



GEOS776

Advanced Geochemical Applications and Techniques

S1 Day 2014

Earth and Planetary Sciences

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General Information

Unit convenor and teaching staff

Unit Convenor

Norman Pearson

norman.pearson@mq.edu.au

Contact via norman.pearson@mq.edu.au

E5B 205

9:00-5:30 Mon-Fri

Credit points

4

Prerequisites

Admission to MRes

Corequisites

Co-badged status

Co-badged with GEOS876

Unit description

This unit provides hands-on training and operation of state-of-the-art instrumentation used in inorganic geochemical analysis to determine major element, trace element and isotopic composition of rocks and minerals. The unit comprises lectures, group instrument instruction and individual projects. The project includes planning the analytical strategy, data collection, data presentation and interpretation.

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:

explain the basic principles of how the XRF, EMP and ICP-MS operate

be able to select an appropriate analytical technique and set-up an analytical protocol for the geochemical analysis of major and trace elements in geological materials

acquire the basic skills to operate the EMP and laser ablation ICP-MS

devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry

develop the knowledge to determine the uncertainty of analytical results
critically evaluate the quality of data obtained using different analytical methods
compare the results obtained from different analytical techniques
interpret geochemical data using the knowledge of analytical uncertainty
organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Assessment Tasks

Name	Weighting	Due
<u>Assignment 1</u>	10%	31 March 2014
<u>Assignment 2</u>	25%	30 April 2014
<u>Assignment 3</u>	25%	28 May 2014
<u>Seminar</u>	10%	28 May 2014
<u>Test</u>	20%	11 June 2014
<u>Class Participation</u>	10%	Each session

Assignment 1

Due: **31 March 2014**

Weighting: **10%**

Assignment 1 will be based on the concepts and skills covered in days 1, 2 and 3. The exercises undertaken in the tutorials in these sessions will provide a framework for self-assessment of your progress and in the preparation of the assignments.

On successful completion you will be able to:

- be able to select an appropriate analytical technique and set-up an analytical protocol for the geochemical analysis of major and trace elements in geological materials
- devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry
- develop the knowledge to determine the uncertainty of analytical results
- critically evaluate the quality of data obtained using different analytical methods
- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Assignment 2

Due: **30 April 2014**

Weighting: **25%**

This practical project will involve EMP instrument usage and the data generated during the practical will be used in the assignment.

On successful completion you will be able to:

- explain the basic principles of how the XRF, EMP and ICP-MS operate
- acquire the basic skills to operate the EMP and laser ablation ICP-MS
- devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry
- develop the knowledge to determine the uncertainty of analytical results
- critically evaluate the quality of data obtained using different analytical methods
- interpret geochemical data using the knowledge of analytical uncertainty
- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Assignment 3

Due: **28 May 2014**

Weighting: **25%**

This practical project will involve use of the laser ablation ICP-MS and the data generated during the practical will be used in the assignment.

On successful completion you will be able to:

- explain the basic principles of how the XRF, EMP and ICP-MS operate
- acquire the basic skills to operate the EMP and laser ablation ICP-MS
- devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry
- develop the knowledge to determine the uncertainty of analytical results
- critically evaluate the quality of data obtained using different analytical methods
- interpret geochemical data using the knowledge of analytical uncertainty
- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Seminar

Due: **28 May 2014**

Weighting: **10%**

The theme of the seminar day is “Recent Advances in Analytical Geochemistry”. A list of topics will be provided in week 2 and you will choose a topic based on one of the instrument techniques covered in the course. Your brief will be to prepare a brief overview of the advances in the analytical method and its application. Each student will be required to produce a PowerPoint presentation (maximum 5 slides) on your topic and give this as a short seminar. A mark will be awarded based on content and presentation.

On successful completion you will be able to:

- be able to select an appropriate analytical technique and set-up an analytical protocol for the geochemical analysis of major and trace elements in geological materials
- devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry
- critically evaluate the quality of data obtained using different analytical methods
- interpret geochemical data using the knowledge of analytical uncertainty
- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Test

Due: **11 June 2014**

Weighting: **20%**

This will be an ‘in-class test’ and involve a 2-hour written examination. This will cover the material presented in the unit and consist of a combination of short answer questions on definitions and concepts and an essay section requiring further descriptions of concepts and theory.

On successful completion you will be able to:

- explain the basic principles of how the XRF, EMP and ICP-MS operate
- acquire the basic skills to operate the EMP and laser ablation ICP-MS
- devise and undertake an analytical program using the appropriate techniques to solve complex petrological problems using geochemistry

Class Participation

Due: **Each session**

Weighting: **10%**

The class mark will be awarded on the basis of performance in the laboratory practicals and participation in class discussions.

On successful completion you will be able to:

- explain the basic principles of how the XRF, EMP and ICP-MS operate
- critically evaluate the quality of data obtained using different analytical methods
- compare the results obtained from different analytical techniques
- interpret geochemical data using the knowledge of analytical uncertainty
- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication

Delivery and Resources

Required and Recommended Texts

There are no prescribed textbooks for this course. A copy of Powerpoint lecture presentations will be available on the unit's WEB page.

The following books are recommended for additional reading. Potts, P.: A Handbook of Silicate Rock Analysis. Blackie (on reserve) Rollinson, H.: Using Geochemical Data. Longman

Unit Web Page

Web resources are on the GEOS776 page in iLearn (http://www.mq.edu.au/iLearn/student_info/index.htm).

This site will have pdfs of lectures, tutorials and assignments, and echo recordings of pre-recorded lectures.

Information for students about access to online units is available at <https://ilearn.mq.edu.au/login/MQ/>

Unit Schedule

Unit of study timetable 2014

Week 1: 5 March 2014: 11:00 – 12:00 (Lecture), 1:00 – 3:00 (Tutorial)

Geochemical Analysis – Basics

Lecture 1 – Introduction

- Overview of analytical methods, instruments and laboratories
- Analytical procedure
- Concepts in analytical geochemistry
- Instruments and methods – a virtual tour of the Geochemical Analysis Unit
- Measurement and calibration • Analytical strategy

Tutorial 1

- Instrument calibration and standardisation
- Standards and reference materials
- Reporting and presenting geochemical data

Week 2: 19 March 2014: 11:00 – 12:00, 1:00 – 3:00

Sampling and Planning an Analytical Program

Lecture 2

- Introduction to uncertainty
- Sampling
- Uncertainty of sampling
- Sampling strategy
- Instrument limits of error

Tutorial 2 – Planning an Analytical Program

Week 3: 26 March 2014: 11:00 – 12:00, 1:00 – 3:00

Data Quality

Lecture 3 – Geochemical data

- Basic statistics refresher
- Uncertainties in quantitative analysis
- Accuracy and precision
- Internal and external precision
- Counting statistics
- Outliers

Tutorial 3 Quality assurance – how good are your analytical data? Standards and Reference Materials

Week 4: 2 April 2014: 11:00 – 12:00, 1:00 – 3:00

X-ray Analytical Techniques I

Lecture 4 – X-ray spectrometry – Basic quantitative X-ray analysis

- What are X-rays?
- How are X-rays produced?
- Characteristic X-rays
- X-ray lines and spectra
- Wavelength X-ray spectrometer
- Energy X-ray spectrometer

Tutorial 4 Characteristic X-ray lines and spectra Mineral Identification

Week 5: 9 April 2014: 11:00 – 12:00, 1:00 – 3:00

X-ray Analytical Techniques II

Lecture 5 X-ray spectrometry – Basic quantitative X-ray analysis

- X-ray fluorescence spectrometry
- Background measurement
- Spectral interference
- Interaction of X-rays and matter
- Attenuation and fluorescence
- Matrix corrections

Tutorial 5 Whole-rock analysis I

- X-ray Fluorescence Spectrometry for major and trace elements

Week 6: 16 April 2014: 11:00 – 12:00, 1:00 – 3:00

X-ray Analytical Techniques III

Lecture 6 Mineral analysis I – major elements

- Electron Microprobe (EMP) Instrumentation
- Quantitative mineral analysis
- Interaction of the electron beam and material

- Electron imaging
- ZAF matrix corrections
- phi-rho-z matrix corrections
- Preparation of samples

Tutorial 6 Mineral chemistry – data reduction and quality • Assessing data quality • Mineral structural formula

Week 7: 23 April 2014: 11:00 – 12:00, 1:00 – 3:00

Mass Spectrometry I

Lecture 7

- Introduction to mass spectrometry
- Isotopes
- Types of mass spectrometer
- Trace element analysis by ICP-MS
- Isotope ratio measurement
- Basics of ICP-MS
- The ICP as a source of ions
- Quadrupole mass analyser
- Detecting and counting ions

Tutorial 7 ICP-MS data reduction and quality

Week 8: 30 April 2014: 11:00 – 12:00, 1:00 – 3:00

Mass Spectrometry II

Lecture 8 – Mineral analysis II – trace elements and isotope ratios

- Laser ablation ICP-MS
- Types of laser
- Ablation processes
- Calibration and quantification
- Time-resolved analysis

Tutorial 8 LAM-ICPMS – trace element analysis

Week 9: 21 May 2014: 11:00 – 12:00, 1:00 – 3:00

Mass Spectrometry III

Lecture 9 Isotope geochemistry – Multi-collector ICP-MS

- Radiogenic and stable isotope systems
- isotope ratio measurement
- multiple collector mass spectrometer
- mass bias
- radioactive decay
- isochron
- In-situ geochronology

Tutorial 9 U-Pb zircon – data reduction and quality

Week 10: 28 May 2014: 11:00 – 12:00, 1:00 – 3:00

New Frontiers In Geochemical Analysis

Lecture 10 New Frontiers In Geochemical Analysis in GEMOC

Seminars “Developments in Analytical Methods”

Week 11: 4 June 2014: 11:00 – 12:00, 1:00 – 3:00

Review – Report and Thesis Preparation

Workshop “Analytical Methods” in your thesis or manuscript Communicating your results

Week 12: 11 June 2014: 1:00 – 3:00 Assessment – In-class test

Times for the analytical sessions for the practical project for Assignment 2 will be arranged between 9-15 April and for Assignment 3 times between 30 April – 6 May. There will be two sessions: one on the electron microprobe and the other using the laser ablation ICP-MS and each session will be approximately 3 hours in duration.

Attendance at lectures/practical/tutorial sessions is compulsory.

Learning and Teaching Activities

Tutorials

Weekly tutorial workshops will be held to review lecture content and undertake exercises to develop skills in analytical geochemistry and generic skills in problem solving, numeracy, data

synthesis, project management and communication.

Instrument Practicals

The practical sessions will involve the use of instruments in the Geochemical Analysis Unit. Basic training will be given in instrument operation to enable you to undertake a small research project. The main aims of the project are to develop an analytical strategy to solve the problem presented to you and to gain experience preparing a report detailing the analytical method, data collection, data processing and data presentation.

Seminar

The theme of the seminar day is “Recent Advances in Analytical Geochemistry”. A list of topics will be provided in week 2 and you will choose a topic based on one of the instrument techniques covered in the course. Your brief will be to prepare a brief overview of the advances in the analytical method and its application. Each student will be required to produce a PowerPoint presentation (maximum 5 slides) of your topic and give this as a short seminar. A mark will be awarded based on content and presentation.

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:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy <http://mq.edu.au/policy/docs/assessment/policy.html>

Grading Policy <http://mq.edu.au/policy/docs/grading/policy.html>

Grade Appeal Policy <http://mq.edu.au/policy/docs/gradeappeal/policy.html>

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy 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/

Student Support

Macquarie University provides a range of support services for students. For details, visit <http://students.mq.edu.au/support/>

[dents.mq.edu.au/support/](https://unitguides.mq.edu.au/support/)

Learning Skills

Learning Skills (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

For help with University computer systems and technology, visit <http://informatics.mq.edu.au/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.