APPLIED SCIENCE AND MANAGEMENT DIVISION
SCHOOL OF SCIENCE
GEOL 211
3 Credit Course
Winter, 2019

COURSE OUTLINE

GEOL 211

Geochemistry

3 **CREDITS**

PREPARED BY: Siobhan McGoldrick, Instructor DATE: 3/12/2018

APPROVED BY: Margaret Dumkee, Dean DATE: 3/12/2018

APPROVED BY ACADEMIC COUNCIL: May 2014

RENEWED BY ACADEMIC COUNCIL: August 2017

APPLIED SCIENCE AND MANAGEMENT DIVISION
SCHOOL OF SCIENCE
GEOL 211
3 Credit Course
Winter, 2019

Geochemistry

INSTRUCTOR: Siobhan McGoldrick, M.Sc.

OFFICE LOCATION: CNIM M105

E-MAIL: smcgoldrick@yukoncollege.yk.ca

TELEPHONE: (867) 456-6958

OFFICE HOURS: Tuesday 2-4 pm

CLASSROOM: CNIM M111 (lecture)
T1090 (lab)

TIME: M/W 8:30-10:00 am (lecture)
W 1:00-4:00 pm (laboratory)

DATES: Jan. 3 – Apr. 10, 2019

COURSE DESCRIPTION

This course examines the chemical processes characteristic of specific geological settings, with an emphasis placed on the processes governing elemental differentiation, migration, and distribution. Discussion topics include high and low temperature fluid-rock interaction, aqueous geochemistry, stable and radiogenic isotopes, thermodynamics and kinetics, biogeochemistry, and solid-Earth geochemistry. Students will be introduced to common analytical techniques for determining whole rock, mineral, soil, and water compositions.

Laboratory exercises will focus on the application of geochemistry to the mining industry, introducing techniques used in mineral exploration, production, and environmental monitoring and remediation. This will utilize analytical equipment housed at the College, including the atomic absorption (AA) and X-ray fluorescence (XRF) spectrometers. Students will be introduced to common methods of reporting and analyzing geochemical results and will gain an ability to independently assess geochemical results.

PREREQUISITES

Mathematics 12 (OR Yukon College equivalent, MATH 060), CHEM 110 (Structure of Matter), and GEOL 105 (Physical Geology) OR permission from the course instructor.

EQUIVALENCY OR TRANSFERABILITY

Simon Fraser University – EASC 208 (3)
University of British Columbia – EOSC 2XX (3)
University of British Columbia Okanagan – EESC 2XX (3)

LEARNING OUTCOMES

Upon successful completion of the course, students will have demonstrated the ability to:

- Describe the geochemical evolution of the solar system and Earth and apply chemical concepts to predict the outcome of geologic and tectonic processes.

- Describe the principles behind common analytical techniques; gather and interpret their own geochemical data using the appropriate instrumentation and data processing techniques.

- Plan and carry out appropriate mathematical strategies for solving applied geochemical problems.

- Apply radiogenic isotope systems to fingerprint reservoir compositions and determine the absolute and/or cooling ages of rocks and minerals; use stable isotopes to reconstruct past climatic conditions.

- Use their understanding of thermodynamics and kinetics to predict mineral and fluid-rock reactions for a geochemical system and given environmental conditions.

- Apply the fundamental principles of aqueous geochemistry to predict the outcome of fluid-rock interactions and the formation of precipitates, evaporites, and hydrothermal mineral deposits.

COURSE FORMAT:

This course consists of two 90-minute lectures and one 3 hour lab period per week. The schedule included in this course outline details the major topics covered and when those topics will be presented throughout the course. Lab exercises will be conducted in classroom, computer lab and field settings.

ASSESSMENTS

Attendance & Participation

Students are strongly encouraged to attend all lectures and lab classes. Hands-on exercises conducted during class time cannot be completed after-hours unless prior permission from the instructor is obtained.

Assignments

The main assessments for this course are weekly lab assignments. Lab sections are intended to give students the opportunity to apply their geochemistry knowledge to real-world, applied problems in the mineral exploration, mining, and environmental geoscience fields. These activities will utilize Yukon examples and case studies wherever appropriate. Lab assignments will be due *at the start of the next lab class* unless otherwise indicated by the instructor. Successful completion of these lab assignments is critical for understanding and reinforcing course material.

Students are expected to supplement lecture instruction with readings from the course textbook. This supplementary reading requires ~1 hour per week outside of class time. Weekly lab assignments will often require time outside of class to complete, typically 1-2 hours.

Tests

There will be two lecture exams in this course: a midterm lecture exam delivered during class time approximately halfway through the course, and a final lecture exam administered during the final exam period. Competencies in hands-on lab work will be assessed throughout the course and are not targeted during a formal exam. A student must pass both the lab and lecture components to receive course credit.

EVALUATION

Tests and Assignments	Weight	Due Dates
Weekly Lab Assignments	50%	Each assignment is due at the start of the following lab period.
Midterm Exam	20%	Scheduled during regular lecture time.
Final Lecture Exam	30%	During the final exam period.
Total	100%	

REQUIRED TEXTBOOKS AND MATERIALS

There is one required textbook for this course, as well as recommended textbooks that will be utilized on a limited basis throughout the course. All texts are available on reserve at the Yukon College Library.

Required textbook

Albarède F. 2009. Geochemistry: an introduction. 2nd ed. Cambridge, UK: Cambridge University Press. 355 p.

Recommended textbooks

Faure G. 1998. Principles and applications of geochemistry. 2nd ed. Upper Saddle River, NJ: Prentice Hall, Inc. 600 p.

White WM. 2013. Geochemistry. New Jersey: Wiley-Blackwell. 668 p.

ACADEMIC AND STUDENT CONDUCT

Information on academic standing and student rights and responsibilities can be found in the current Academic Regulations that are posted on the Student Services/ Admissions & Registration web page.

PLAGIARISM

Plagiarism is a serious academic offence. Plagiarism occurs when students present the words of someone else as their own. Plagiarism can be the deliberate use of a whole piece of another person's writing, but more frequently it occurs when students fail to acknowledge and document sources from which they have taken material. Whenever the words, research or ideas of others are directly quoted or paraphrased, they must be documented according to an accepted manuscript style (e.g., APA, CSE, MLA, etc.). Resubmitting a paper which has previously received credit is also considered plagiarism. Students who plagiarize material for assignments will receive a mark of zero (F) on the assignment and may fail the course. Plagiarism may also result in dismissal from a program of study or the College.

YUKON FIRST NATIONS CORE COMPETENCY

Yukon College recognizes that a greater understanding and awareness of Yukon First Nations history, culture and journey towards self-determination will help to build positive relationships among all Yukon citizens. As a result, to graduate from ANY Yukon College program, you will be required to achieve core competency in knowledge of Yukon First Nations. For details, please see www.yukoncollege.yk.ca/yfnccr.

ACADEMIC ACCOMMODATION

Reasonable accommodations are available for students requiring an academic accommodation to fully participate in this class. These accommodations are available for students with a documented disability, chronic condition or any other grounds specified in section 8.0 of the Yukon College Academic Regulations (available on the Yukon College website). It is the student's responsibility to seek these accommodations. If a student requires an academic accommodation, he/she should contact the Learning Assistance Centre (LAC) at (867) 668-8785 or lassist@yukoncollege.yk.ca.

LECTURE TOPIC OUTLINE

Module	Topic	Accompanying Readings
1	**Properties of elements:** periodic table, chemical bonding, states of matter, geochemical classifications, elemental reservoirs, nuclei, radioactivity.	Ch. 1 (5-24)
2	**Earth in the solar system:** formation of elements and nucleosynthesis, formation of the solar system, condensation of planetary material, composition of Earth and its ongoing differentiation, origin of seawater.	Ch. 11 (248-287)
3	**Mass conservation and elemental fractionation:** conservation of mass, elemental fractionation, films and interfaces, distillation processes.	Ch. 2 (25-44)
4	**Solid-Earth geochemistry:** distribution of trace elements between coexisting phases, factors governing the value of partition coefficients, geochemical variability of magmas, mantle and crustal melting, magmatism at specific tectonic sites, mantle convection and geochemical reservoirs, growth of continental crust.	Ch. 10 (218-247)
5	**Stable isotopes:** principles of fractionation in hydrological and biological systems, delta notation; isotope geothermometry, stable isotopes in hydrothermal systems and ore deposits, stable isotopes in the mantle and magmatic systems, paleoclimatology.	Ch. 3 (45-70)
6	**Radiogenic isotopes and geochronology:** decay systems and their applications, cosmogenic and fossil isotopes, isochrons, radiogenic tracers.	Ch. 4 (70-100)
7	**Element transport:** reaction kinetics and reaction rates, relationship between kinetics and thermodynamics, advection, adsorption, diffusion, concept of closure temperature, kinetics of dissolution and leaching.	Ch. 5 (101-119)
8	**Geochemical systems:** single-reservoir dynamics, interaction of multiple reservoirs, mixing and stirring.	Ch. 6 (120-137)
9	**Aquatic chemistry:** acid-base reactions, speciation and complexation in solutions, electrolyte chemistry, dissolution and precipitation reactions, clays and clay properties, interaction of mineral surfaces with solutions, the carbonate system, marine chemistry.	Ch. 7 (138-167)
10	**Biogeochemistry:** the geological record, organic	Ch. 8 (168-183)

	compounds and their nomenclature, important biochemical processes and the chemical properties of organic molecules, biominerals and biomarkers, biological controls on the ocean-atmosphere system, carbon cycle and climate.	
11	**Environmental applications of geochemistry:** characterization of metal leaching and acid rock drainage (MLARD) potential, mine water treatment, water monitoring.	
12	**Methods for geochemical analysis:** atomic absorption spectroscopy, X-ray fluorescence spectroscopy, electron microprobe analysis (wavelength and energy-dispersive spectroscopy), mass spectrometry (ICP-MS, TIMS), Raman spectroscopy.	

LABORATORY SCHEDULE

Week	Topic
1	**Sample preparation practices:** Field trip to ALS Minerals preparation facility in Whitehorse
2	**In-house sample preparation:** Geological Technology laboratory safety procedures; cutting and crushing samples
3	**Loss-on-ignition (LOI) analysis**: analysis, iron oxidation corrections
4	**Aqua regia digestions and assay preparation**: dissolution of powdered, ignited ores for base metal assay analysis using industry-standard hot digestion methods
5	**Atomic absorption spectrometry:** determination of base metal concentrations in powdered ores using flame atomic absorption spectrometry (FAAS); construction of calibration curves using synthesized standards
6	**Whole rock fusion analysis**: preparation of samples using whole rock fusion technique, analysis of beads using 1) XRF and 2) nitric acid dissolution + FAAS analysis with sample addition technique.
7	**Marine oxygen isotopes**: exercise to identify patterns of marine oxygen isotope change from benthic forams; relate these changes to patterns of ice-volume change over past 2 Ma.
8	**Strontium isotopes**: Use of Rb-Sr isotope data and whole-rock isochrons to calculate isochrone ages and make inferences about magma source regions
9	**Aqueous geochemical analysis:** applications of aqueous geochemistry in mine water treatment, sample preparation, analysis of water samples using flame atomic absorption spectrometry (FAAS)
10	**Metal Leaching and Acid Rock Drainage (MLARD):** characterizing the potential for metal leaching and acid rock drainage in aqueous and/or solid samples