

# EARTH SCIENCES 3313A IGNEOUS PETROLOGY

## Fall 2017

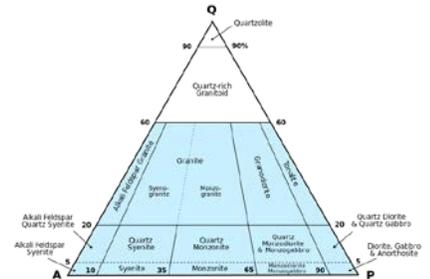
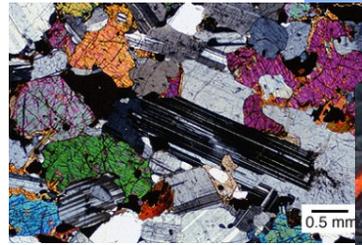
**Instructor:** Dr. Audrey Bouvier  
**Office:** B&GS 1081  
**Email:** audrey.bouvier@uwo.ca or OWL Message

**Tel:** 519 661 2111, ext: 88516  
**Meeting hours:** fixed office hours do not work with everyone's class schedules, so please set up an appointment

**Teaching Assistants:**  
Bruna Borba de Carvalho (bborbade@uwo.ca)  
Annika Van Kessel (avankes2@uwo.ca)

**Guest Lecturer:**  
Dr. Tony Withers (tony.withers@uwo.ca)

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



## SCHEDULE

**Lectures:** Tuesdays & Thursdays: 12:30-13:20, Room: Physics & Astronomy Building 117

**Labs:** 2 group sessions on Thursdays 2:30-5:30pm and 6.00-9.00pm, Room: B&GS-1065, start on Thursday, September 14<sup>th</sup>. Print and fill up your microscope loan form (posted on OWL) and bring your \$20 deposit for your cabinet key at the first lab session.

## IMPORTANT DATES

**\*New\* Fall Reading Week October 9-13<sup>th</sup>**

**Tuesday, October 17<sup>th</sup>:** Midterm exam in class

**Thursday, November 30<sup>th</sup>:** Lab exam in BGS 1065

**December 10<sup>th</sup> – 21<sup>st</sup>:** Examination period. Final exam, date and location TBA.

## WHAT ARE THE PRINCIPAL 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 and tectonic environments.

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

In class, we will discuss:

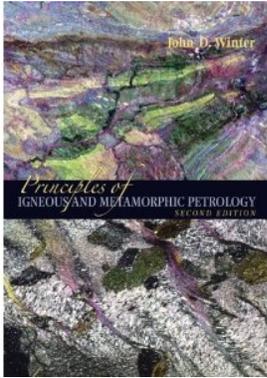
- The origin and conditions for producing melts
- How different compositions and conditions influence the phases present in a rock (phase equilibria)
- The association of different rock types with plate tectonic settings
- The major and trace element behavior in igneous systems which is used to understand the formation and evolution of the crust-mantle system on Earth and other planets

During the labs: you will study of igneous processes using rock hand sample and thin section descriptions (petrography).

## 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 mantle 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.

## LEARNING RESOURCES



The **required textbook** for this course is Igneous and Metamorphic Petrology (2010) 2<sup>nd</sup> Edition, by John Winter. The cost is high for a new textbook, \$140-160, but it is also used in the ES 3315 course – Metamorphic Petrology. You may also be able to purchase it on used book websites (make a web search), or as electronic version.

**You are required to read the book chapters associated with the corresponding lectures prior to class to get familiarized with the contents and technical vocabulary (see tentative schedule below and announcements made during classes).**

**Materials from other sources will be also discussed in class.**

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 to fix in your own book).

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

Igneous Petrology 2<sup>nd</sup> Ed., Anthony Hall (1996)

Principles of Igneous and Metamorphic Petrology, A.R. Philpotts (1990)

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

Using Geochemical Data: Evaluation, Presentation, Interpretation, H. Rollinson

## LABORATORIES

An **optical mineralogy book is required**, suggested books are:

Introduction to Optical Mineralogy. Oxford. 3<sup>rd</sup> Ed. Nesse, 2003

An Introduction to Rock-Forming Minerals. Deer, Howie and Zussman, 1992

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

### Other recommended materials:

-10x or better hand lens

- a pencil magnet

## EXAMS & ASSIGNMENTS

- **15%** mid-term exam on **Tuesday October 17<sup>th</sup>** during class time (50 mn)
- **30%** final exam, **date and location TBA (examination period: December 10<sup>th</sup> to 21<sup>st</sup>)**
- **20%** lab exam: open book and 1-page limited hand written notes (figures, notes or previous lab assignments specific to the studied lab materials will not be accepted), **Thursday November 30<sup>th</sup> in BGS 1065 during your lab group session**

**Note: for both the mid-term and final exams, students should bring a non-programmable calculator (other electronic devices will not be allowed), color pencils, and a ruler.**

- **10%** home assignments: 4 assignments due in class usually 7 days after being assigned unless instructed with due date. Penalty: 10% off for each late day (only exceptions are if you have special SSD arrangement, or exceptional reason approved by counseling), maximum 3 days late for credits (for everyone), due in class. **Assignments are an important part of your preparation for your exams, so I strongly encourage you to turn in your assignments on time.**
- **25%** lab assignments: **due at the end of each lab**, 10% off for each late day, (only exception are if you have special SSD arrangement, or exceptional reason approved by counseling), **3 days late maximum for credits**. Each assignment will be posted on OWL on Monday of each week, **you are responsible for printing and reading lab hand outs prior to the lab session on Thursday.**

**Up to two pop quizzes will be given during lectures and credited for a bonus point.**

## MARKING SCHEME

Each student is required to complete labs and assignments individually (see academic integrity below). Your presentation (writing and clarity) will be marked for one point. 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 10% per day for each day they are late and a mark of zero percent is given if the assignment is not submitted within 3 days from the due date (you have thus maximum 10 days to complete).

In preparation for assignments and exams, students are responsible to review 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, materials from other sources are also discussed during lectures. Also note that materials shown in class and labs will be posted on the OWL web site for the course. Material discussed on the board and orally during class will not be posted on OWL. Take hand notes during lectures and ask questions to better understand the course material and in preparation for your examinations.

## ***PLANNED CLASS SCHEDULE***

***Some topics may not be covered or at a different week.***

***Take notes of announcements in class or on OWL for updates on your reading assignments.***

Introduction - Structure of the Earth – Chapter 1

Classification of Igneous Rocks – Chapters 2 & 3

Phase Equilibria: binary diagrams -fractional/equilibrium crystallization/melting – Chapters 5 & 6

Magmatic environments and tectonic setting - Physical Properties of Magma: cooling mechanisms of flows -predicting volcanism versus plutonism -viscosity, diffusion -melt structure – Chapter 4

Major Element Geochemistry: characteristic normative minerals -Harker diagrams -Pearce Element Ratios -fractional crystallization -magma series and tectonic settings. – Chapters 8 and 11

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. – Chapter 10

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

MORB and OIB – Chapters 13, 14 & 15

- major element, trace element

Ternary Diagrams – Chapter 7

Layered Intrusions – Chapter 12

Arc Magmas – Chapters 16 & 17

- major element, trace element and petrogenesis of continental and island arcs

Alkaline magmatism – Granitoid rocks – Chapters 18 & 19

Archean magmatism (not covered in textbook)

- archean magma suites and geochemical characteristics

### **Learning Outcomes:**

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

- explain magmatic processes and igneous rock formation within the Earth's crust and mantle using elemental geochemistry, phase diagrams, and petrography.
- describe the geochemical and physical processes responsible for producing magmas and the diversity of igneous rock types by using real and theoretical examples.
- classify igneous rocks based on their petrography or geochemistry and associate these characteristics with plate tectonic settings.
- observe and identify key minerals, and important features of igneous rocks in thin section and hand specimen, and apply their observations to rock forming processes.
- use numerical, graphical, and synthesizing techniques to solve igneous petrological problems.

## **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/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.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 *first* to the Faculty of Science's Academic Counselling Unit 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 Academic Counselling Unit immediately.

For further information please see: Policy on Accommodation for Illness

[www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_illness.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_illness.pdf)

(which includes a link to the Student Medical Certificate)

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 Academic Counselling Unit) 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 materials 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. Students with Disabilities will be accommodated according to the request received for the duration and location of examination. Assignments deadlines remain the same for everyone but no late penalty will be applied within the allocated period for home and lab assignments.

Link to the policy on Accommodation for Students with Disabilities

[www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_disabilities.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_disabilities.pdf)

Link to the policy on Accommodation for Religious Holidays

[www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_religious.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

Link to services provided by the University Students' Council:

<http://westernusc.ca/services/>

The revised policy at [http://www.uwo.ca/univsec/pdf/academic\\_policies/exam/definitions.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/exam/definitions.pdf) specifies that make-up examinations for December exams will be held on the first Thursday in January following the first day of classes

### **Statement on services for students in emotional/mental health distress**

Students who are in emotional/mental distress should refer to Mental Health@Western

<http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

### **Responsibility for checking prerequisites**

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.