

# EARTH SCIENCES 3313A IGNEOUS PETROLOGY

Fall 2013

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**Pre-requisites:** ES 2206A Mineral Systems, Crystallography and Optics

## Schedule

**Lectures:** Tuesdays & Thursdays: 11:30-12:20, Room: P&AB-150

**Labs:** Start week #2, Thursdays 2:30-5:30 and 6:00-9:00, Room: B&GS-1065

**Fall Study Break:** no classes and labs scheduled on Thursday, October 31<sup>st</sup> (and until November 3<sup>rd</sup>).

## CALENDAR DESCRIPTION OF EARTH SCIENCES 3313A/B "IGNEOUS PETROLOGY"

Study of igneous processes using rock and thin section descriptions (petrography). Discussion of how different compositions and conditions influence the phases present in a rock (phase equilibria). Association of different rock types with plate tectonic setting.

### WHAT ARE THE PRINCIPLE OBJECTIVES OF THIS COURSE?

To outline the physical and chemical properties of magma, to introduce the techniques that are used to interpret the origin and evolution of different series of magmas and to examine in more detail magma evolution in specific igneous/tectonic environments.

The laboratory is an integral part of the course and students will learn to identify common igneous rocks and textures in hand specimen and in thin section using a petrographic microscope.

### WHY STUDY IGNEOUS PETROLOGY?

Volcanoes are one of the main natural hazards to mankind. It is therefore important to understand the mechanisms and processes controlling volcanic eruptions. It is also clear that the materials which constitute the Earth's atmosphere, oceans, and crust ultimately originated from the Earth's interior and were brought to the Earth's surface via igneous processes. Consequently igneous petrology is a key component to understanding how the Earth works as a system and how that system has changed over time. Igneous rocks are also the source of metals in many types of ore deposits, thus understanding the behavior of metals in igneous processes is fundamental to mineral exploration.

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### LEARNING RESOURCES

The **required text** for this course is *Igneous and Metamorphic Petrology* (2010), by John Winter. The cost is somewhat high, ~\$140, but this textbook is also used in the course *Earth 3315A/B – Metamorphic Petrology*. **You are strongly advised to read the book chapters associated with the corresponding lectures prior to class to get familiarized with the contents and technical vocabulary (see Syllabus schedule).**

There is a copy on reserve in the library. For additional information and power point copies of the figures, see <http://www.whitman.edu/geology/winter/> (the website also has a list of errata).

Some additional material in ES 3313 comes from other sources. Most of the additional figures and material come from: Igneous Petrology 2<sup>nd</sup> ed., Anthony Hall (1996), QE461.H256 and Principles of Igneous and Metamorphic Petrology, A.R. Philpotts (1990), QE461.P57 (there is also an updated version of the latter text on reserve in the library QE461.P572x 2009).

There are several other excellent textbooks of Volcanology, Igneous Petrology and related subjects in the library. These include:

Igneous Petrology, M.G. Best and E.H. Christiansen, 2001, QE461 .B54 2001

Igneous Petrogenesis, Marjorie Wilson, QE 461.W55 1989

Igneous Petrology 2<sup>nd</sup> ed., A.R. McBirney, QE461 .M46 2007

Origins of igneous rocks, Paul C. Hess, QE 461.H47 1989

Basalts and phase diagrams: An introduction to the quantitative use of phase diagrams in igneous petrology, S.A. Morse, QE462.B3M67 1994

Using Geochemical Data: Evaluation, Presentation, Interpretation, H. Rollinson, QE515.R62 1993

Radiogenic Isotope Geology, A.P. Dickin, QE501.4.N9D53 2005

## LABORATORIES

An **optical mineralogy text is also highly recommended**, e.g., Nesse, 2003, Introduction to Optical Mineralogy. Oxford. 3<sup>rd</sup> Ed. or Deer, Howie and Zussman, 1992, An Introduction to Rock-Forming Minerals. Longman.

*Some other useful textbooks for the lab are:*

Petrography of igneous and metamorphic rocks, A.R. Philpotts QE461.P56 1989 Atlas of igneous rocks and their textures, W.S. MacKenzie, C.H. Donaldson and C. Guilford QE461.M219 1982

## WORKSHOP

A workshop will be organized on campus tentatively on Saturday, November 9<sup>nd</sup>, and November 16<sup>th</sup> to further observe and discuss the formation of selected rocks from Earth and other planets (student must attend one of these two dates which notes taken will be handed and graded as a fourth assignment). More information will be given in class.

### Exams:

mid term **15%** on **Tuesday October 22<sup>nd</sup>** during class time

final exam **40%**, **date and location TBA**

***Note: for both the mid term and final exam students should bring a non-programmable calculator, color pencils, and a ruler. Electronic devices such as laptops, tablets, cell phones or programmable calculators MUST BE TURNED OFF AND REMAIN IN YOUR BAG during the duration of the exams.***

***Both exams will consist of a mixture of multiple choices, short answer questions and a problem.***

lab **25%**: 9 due at the end of the lab

lab exam **15%**: open book, **last Thursday of the semester December 5<sup>th</sup>**

assignments **5%** four assignments, three due one week after being assigned, and a fourth as the workshop notes.

Pop quizzes might be given at the end of some classes and credited for bonus point.

**Other Required Materials:**

- 10x or better hand lens (a pencil magnet is also recommended)
- \$20 deposit for your microscope key

**MARKING SCHEME**

Each student is required to complete labs and assignments individually (see academic integrity below). Assignments are normally marked and returned one week after they are due (they are normally due one week after they are handed out). Late assignments are penalized 20% per day for each day they are late and a mark of zero percent is given if the assignment is not submitted before corrected assignments are returned. Students are responsible for all material that is presented during lectures. Note that, although there is a course text and most of the material comes from this text, material from other sources is also discussed during lectures. Also note that all additional material will be posted on the web site for the course.

***SYLLABUS***

*(some topics may not be covered)*

**Chapter 1 -Introduction**

-magmatic environments/tectonic setting -structure of the Earth

**Chapter 2 -Classification of Igneous Rocks**

-based on minerals -based on chemistry -based on CIPW norms

**Chapter 3 -Volcanology – Field Relations**

-forms of volcanoes -volatile contents of volcanic glasses -temperatures of volcanic rocks

**Chapter 4 -Intrusions – Field Relations**

-forms of intrusions

**Chapter 5 -Physical Properties of Magma**

-cooling mechanisms of flows -predicting volcanism versus plutonism -viscosity, diffusion -melt structure

**Chapter 6 -Phase Equilibria**

-binary diagrams, ternary diagrams -fractional/equilibrium crystallization/melting

**Chapter 7 – Major Element Geochemistry**

-characteristic normative minerals -Harker diagrams -Pearce Element Ratios -fractional crystallization -magma series and tectonic settings

**Chapter 8 -Element Partitioning**

-major and trace element substitution in crystals -partition coefficients -effects of temperature, melt composition, crystal composition -batch melting and fractional crystallization -partitioning of REE's - tectonic applications

**Chapter 9 -Basalts -evaluation of source, primary versus evolved**

-melting of peridotite: effects of H<sub>2</sub>O, degrees of partial melting, P-T

-origin of alkaline and tholeiitic basalts

-radiogenic isotope systematics, mantle heterogeneity

**Chapter 10 – MORB and OIB**

-major element, trace element and isotopic composition of MORB

-petrogenesis of MORB

-major element, trace element and isotopic composition of OIB

-petrogenesis of OIB

**Chapter 11 – Island Arc Magmas**

-major element, trace element and isotopic composition of island arcs

-petrogenesis of island arcs

**Chapter 12 – Continental Arc Magmas**

-major element, trace element and isotopic composition of continental arcs

-petrogenesis of continental arcs

### ***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>

#### **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 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/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 (located in the Dean's Office) for visits to Student Health Services. The form can be found here:

[https://studentservices.uwo.ca/secure/medical\\_document.pdf](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.