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

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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://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes
On successful completion of this unit, you will be able to:

- 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

https://unitguides.mq.edu.au/unit_offerings/49111/unit_guide/print
On successful completion you will be able to:

- an ability to recognize and interpret igneous and ore micro-textures
- experience in interpreting and modelling geochemical data
- 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**

<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.

On successful completion you will be able to:

- 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

On successful completion you will be able to:
• 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

On successful completion you will be able to:
• 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


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

to the Steelpoort pericline: implications for syn-Bushveld tectonism in the eastern Bushveld Complex, SOUTH AFRICAN JOURNAL OF GEOLOGY 108 (3): 397-412


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.

On successful completion you will be able to:

- 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:

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

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**


Saez, R; Pascual, E; Toscano, M, et al., 1999. The Iberian type of volcano-sedimentary massive sulphide deposits. *MINERALIUM DEPOSITA* 34 (v5-6): 549-570


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


**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**

Phillips, GN; Powell, R., 2009. Formation of gold deposits: Review and evaluation of the
continuum model. EARTH-SCIENCE REVIEWS, 94 (1-4): 1-21


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.

On successful completion you will be able to:

- 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

https://unitguides.mq.edu.au/unit_offerings/49111/unit_guide/print
**Delivery and Resources**

You are required to attend 2 lectures and 1 practical session per week. Both sessions will be held in E5A 210. Scheduled times are:

Lectures: Wednesday 11am-1 pm

Practicals: Wednesday 3–6 pm

However we may be able to shift things around on this day to make more convenient times for everybody.

The iLearn site is the main source of resources for this unit.

**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 25/2</td>
<td>Nomenclature, tectonic associations; chemistry and mineralogy refresher</td>
<td>Petrology refresher, volcanic rocks</td>
<td>BFS</td>
</tr>
<tr>
<td>2 4/3</td>
<td>i) Phase equilibria, melting processes; ii) Binary and Ternary systems</td>
<td>Bushveld I: Mineralogy, textures, macroscopic layering</td>
<td>SPT</td>
</tr>
<tr>
<td>3 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>
<td>SPT</td>
</tr>
<tr>
<td>4 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>
<td>MT/SPT</td>
</tr>
<tr>
<td>5 25/3</td>
<td><strong>Volcanology</strong></td>
<td>Volcanic rocks; alkalic systems</td>
<td>SPT computing prac</td>
</tr>
</tbody>
</table>

Mid semester Break (3/4 – 20/4 2015)
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Subtopics</th>
<th>Activity</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>22/4</td>
<td>Island Arc Magmatism</td>
<td>Bulk mixing, discriminating between mixing vs AFC, isochron</td>
<td>CF/SPT computing prac</td>
<td>BFS, SPT, MT, CF</td>
</tr>
<tr>
<td>7</td>
<td>29/4</td>
<td>Basaltic magmatism in ocean basins</td>
<td>Primary magma compositions (chilled compositions) Forward and inverse melt modelling</td>
<td>SPT computing prac</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6/5</td>
<td>Principles of ore petrogenesis; S saturation, differentiation, accumulation, phase equilibria (redox)</td>
<td>Bushveld III: Reflected light microscopy; textures, mineralogy, chemical compositions</td>
<td>BFS</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>13/5</td>
<td>Mineralising processes: BIFs, hydrothermal systems, placers, redox (U), regolith</td>
<td>Hand specimens, mineralogy, reflected light of examples</td>
<td>BFS</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>20/5</td>
<td>Granites, I, S, A, crustal growth and evolution, skarns; sedimentary provenance, detrital systems</td>
<td>Crustal mass balance, granite petrogenesis from TS and hand specs</td>
<td>BFS</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>27/5</td>
<td>Isotopes in magmatic and ore forming systems: Stable, cosmogenic, U-series,</td>
<td>Isotope geodynamics prac</td>
<td>BFS</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3/6</td>
<td>Solar system and planet formation, atmospheric formation and evolution, meteorites</td>
<td></td>
<td>BFS/guest lecturers from ANU</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>10/6</td>
<td>Review Lecture</td>
<td>Practical Exam (TBC)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BFS: Bruce Schaefer, SPT: Simon Turner; MT: Michael Turner, CF: Chris Firth

**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:


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.

**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 Services and 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.

**Student Enquiries**

For all student enquiries, visit Student Connect at ask.mq.edu.au

**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

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

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

**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
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

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

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 appropriate scientific information
• a capacity to communicate the findings of research through scientific writing

Assessment tasks
• 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