Calcium Carbonate Solubility
- Dolomite
- High-Magnesium Calcite
- Ground and Surface Waters in Carbonate Terrains

Reading: Chapter 3, (James I. Derver) and handout

6. Clays Minerals and the environment:

- The Geochemistry of Clay Minerals
- Clay Minerals and Cation Exchange
- Mineralogy and
  - Brucite [Mg(OH),] and Gibbsite [AI(OH)3
  - Kaolinite and Related Minerals
  - 2:1 Clay Minerals
  - Chlorite
  - Mixed-Layer Clays
  - Sepiolite and Palygorskite
- Colloid Properties
  - The Double Layer
  - Membrane Filtration
  - lon Exchange

Reading: Chapter 4, (James I. Derver)

Name	Reading articles from prof.	Date
Ault, Andrew P.	Ito	5-May
Johnson, Micah O.	Ito	5-May
Miltich, Louise I.	Ito	5-May
Jones, Daniel S.	Fox	5-May
Lundquist, Rebekah M.	Fox	5-May
Moeller, Pamela J.	Fox	5-May
Christianson, Keith T.	Edwards	17-May
Hereid, Kelly A.	Edwards	17-May
Pang, Selena T.	Edwards	17-May
Shapiro, Daniel S.	Theissen	17-May
Yospin, Sarina A.	Theissen	17-May
Miltich, Cicely R.	Theissen	17-May
☐	☐	☐
Everyone should the articles and the responsible student should lead the discussion.	☐	☐

Selected Articles by Emi Ito

1. Dorale JA, Edwards RL, Ito E and González LA (1998) Climate and vegetation history of the midcontinent from 75 to 25 ka: a speleothem record from Crevice Cave, Missouri, USA. Science 282: 1871-1874.
2. Hu, F.S., Ito E., Brubaker L.B., and Anderson P.M. (1998) Ostracode geochemical record of Holocene climatic change and implications for vegetational response in the northwestern Alaska Range. Quaternary Research 49:86-95.
3. Anderson, W.T., Mullins, H.T. and Ito E. (1997) Stable isotope record from Seneca Lake, New York: evidence for a cold/dry paleoclimate following the Younger Dryas. Geology, 25:135-138.

Articles by David Fox

4. Fox, D.L. and Fisher, D.C., 2001. Stable isotope ecology of a Late Miocene population of Gomphotherium productus (Mammalia, Proboscidea) from Port of Entry Pit, Oklahoma, USA. PALAIOS 16: 279-293.
5. Fox, D.L., 2000. Growth increments in Gomphotherium and implications for late Miocene climate change in North America. Palaeogeography, Palaeoclimatology, Palaeoecology 156: 327-348.

6. *Fox, D.L., Fisher, D.C. and Leighton, L.R., 1999. Reconstructing phylogeny with and without temporal data. Science 284: 1816-1819.

Articles by Larry Edwards

7. Wang, Y.G., Cheng, H., Edwards, R.L., An, Z.S., Wu, J.Y., Shen, C.-C. and Dorale, J.A. (2001) A high-resolution absolute-dated late Pleistocene monsoon record from Hulu Cave, China. Science 294, 2345-2348.
8. Shen, G.J., Ku, T.-L, Chen, H., Edwards, R.L., Yuan, Z.X. and Wang, Q. (2001) High precision U-Series dating of Locality 1 at Zhoukoudian, China. Journal of Human Evolution 41, 679-688.
9. Beck, J.W., Richards, D.A., Edwards, R.L., Smart, P.L., Donahue, D.J., Hererra-Osterheld, S., Burr, G.S., Calsoyas, L., Jull, A.J.T., and Biddulph, D. (2001) Extremely large variations of atmospheric CO14 during the last glacial period. Science 292, 2453-2458.

Articles by Theissen

10. Theissen, K.M., Dunbar, R.B., and Cooper, A.K., 2003. Stable isotopic measurements of sedimentary organic matter and N. pachyderma (s.) from Site 1166, Prydz Bay continental shelf. In Cooper, A.K., O'Brien, P.E., and Richter, C. (Eds.), Proc. ODP, Sci. Results, 188 [Online]. World Wide Web: http://www-odp.tamu.edu/publications/188_SR/VOLUME/CHAPTERS/005.PDF

11. Theissen, K. M., Dunbar, R. B., Cooper, A. K., Mucciarone, D. A., and Hoffmann, D., 2003. The Pleistocene history of the East Antarctic Ice Sheet in the Prydz Bay region: stable isotopic results from ODP Site 1167. Global and Planetary Change. 39, 227-256.

12. Warnke, D. A., Richter, C., Florindo, F., Damuth, J. E., Balsam, W. L., Strand, K., Ruikka, M., Juntila J., Theissen, K., and Quilty, P., 2004. The Plio-Pleistocene section of ODP Site 188-1165, Prydz Bay, Antarctic continental margin: a high-resolution integrated-stratigraphy committee (HIRISC) report. In: Cooper, A.K. and O'Brien, P.E., (Eds.) Proc. ODP, Sci. Res., 188, 1-38 [Online]. Available from World Wide Web: http://www-odp.tamu.edu/publications/188_SR/VOLUME/CHAPTERS/014.PDF.