GEOS343
Magmas, Ores and Geochemistry
S1 Day 2015
Dept of Earth and Planetary Sciences

Contents

General Information ........................................ 2
Learning Outcomes ........................................ 2
Assessment Tasks ......................................... 3
Delivery and Resources .................................. 8
Unit Schedule ............................................. 9
Policies and Procedures ................................. 10
Graduate Capabilities ................................. 12

Disclaimer
Macquarie University has taken all reasonable measures to ensure the information in this publication is accurate and up-to-date. However, the information may change or become out-dated as a result of change in University policies, procedures or rules. The University reserves the right to make changes to any information in this publication without notice. Users of this publication are advised to check the website version of this publication [or the relevant faculty or department] before acting on any information in this publication.
General Information

Unit convenor and teaching staff
Bruce Schaefer
bruce.schaefer@mq.edu.au

Simon Turner
simon.turner@mq.edu.au

Credit points
3

Prerequisites
GEOS207 and GEOS272

Corequisites

Co-badged status

Unit description
This unit explores the behaviour and evolution of silicate magmas and aqueous fluids in both the crust and mantle. We use examples of mafic/ultramafic and intermediate-silicic magmatic rock associations, and their associated fluids and ore deposits to investigate the geochemistry and petrology of magmatic systems. Such associations are investigated from a deposit to mantle domain scale. Physical attributes of magma-fluid systems and isotopes are considered as exploration and petrogenetic tools. Important ore deposits in sedimentary basins are also considered. Practical work involves integrating geochemical databases with microscopic investigation of key magmatic suites.

Important Academic Dates
Information about important academic dates including deadlines for withdrawing from units are available at https://students.mq.edu.au/important-dates

Learning Outcomes

1. an understanding of the genesis and geochemistry of the major igneous rock suites
2. a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
3. an ability to identify the major rock-forming and ore minerals using a petrographic microscope
4. an ability to recognize and interpret igneous and ore micro-textures
5. experience in interpreting and modelling geochemical data
6. understanding scientific methodology and an ability to access, research and assess appropriate scientific information
7. a capacity to communicate the findings of research through scientific writing

Assessment Tasks

<table>
<thead>
<tr>
<th>Name</th>
<th>Weighting</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes</td>
<td>15%</td>
<td>ongoing</td>
</tr>
<tr>
<td>Exam: Theory</td>
<td>45%</td>
<td>TBA</td>
</tr>
<tr>
<td>Practical exam</td>
<td>20%</td>
<td>Week 13 (TBC)</td>
</tr>
<tr>
<td>Bushveld Complex</td>
<td>10%</td>
<td>18/3/15</td>
</tr>
<tr>
<td>Ore Deposits and Geodynamics</td>
<td>10%</td>
<td>6/5/15</td>
</tr>
</tbody>
</table>

Practical classes
Due: ongoing
Weighting: 15%

Practical work to be handed in during the semester, a maximum of 4 will be assessed.

This Assessment Task relates to the following Learning Outcomes:
- an understanding of the genesis and geochemistry of the major igneous rock suites
- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- an ability to identify the major rock-forming and ore minerals using a petrographic microscope
- an ability to recognize and interpret igneous and ore micro-textures
- experience in interpreting and modelling geochemical data

Exam: Theory
Due: TBA
Weighting: 45%

End of semester written theory exam

This Assessment Task relates to the following Learning Outcomes:
- an understanding of the genesis and geochemistry of the major igneous rock suites
- a process oriented understanding of the genesis and exploration criteria of the major ore
deposit types
  • experience in interpreting and modelling geochemical data

Practical exam
Due: **Week 13 (TBC)**
Weighting: **20%**

Optical microscopy practical exam

This Assessment Task relates to the following Learning Outcomes:
  • an understanding of the genesis and geochemistry of the major igneous rock suites
  • an ability to identify the major rock-forming and ore minerals using a petrographic microscope
  • an ability to recognize and interpret igneous and ore micro-textures

**Bushveld Complex**
Due: **18/3/15**
Weighting: **10%**

A number of specific sub-topics are available for each of the broad assignment topics. Included below is the list of topics and recommended starting reading/references. Your assigned topic can be found in the table in the unit guide on iLearn.

Much of your reading for this unit will be from articles in academic journals and chapters of specialist books. These sources will be critical for your individual research projects. While the vast majority of these are available online through the university library (although logging on externally can sometimes be slow and/or problematic), **some are available in hard copy only**. Therefore plan your access to these resources carefully and obtain photocopies etc for your assignments early. This is particularly the case for ore deposit geology, where some of the journals are:

- Economic Geology (QE1.E15)
- Mineralium Deposita (QE351.M27)
- Ore Geology Reviews (QE390.O74)

I also have .pdf’s for most of the recommended journal articles for the research assignments which are not available electronically through the library. I will endeavour to put these on iLearn upon request.

**Assignment 1. The Bushveld Complex.**

**Topic 1: Geodynamic setting of the Bushveld Complex**

Richardson SH, Shirey SB, 2008. *Continental mantle signature of Bushveld magmas and coeval...*

**Topic 2: Geochemical evolution of the Bushveld Complex**


**Topic 3: Mineralisation within the Bushveld Complex**


**Topic 4: Magmatic layering in the Bushveld Complex: origin and significance**


**Topic 5: Thermal and structural effects and controls on the emplacement of the Bushveld Complex**


Note that these assignments differ from conventional essays in that they are **true research review style articles**. As such it is anticipated that your primary reference sources will be peer reviewed scientific literature that is appropriately cited and referenced. Some articles of this nature are included under each topic to get you started. Note that you will be expected to supplement these with at least four **extra** research articles that you find through your own research. You must use figures to illustrate key concepts.

These are assignments of at least 1000 words and a **maximum of 1500 words**, and are designed to give you some grounding in the material to be covered in the week they are due to be handed in.

This Assessment Task relates to the following Learning Outcomes:

- an understanding of the genesis and geochemistry of the major igneous rock suites
- understanding scientific methodology and an ability to access, research and assess appropriate scientific information
- a capacity to communicate the findings of research through scientific writing

Ore Deposits and Geodynamics

Due: 6/5/15
Weighting: 10%

A number of specific sub-topics are available for each of the broad assignment topics. Included below is the list of topics and recommended starting reading/references. Your assigned topic can be found in the table in the study guide in iLearn.

Much of your reading for this unit will be from articles in academic journals and chapters of specialist books. These sources will be critical for your individual research projects. While the vast majority of these are available online through the university library (although logging on externally can sometimes be slow and/or problematic), **some are available in hard copy only**. Therefore plan your access to these resources carefully and obtain photocopies etc for your assignments early. This is particularly the case for ore deposit geology, where some of the journals are:

- Economic Geology (QE1.E15)
- Mineralium Deposita (QE351.M27)
- Ore Geology Reviews (QE390.O74)

I also have .pdf’s for most of the recommended journal articles for the research assignments which are **not** available electronically through the library. I will endeavour to put these on iLearn.

https://unitguides.mq.edu.au/unit_offerings/49111/unit_guide/print
Assignment 2: Geodynamics and ore deposits:

**Topic 1: Setting and characteristics of Volcanic Hosted Massive Sulphide (VHMS) deposits**

Huston, DL; Stevens, B; Southgate, PN, et al. 2006. *Australian Zn-Pb-Ag ore-forming systems: A review and analysis.* ECONOMIC GEOLOGY 101 v6: 1117-1157

Saez, R; Pascual, E; Toscano, M, et al., 1999. *The Iberian type of volcano-sedimentary massive sulphide deposits.* MINERALIUM DEPOSITA 34 v 5-6: 549-570


**Topic 2: Setting and characteristics of Sedex (including MVT) deposits**


Large, RR; Bull, SW; Cooke, DR, et al., 1998. A genetic model for the HYC deposit, Australia: Based on regional sedimentology, geochemistry, and sulfide-sediment relationships. ECONOMIC GEOLOGY AND THE BULLETIN OF THE SOCIETY OF ECONOMIC GEOLOGISTS, 93 (8): 1345-1368.

**Topic 3: Porphyry Cu (±Mo) mineralization: Characteristics and geodynamic controls**


Seedorff, E; Barton, MD; Stavast, WJA, et al., 2008. *Root Zones of Porphyry Systems: Extending the Porphyry Model to Depth.* ECONOMIC GEOLOGY, 103 (5): 939-956

Proffett, JM., 2009 High Cu grades in porphyry Cu deposits and their relationship to emplacement depth of magmatic sources GEOLOGY, 37 (8): 675-678

**Topic 4: Hydrothermal (including Epi- and Mesothermal) ore deposits**


systems: A review ORE GEOLOGY REVIEWS 13(1-5): 307-321


Goldfarb, R.J.; Groves, D.I.; Gardoll, S. Orogenic gold and geologic time: a global synthesis Ore Geology Reviews

**Topic 5: Iron Oxide Copper Gold deposits: Features, temporal and spatial controls**

HITZMAN, MW; ORESKES, N; EINAUDI, MT., 1992 Geological characteristics and tectonic setting of Proterozoic Iron-Oxide (Cu-U-Au-REE) deposits. PRECAMBRIAN RESEARCH 58 v1-4: 241-287

Bastrakov, EN; Skirrow, RG; Didson, GJ., 2007. Fluid evolution and origins of iron oxide Cu-Au prospects in the Olympic Dam district, Gawler Craton, South Australia, ECONOMIC GEOLOGY, 102 (8): 1415-1440


*Note that these assignments differ from conventional essays in that they are true research review style articles. As such it is anticipated that your primary reference sources will be peer reviewed scientific literature that is appropriately cited and referenced. Some articles of this nature are included under each topic to get you started. Note that you will be expected to supplement these with at least four extra research articles that you find through your own research. You must use figures to illustrate key concepts.*

These are assignments of at least 1000 words and a maximum of 1500 words, and are designed to give you some grounding in the material to be covered in the week they are due to be handed in.

This Assessment Task relates to the following Learning Outcomes:

- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- understanding scientific methodology and an ability to access, research and assess appropriate scientific information
- a capacity to communicate the findings of research through scientific writing

**Delivery and Resources**

You are required to attend 2 lectures and 1 practical session per week. Both sessions will be
Unit Schedule

Provisional unit timetable for GEOS343, Semester 1, 2015; All classes in E5A210

<table>
<thead>
<tr>
<th>Week</th>
<th>Lectures</th>
<th>Practical</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25/2</td>
<td>Nomenclature, tectonic associations; chemistry and mineralogy refresher</td>
<td>Petrology refresher, volcanic rocks</td>
</tr>
<tr>
<td>2</td>
<td>4/3</td>
<td>i) Phase equilibria, melting processes; ii) Binary and Ternary systems</td>
<td>Bushveld I: Mineralogy, textures, macroscopic layering</td>
</tr>
<tr>
<td>3</td>
<td>11/3</td>
<td>Geochemistry: i) Major elements ii) Trace elements</td>
<td>Bushveld II: Textural relationships; petrogenetic sequences, liquid line of descent and binary phase diagrams</td>
</tr>
<tr>
<td>4</td>
<td>18/3</td>
<td>i) Origin of basaltic magma ii) Diversification of magmas</td>
<td>Major element modelling; inflections due to modal mineralogy changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1st assignment due (Bushveld)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>25/3</td>
<td>Volcanology</td>
<td>Volcanic rocks; alkalic systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mid semester Break (3/4 – 20/4 2015)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>22/4</td>
<td>Island Arc Magmatism</td>
<td>Bulk mixing, discriminating between mixing vs AFC, isochron</td>
</tr>
<tr>
<td>Week</td>
<td>Date</td>
<td>Topic</td>
<td>Lecture Notes</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
| 7    | 29/4 | Basaltic magmatism in ocean basins  
  i) MORB  
  ii) OIB  
  iii) LIPs and CFBs | Primary magma compositions (chilled compositions)  
  Forward and inverse melt modelling | SPT computing prac |
| 8    | 6/5  | Principles of ore petrogenesis; S saturation, differentiation, accumulation, phase equilibria (redox)  
  2nd assignment due (Geodynamics and ore deposits) | Bushveld III:  
  Reflected light microscopy; textures, mineralogy, chemical compositions | BFS |
| 9    | 13/5 | Mineralising processes: BIFs, hydrothermal systems, placers, redox (U), regolith | Hand specimens, mineralogy, reflected light of examples | BFS |
| 10   | 20/5 | Granites, I, S, A, crustal growth and evolution, skarns; sedimentary provenance, detrital systems | Crustal mass balance, granite petrogenesis from TS and hand specs | BFS |
| 11   | 27/5 | Isotopes in magmatic and ore forming systems: Stable, cosmogenic, U-series, | Isotope geodynamics prac | BFS |
| 12   | 3/6  | Solar system and planet formation, atmospheric formation and evolution, meteorites | | BFS/guest lecturers from ANU |
| 13   | 10/6 | Review Lecture | Practical Exam (TBC) | |

**Policies and Procedures**

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

- **Disruption to Studies Policy** [http://www.mq.edu.au/policy/docs/disruption_studies/policy.html](http://www.mq.edu.au/policy/docs/disruption_studies/policy.html) *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special*
Consideration Policy.

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

**Student Code of Conduct**

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: [https://students.mq.edu.au/support/student_conduct/](https://students.mq.edu.au/support/student_conduct/)

**Results**

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in *eStudent*. For more information visit [ask.mq.edu.au](http://ask.mq.edu.au).

**Student Support**

Macquarie University provides a range of support services for students. For details, visit [http://students.mq.edu.au/support/](http://students.mq.edu.au/support/)

**Learning Skills**

Learning Skills ([mq.edu.au/learningskills](http://mq.edu.au/learningskills)) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

**Student Enquiry Service**

For all student enquiries, visit Student Connect at [ask.mq.edu.au](http://ask.mq.edu.au)

**Equity Support**

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

**IT Help**


When using the University's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students.
Graduate Capabilities

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

• an understanding of the genesis and geochemistry of the major igneous rock suites
• a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
• an ability to identify the major rock-forming and ore minerals using a petrographic microscope
• an ability to recognize and interpret igneous and ore micro-textures
• experience in interpreting and modelling geochemical data

Assessment tasks

• Practical classes
• Exam: Theory
• Practical exam
• Bushveld Complex
• Ore Deposits and Geodynamics

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcomes

• a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
• understanding scientific methodology and an ability to access, research and assess
Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- an understanding of the genesis and geochemistry of the major igneous rock suites
- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- an ability to recognize and interpret igneous and ore micro-textures
- understanding scientific methodology and an ability to access, research and assess appropriate scientific information
- a capacity to communicate the findings of research through scientific writing

Assessment tasks

- Practical classes
- Exam: Theory
- Practical exam
- Bushveld Complex
- Ore Deposits and Geodynamics

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:
Learning outcomes

• an understanding of the genesis and geochemistry of the major igneous rock suites
• a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
• an ability to identify the major rock-forming and ore minerals using a petrographic microscope
• an ability to recognize and interpret igneous and ore micro-textures
• experience in interpreting and modelling geochemical data

Assessment tasks

• Practical classes
• Exam: Theory
• Practical exam
• Bushveld Complex
• Ore Deposits and Geodynamics

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

• an understanding of the genesis and geochemistry of the major igneous rock suites
• a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
• an ability to identify the major rock-forming and ore minerals using a petrographic microscope
• an ability to recognize and interpret igneous and ore micro-textures
• experience in interpreting and modelling geochemical data

Assessment tasks

• Practical classes
• Exam: Theory
• Practical exam
• Bushveld Complex
Ore Deposits and Geodynamics

Creative and Innovative
Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes
- an understanding of the genesis and geochemistry of the major igneous rock suites
- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- an ability to recognize and interpret igneous and ore micro-textures

Assessment tasks
- Practical classes
- Exam: Theory
- Practical exam
- Bushveld Complex
- Ore Deposits and Geodynamics

Effective Communication
We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes
- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- an ability to identify the major rock-forming and ore minerals using a petrographic microscope
- an ability to recognize and interpret igneous and ore micro-textures
- understanding scientific methodology and an ability to access, research and assess appropriate scientific information
- a capacity to communicate the findings of research through scientific writing
Assessment tasks

- Practical classes
- Exam: Theory
- Practical exam
- Bushveld Complex
- Ore Deposits and Geodynamics

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcomes

- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- understanding scientific methodology and an ability to access, research and assess appropriate scientific information
- a capacity to communicate the findings of research through scientific writing

Assessment tasks

- Bushveld Complex
- Ore Deposits and Geodynamics

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcomes

- an understanding of the genesis and geochemistry of the major igneous rock suites
- a process oriented understanding of the genesis and exploration criteria of the major ore deposit types
- an ability to identify the major rock-forming and ore minerals using a petrographic
microscope
• an ability to recognize and interpret igneous and ore micro-textures
• understanding scientific methodology and an ability to access, research and assess appropriate scientific information
• a capacity to communicate the findings of research through scientific writing

Assessment tasks

• Exam: Theory
• Practical exam
• Bushveld Complex
• Ore Deposits and Geodynamics