

ES 4432A - Geochemistry of Metals, Melts and Fluids in the Crust

Syllabus

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Pre-requisites:

ES2230a/b Introduction to Geochemistry;

ES3370a/b Metallogeny I: Ore Petrology

Schedule

Lectures: 3 hrs per week, M-W-F 12:30-1:30, PAB-106

Tutorial: 1 hr per week: W 1:30-2:30, BGS-1084

CALENDAR DESCRIPTION

The principals of metal concentration and deposition in magmatic and hydrothermal environments are examined. Natural and experimental data, including fluid inclusion, stable isotope, metal solubility, mineral stability and metal partition behavior are used to develop genetic models for ore deposits, which form the basis of mineral exploration strategies.

Prerequisite(s): Earth Sciences 2230A/B and 3370A/B.

WHAT ARE THE PRINCIPAL OBJECTIVES OF THIS COURSE?

Ore deposit models are the foundation on which mineral exploration and exploitation are based on. This course first develops the geochemical tools that are used to study mineral deposits and interpret how deposits form and what controls metal distribution. A variety of ore-forming processes are examined by using a variety of mineral deposit types from igneous, metamorphic and sedimentary environments.

WHY STUDY MINERAL DEPOSITS?

Mining is one of Canada's most important industries and mineral exploration and exploitation is one of the largest sectors that employs geologists, geological engineers and other Earth scientists and engineers. There is also an environmental cost to mining and in order to understand the environmental impact of mining a solid understanding of mineral deposits is required.

There is no formal text, but **notes will be posted on the OWL website**. There are several useful mineral deposits textbooks in the library. These include:

Moon, C.J., Whateley, M.K.G. and Evans, A.M., 2006, Introduction to mineral exploration.

Robb, L.J., 2005, Introduction to ore-forming processes

MARKING SCHEME

Mid Term	week before Reading Week	25%
Assignments	3 problem sets	5%
Term Paper	last week of classes	25%
Term Paper Presentation	last week of classes	10%
Final Exam		35%

For the Mid Term and Final Exam students should bring a calculator and a ruler. Both will consist of a mixture of multiple choice, short answer questions and possibly a problem.

Written Assignment: This is to be written as a journal paper. **Follow the format of the journal Economic Geology** (marks will be deducted if this format, including references, is not adhered to). The theme of the assignment is 'Genetic Modeling in Economic Geology'. Subject material could be an analysis of a single ore deposit or mining camp, a comparison of different styles of mineralization, evaluation of a general type of mineralization, geochemistry of a particular element (solubility, transport and deposition), or any other topic that would be suitable for publication in the journal Economic Geology. **You are encouraged to come up with your own topic.** However, a list of potential topics is also provided below. Topics should be selected by **January 29th**. You should use the **Georef** program in the library to get up-to-date references and request interlibrary loans if necessary (I will use this program to see what references are available).

The report should consist of a Title, Abstract and Introduction, followed by the main body of the text (including figures), Conclusions and References. The written assignment is **due April 1st**. The length of the text and figures should be 10-15 pages, using a 12 pt. font, (Times Roman, Helvetica or Courier), double spacing and "normal" margins.

There should be some figures (with figure captions) containing geochemical data or phase equilibria etc., and the figures should be properly explained in the text. A model for the genesis

of mineralization should be proposed and evaluated in light of alternative models. All material must be properly referenced and the list of references should reflect the fact that your knowledge of the presented material is up to date. The marks will be based on originality, the depth of understanding, logic of arguments etc., as well as presentation and writing style.

The term 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>).

Oral Presentation of the subject chosen for the written assignment will consist of a **10 minute talk and 2 minutes for questions**. 80% of the mark for this is based on the presentation and 20% is based on your participation of the discussion of other people's presentations.

Some Potential Topics for the Written Report

Email your topic to me by **January 29th**, the same topic will not be presented by two students so the first student to email me will be given the topic.

Magmatic deposits:

- anorthosite-hosted Ti deposits.
- podiform chromite deposits.
- Komatiite-hosted (Kambalda-type) Ni sulphide deposits
- carbonatite-hosted mineralization (Nb, REE).

Hydrothermal deposits associated with igneous rocks

- skarn deposits W, Cu or Au (or other metals).
- SnW mineralization associated with greisen alteration.
- granite-hosted U deposits
- Mexican silver province.
- geothermal systems as a natural laboratory.
- The Olympic Dam (Fe-REE-Cu-U) deposit, or other IOCG deposits
- REE deposits associated with alkaline granitic rocks

Hydrothermal deposits associated with metamorphic rocks.

- origin of the Hemlo or Red Lake (Ontario) Au deposits (structural controls, alteration, fluid inclusions).
- genesis of the Broken Hill (Australia) Pb-Zn-Ag deposit.
- genesis of the Mt. Isa (Australia) Pb-Zn-Cu-Ag deposits.
- consequences of metamorphism of volcanogenic massive sulphide deposits.

Hydrothermal deposits associated with sedimentary rocks

- the role of organic material in ore-forming processes.
- genesis of sandstone-hosted Pb deposits.
- formation of Au deposits in banded iron formations.
- genesis of 'Carlin-type' Au deposits.
- origin of unconformity-type U deposits of Saskatchewan

Ore deposits associated with surficial processes

- 'supergene' enrichment of Cu in porphyry Cu deposits.
- Au deposits of the Witwatersrand, South Africa, placer versus hydrothermal?
- genesis of the Elliot Lake (Ontario) paleoplacer U deposits.
- formation of Ni laterite deposits.
- Mn nodules on the seafloor: their origin and significance.

Industrial Minerals

- gem deposits (emeralds, sapphire, ruby), graphite, wollastonite, talc

SYLLABUS

Introduction

- why are models important in economic geology

Stable Isotopes

- nomenclature, fractionation, thermodynamics
- O and H isotopic compositions of natural waters
- fluid-rock interactions
- C and S isotopes

Geothermometry

- estimation of lithostatic pressure
- use of phase equilibria
- thermodynamics of mineral exchange reactions
- isotope geothermometry

Diamonds

- igneous background
- kimberlites
- indicator minerals
- geothermometry and geobarometry of kimberlites and diamonds

Nickel Deposits

- review of deposit types
- constraints from experimental petrology
- sulphide-silicate melt partitioning
- depositional model

Platinum Group Element (PGE) and Chromium Deposits

- review of the Bushveld and Stillwater complexes
- constraints from phase equilibria
- sulphur solubility in silicate melts
- comparison of the origin of PGE and Ni deposits

Fluid Inclusions

- origin and classification of fluid inclusions
- interpretation of fluid inclusion data
- H₂O-NaCl and H₂O-CO₂ systems

Porphyry Copper Deposits

- review of deposit types
- geochemistry of alteration and mineralization
- fluid-melt partitioning and metal solubility in porphyry systems

Other Granite-Related Deposits (Mo, Sn, W)

- review of molybdenum, tin and tantalum deposits
- controls of metal solubility in granitic melts

Gold Deposits

- review of epithermal and orogenic gold deposits
- behaviour of sulphur
- transport and deposition of gold
- fluid inclusions in gold deposits
- structural aspects of greenstone gold deposits

Volcanogenic Massive Sulphide (VMS) Deposits

- environments of modern seafloor mineralizing systems
- hydrothermal alteration in VMS systems
- chemical reactions of Cu-Pb-Zn deposition
- isotopic constraints on the genesis of VMS deposits

Sedimentary Exhalative (SEDEX) Deposits

- review of SEDEX deposits
- heat flow, fluid inclusions and isotopic constraints
- role of anoxic basins and interpretation of sulphur isotopic data
- comparison to VMS deposits

Mississippi Valley Type (MVT) Deposits

- fluid inclusion characteristic
- transport and deposition of Pb-Zn
- isotopic and heat constraints

General Information

Statement on Academic Offences: "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:

<http://www.uwo.ca/univsec/handbook/appeals/scholoff.pdf> ."

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Student's responsibilities in the event of a medical issue:

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 Academic Counseling Unit at the Faculty of Science 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. For further information please see: <http://www.uwo.ca/univsec/handbook/appeals/medical.pdf>

A student requiring academic accommodation due to illness, should use the Student Medical Certificate when visiting an off-campus medical facility or request a Records Release Form for visits to Student Health Services. The form can be found at:
https://studentservices.uwo.ca/secure/medical_document.pdf

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.