GEOS876

Advanced Geochemical Applications and Techniques

S1 Day 2014

Earth and Planetary Sciences

Contents

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General Information

Unit convenor and teaching staff
Unit Convenor
Norman Pearson
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Contact via norman.pearson@mq.edu.au
E5B 205
9:00-5:30 Mon-Fri

Credit points
4

Prerequisites
Permission of Executive Dean of Faculty

Corequisites

Co-badged status
Co-badged with GEOS776

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
Assignment 1	10%	31 March 2014
Assignment 2	25%	30 April 2014
Assignment 3	25%	28 May 2014
Seminar	10%	28 May 2014
Class Participation	10%	Each session
Test	20%	11 June 2014

Assignment 1

Due: **31 March 2014**
Weighting: **10%**

Assignment 1will 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%**

The 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.

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.

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

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 GEOS876 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 skils 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/

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.

Graduate Capabilities

PG - Discipline Knowledge and Skills

Our postgraduates will be able to demonstrate a significantly enhanced depth and breadth of knowledge, scholarly understanding, and specific subject content knowledge in their chosen fields.

This graduate capability is supported by:

Learning outcomes

- 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
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- 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

Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Seminar
- Class Participation
- Test

PG - Critical, Analytical and Integrative Thinking

Our postgraduates will be capable of utilising and reflecting on prior knowledge and experience, of applying higher level critical thinking skills, and of integrating and synthesising learning and knowledge from a range of sources and environments. A characteristic of this form of thinking is the generation of new, professionally oriented knowledge through personal or group-based critique of practice and theory.

This graduate capability is supported by:

Learning outcomes

- 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
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- organise and present geochemical data in table and graphical format suitable for a report, thesis or publication.

Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Seminar
- Class Participation
- Test

PG - Research and Problem Solving Capability

Our postgraduates will be capable of systematic enquiry; able to use research skills to create new knowledge that can be applied to real world issues, or contribute to a field of study or practice to enhance society. They will be capable of creative questioning, problem finding and problem solving.

This graduate capability is supported by:

Learning outcomes

- 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

Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Class Participation

PG - Effective Communication

Our postgraduates will be able to communicate effectively and convey their views to different social, cultural, and professional audiences. They will be able to use a variety of technologically supported media to communicate with empathy using a range of written, spoken or visual formats.

This graduate capability is supported by:

Learning outcomes

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

- Assignment 1
- Assignment 2
- Assignment 3
- Seminar
- Class Participation
- Test

PG - Engaged and Responsible, Active and Ethical Citizens

Our postgraduates will be ethically aware and capable of confident transformative action in relation to their professional responsibilities and the wider community. They will have a sense of connectedness with others and country and have a sense of mutual obligation. They will be able to appreciate the impact of their professional roles for social justice and inclusion related to national and global issues

This graduate capability is supported by:

Learning outcomes

- 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

Assessment tasks

- Assignment 2
- Assignment 3
- Seminar
- Class Participation

PG - Capable of Professional and Personal Judgment and

Initiative

Our postgraduates will demonstrate a high standard of discernment and common sense in their professional and personal judgment. They will have the ability to make informed choices and decisions that reflect both the nature of their professional work and their personal perspectives.

This graduate capability is supported by:

Learning outcomes

- 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
- 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
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- 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

- Assignment 2
- Assignment 3
- Seminar
- Class Participation