Earth Sciences 9506a. Stable Isotope Geochemistry in Earth & Environmental Sciences

When: Monday, Wednesday, Friday, 11:30 to 12:20 pm,
Where: P&AB, Room 117 (lectures are combined with Earth Sciences 4431a)
Instructor: Fred J. Longstaffe, 1023 BGS (Biological and Geological Sciences)
flongsta@uwo.ca
Office hours: by appointment

Teaching Assistants: tba

Prerequisites: Some undergraduate experience in chemistry, geochemistry and/or biology, or permission of the instructor.

Anti-requisite: Earth Sciences 4431a or 431a

Grading:
- Mid-term test: 20%
- Final examination: 40%
- Graduate Project: 20%
- Problem sets (7): 20%


While this textbook is permanently out of print, the author is planning to provide interactive access, and/or a pdf free-of-charge. He has informed me that he has acquired these rights back from the publisher. Stay tuned for updates.

There are assigned readings from the textbook associated with most lectures.

As needed, other materials for this course will be placed on-line on the OWL system: https://owl.uwo.ca/portal

Important dates:
1. Mid-term test: Wednesday, October 19, 2016 (during regular class time)
2. Graduate project due: Friday, November 11, 2016
   This project will require you to assess an isotopic data set and provide an interpretation.
   The data and guidelines on how to begin will be provided to you in mid-October.
3. Due dates of problem sets will be announced in class and indicated on OWL.
4. Final examination date will be set by the Registrar’s office and will be held at the same time as Earth Sciences 4431a.

The Midterm examination date is firm and make-up examinations will not be permitted. Please consult the instructor if you have valid reason for missing the examination. Five % per day will be deducted from the mark assigned to late projects for the first 5 days. Projects submitted more than 5 days late will not be accepted.

Illness and Other Circumstances: If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean’s office as soon as possible and contact your instructor immediately. It is the student’s responsibility to make alternative arrangements with their
instructor once the accommodation has been approved and the instructor has been informed. In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office immediately. For further information please see: 
http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf

A UWO Student Medical Certificate (SMC) is required where a student is seeking academic accommodation. This documentation should be obtained at the time of the initial consultation with the physician or walk-in clinic. An SMC can be downloaded under the Medical Documentation heading of the following web site: 
https://studentservices.uwo.ca/secure/index.cfm

Accessibility Statement: Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x.82147 for any specific question regarding an accommodation.

Plagiarism: Plagiarism is a serious academic offence. The UWO Senate Academic Handbook defines plagiarism as "The act of appropriating the literary composition of another, or parts or passages of his writings, or the ideas or language of the same, and passing them off as the product of one's own mind." Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as citations. For more information see Scholastic Offence Policy in the Western Academic Calendar. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following web site: 
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Electronic devices: Scientific calculators are mandatory for all exams. No other electronic devices will be permitted.

Support Services: Registrarial Services http://www.registrar.uwo.ca/ 
Student Support Center: http://www.sdc.uwo.ca/
Course Outline: This outline is a guide only. Stable Isotope Science is a dynamic tool applied to scientific research in many different fields. Course content may change depending on class feedback and current topics. If you have interest in a subject not covered here, please contact the instructor.

1. Introduction
Importance to earth and environmental sciences, laboratory tour, isotopes of interest, some general principles, the atom, chart of the nuclides, atomic mass units, atomic weight, binding energy, nuclear stability, abundance of the elements in the solar system, brief history of stable isotope geochemistry, definitions ($\delta$, $\alpha$, $10^3\ln\alpha$, $\Delta$), standards, introduction to analytical methods and instruments (extraction techniques, mass spectrometry).

2. Stable isotopes in the atmosphere and hydrosphere
Equilibrium fractionation of isotopes, kinetic processes, O and H in water and water vapour, Rayleigh distillation, Global Meteoric Water Line, kinetic isotope fractionation and $d$-excess, evaporation line, regional effects (latitude, altitude, continentality, temperature, precipitation amount), Kuhn, shallow ground water, atmospheric oxygen and carbon dioxide, juvenile water, geothermal water, rock-water ratio, oceanic pore water, formation water, brines (southwestern Ontario examples), ocean water (salinity, evaporation, dilution, ice-cap effects, ocean currents, climatic effects), snow and ice, marine paleoclimate reconstruction (ice cores, marine foraminifera), terrestrial and lacustrine paleoenvironmental reconstruction (speleothems, mammalian teeth and bones, ostracodes, diatoms), plant phytoliths, tree rings.

3. Stable isotopes in igneous rocks
Introduction to igneous rocks, oxygen reservoirs (water, sediments, mantle and derivative rock types), mineral ordering, fractional crystallization, oxygen-isotope geochemistry of granitoid rocks (normal $^{18}O$, low-$^{18}O$, meteoric water interaction, high $^{18}O$, role of sediments, isotopic exchange with country rocks), oxygen-isotope geothermometry, high temperature concordancy, retrograde isotopic exchange and disequilibrium, Pegmatite Paradise; meteorites, mass independent fractionation.

4. Stable isotopes in sedimentary rocks, weathering and diagenesis
Chemical sediments (carbonate, chert), clastic sediments, submarine weathering (halmyrolysis), oxygen isotopic composition of the ocean through time and its significance, clay mineral structures, controls on clay mineral isotopic compositions during weathering and diagenesis, clay isotope geothermometry, oxygen and hydrogen isotopic variation in soil and weathering clays.

5. Carbon- and nitrogen-isotopes in organic matter
Introduction to carbon isotopes on Earth, photosynthesis ($C_3$, $C_4$, CAM and aquatic plants), carbon isotopic fractionation during photosynthesis (diffusive, enzymatic), fractionation during organic synthesis, carbon isotope behaviour during vegetation shifts and climate change, isotopic alteration of soil organic matter (oxidation, microbial), humic substances, tracking carbon storage in soils (Maya examples), nitrogen isotopic variations in air, soil, plants and animals, diet and paleodiet (collagen, structural carbonate in bioapatite, keratin), carbon and nitrogen isotopic trophic effects, food webs, N-isotope baselines, are you what you eat?

6. Carbon-isotopes in the carbon cycle
Carbon cycle (long- versus short-term), carbon reservoirs (δ and fluxes), long-term carbon cycle, carbonates, equilibrium carbon-isotope fractionation, vital effects, coal, petroleum, natural gas, biogenic methane, tracing hydrocarbon leaks, short-term carbon cycle (atmospheric CO₂, atmosphere-biosphere-hydrosphere transfer, ice-cores, biological pump, ocean productivity), Phanerozoic C-isotope secular variations (atmospheric oxygen, extinction events, Strangelove Ocean, PETM), Earth carbon isotope budget.

7. Sulphur isotopes
Introduction to sulphur isotopes, fractionation in abiotic and biotic systems, Rayleigh distillation, Recent sediments, ocean water, secular variation, atmospheric sulphur, petroleum, coal, S-isotopes as a tracer (petroleum migration, air pollution), mass independent sulphur-isotope fractionation, sulphur isotopes in ore deposits, crystal chemistry and bond-strength controls on sulphur isotopic fractionation, speciation effects on sulphur isotopic compositions (f[O₂] and pH), comparison with carbon isotopic system.

8. Thinking like an Isotopist

Useful reference materials


Western’s Laboratory for Stable Isotope Science (LSIS)