ES2230 Introduction to Geochemistry

Aim of Course: To introduce the field of Geochemistry to undergraduate students.

Prerequisites: Chemistry 1301A/B or the former Chemistry 1100A/B and ES 2200A/B, or permission of the Department

Instructor: Sean Shieh, B&GS room 1066 (email: sshieh@uwo.ca)

Course Format: 2 lecture hours: 3 laboratory hours

Lecture: Mon and Wed 11:30 – 12:30

Lab: Thu 14:30-17:30

Learning Outcome:

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

• Define the formation and evolution of the Solar System

• Define the formation and evolution of the Earth and Moon

• Define the formation and evolution of the atmosphere of the Earth

• Define the formation of the elements in the solar system

• Apply knowledge of the age determination to Earth's rocks and minerals as well as creature's fossils

• Apply the knowledge of binary and ternary phase diagram to formation of magma and mantle rocks

Course Outline, Readings and Laboratory Exercises

Topic

Primordial and Stellar Nucleosynthesis, Radioisotopic Systems and Ages

- Formation of the Elements, Solar System, Earth and Moon.
- Stable and unstable nuclei and rate of decay of unstable nuclei
- Absolute Ages of Rocks, Earth and the Solar System
- The Sm/Nd system as example: The isochron, Ages and Model Ages.

Lab#1 - (1 week) scientific paper relevant to formation, composition & evolution of solar system

Lab#2 - (1 week) Calculate the Molar and Atomic proportions of elements in Minerals

Lab#3 - (2 weeks) Applications of Sm/Nd system to basalts, recent and ancient.

Composition and Stability of Minerals, Glasses and Fluids (i.e., liquids and gases)

- Some geochemically important properties of the elements of the periodic table
- Substitutions in minerals, Immiscibility in Glasses and Natural Fluids
- Stability of phases in natural settings: thermodynamic and kinetic stability
- Heat Capacity, Enthalpy and the First Law of Thermodynamics
- Entropy and the Second Law of thermodynamics
- Free Energy, the Clausius-Claperyon Eqn and phase stability as a function of T and P

Lab#4 - (2 weeks) Thermodynamic stability of SiO2 and Al2SiO5 polytypes at STP and calculation of the Al2SiO5 phase boundaries in P-T space

The Phase Rule, Phase Diagrams and Their Interpretation

- The Unary Phase Diagram and the Phase Rule (H2O system as example)
- Binary Phase Diagrams (Olivine and Plagioclase, NaCl-H2O, MgO-SiO2, systems)
- Ternary Phase Diagrams (Qz-Ab-Ksp system as example).

Lab #5 (1 week) - Interpretation of Phase diagrams

Major Element Geochemistry

- The Major Elements: Rock and mineral compositions, Wt.% and Molar Proportions
- Compositions of Igneous, Sedimentary and Metamorphic Rocks and Ternary Diagrams
- Igneous Rocks: Magmas and Crystal Fractionation
- Sedimentary Rocks and Chemical Weathering
- Metamorphic Rocks and Mineralogical Changes during prograde metamorphism

Lab#6 (1week) - Compositional changes during fractionation and weathering

Trace Element Geochemistry

- Igneous Petrology: Compatible and Incompatible Elements
- Sedimentary Petrology: Labile and Conservative Elements
- Rare Earth and Incompatible Elements in Igneous and Sedimentary Environments.

Lab #7 (2 weeks) - Partitioning of Trace elements between minerals and liquids

The Chemical Potential and the Distribution (Partition) Coefficient

- The Chemical Potential and phase stability as a function of composition
- Theory and use of Distribution Coefficients.
- Calculated and observed distribution of Fe and Mg between melts and basaltic magma.

* Contents may change upon necessity.

Marking Scheme for ES 2230:

- Midterm test: 20%*
- Final examination: 35%
- Laboratory mark: 40%
- Class participation: 5%

* Students have the option of reweighting their midterm if their grade on the final exam is significantly greater than their mid-term mark (i.e. greater than 30%). In the event a student is able to demonstrate this improvement, they are able to have the final exam count for 55% of their final grade.

Important days

• Midterm test: **TBA**

• Final exam date will be set by the Office of Registrar

Statements Concerning Tests and Exams

Calculators may be used during tests

Additional Statements (PLEASE READ)

The instructor owns the IP in the lecture and lecture materials even when such lectures or materials are posted online and students are not to post lectures or lecture materials to any other websites or platforms or use the lecture recording or materials for any other purpose without your consent. It also prohibits the recording of live lectures or recorded lectures.

Student Absences

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. 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.

For further information, please consult the University's medical illness policy at https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration.pdf.

The Student Medical Certificate is available at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).

You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

Accommodation and Accessibility

Religious Accommodation

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request an accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please visit the Diversity Calendars posted on our university's EDID website for the recognized religious holidays:

https://www.edi.uwo.ca.

Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf.

University Policies:

The website for Registrarial Services is https://www.registrar.uwo.ca/.

In accordance with policy,
https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf,

the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their official university address is attended to in a timely manner.

1) Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

2) Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

3) **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 for such checking 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).

Support Services

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: https://www.uwo.ca/sci/counselling/.

Students who are in emotional/mental distress should refer to Mental Health@Western (https://uwo.ca/health/) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at

https://www.uwo.ca/health/student_support/survivor_support/get-help.html.

To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at
http://academicsupport.uwo.ca/accessible_education/index.html

if you have any questions regarding accommodations.

The Exceptional Contributor: "The Class Was Better Because You Were Here"

As part of the learning process I expect all students to participate actively in class. Here are some guidelines to keep in mind when in class:

- You provide clear, concise, and correct explanations that help others gain a better understanding of concepts.
- You make outstanding, original, and informative comments.
- You make highly attentive and constructive comments on other people's statements.
- You ask questions that are penetrating or help clarify.
- You raise your hand strategically (understanding that there are other students in class).
- You actively encourage others to express their ideas.
- You display body language that communicates interest in what others are saying.
- You arrive to class on time and are not absent without reason.