GEOS922

Microstructures to Large Scale Processes: Rheology, Metamorphism and Fluids

S1 Day 2015

Dept of Earth and Planetary Sciences

Contents

General Information

Unit convenor and teaching staff
Co-convener
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Unit Convenor
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Credit points
4

Prerequisites
Admission to MGeoSc and GEOS207

Corequisites

Co-badged status
GEOS707

Unit description
This unit aims to give the student an in-depth knowledge of how to document, analyse and interpret microstructures in thin section with special emphasis on deformation and reaction microstructures. Importantly it additionally gives an overview over the rheological behaviour of different minerals at variable conditions and provides the link between microstructure, metamorphism, fluids and rheology. This knowledge is essential in order to link small-scale behaviour to large-scale behaviour in the earth crust and mantle.The course comprises lectures, practicals, and directed reading, which form the basis for an individual project that focus on two of the tools introduced. Individual projects will involve an oral presentation and submission of a report.

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:

Recognize a large variety of deformation and metamorphic microstructures
Quantitatively record and analyse deformation and metamorphic microstructures
Relate microstructures to the rheology and history of the specimen analysed
Interpret microstructures in terms of possible geodynamic settings
Understand and describe accurately the basics principles of phase equilibria, metamorphic textures and reaction textures
Understand the basics of tools such as numerical modelling, EBSD analysis, thermodynamic modelling and image analysis

Assessment Tasks

Name	Weighting	Due
Thinsection Description I	15%	April 12th
Thinsection Description II	15%	April 12th
Pseudosections	20%	29 April 2014
Project	50%	13 May 2014

Thinsection Description I

Due: **April 12th**
Weighting: **15%**

These will be small topic-based presentations 5-10 min on initial practical work describing microstructures and their interpretation.

On successful completion you will be able to:

- Recognize a large variety of deformation and metamorphic microstructures
- Quantitatively record and analyse deformation and metamorphic microstructures
- Relate microstructures to the rheology and history of the specimen analysed
- Interpret microstructures in terms of possible geodynamic settings

Thinsection Description II

Due: **April 12th**
Weighting: **15%**

These will be small topic-based presentations 5-10 min on second part of practical work.

On successful completion you will be able to:

- Recognize a large variety of deformation and metamorphic microstructures
- Quantitatively record and analyse deformation and metamorphic microstructures
- Relate microstructures to the rheology and history of the specimen analysed

Pseudosections

Due: **29 April 2014**
Weighting: **20%**

Presentation of calculated Pseudosections which is part of the Thermodynamics Part of the course

On successful completion you will be able to:

- Understand and describe accurately the basics principles of phase equilibria, metamorphic textures and reaction textures
- Understand the basics of tools such as numerical modelling, EBSD analysis, thermodynamic modelling and image analysis

Project

Due: **13 May 2014**
Weighting: **50%**

Each student will undertake a detailed analysis (image analysis, chemical analysis, EBSD etc.) of one to two thinsections. Each student will write a report about the findings of the analysis and give a presentation of those findings in form of a scientific paper. This could be also a “warm-up” for a potential Masters Project (year 2 of MRes)

On successful completion you will be able to:

- Recognize a large variety of deformation and metamorphic microstructures
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Delivery and Resources

Textbook, Webpages and Technology Used.

The textbooks for the unit are

A Practical Guide to Rock Microstructure. Vernon, R.H. 2004.

Microtectonics. Passchier & Trouw, 2005.

Rheology of the Earth. Ranalli, G., 1995.

Metamorphic phase modeling software - Thermocalc: http://www.metamorph.geo.uni-mainz.de/thermocalc/

Elle Microstructure Modelling software - http://www.materialsknowledge.org/elle/

Deformation Microstructure Course - http://virtualexplorer.com.au/special/meansvolume/contribs/jessell/index.html

Image Analysis Program (for Mac) NIH Image - http://rsb.info.nih.gov/nih-image/about.html

Image Analysis Program (for PC) Image J - http://rsb.info.nih.gov/ij/

Unit Schedule

Microstructures to Plate tectonics: S Piazolo and N. Daczko

Date	Weekday	Time	Location	Lectures (all recorded in 2013) *Listen to recorded lecture only (no live performance)	Practicals / Laboratory work	Readings / Online EBSD course / Online Thermocalc course
2-Mar	Mo	2.00-4.00	E5A 210	SPLect 1a: Intro to Rheology		Ranalli: chapter 1, chapter 2, chapter 3
5-Mar	Thurs	9.00-11.00	E5A 210	SPLect 1b: The atomic basis for deformation mechanisms		Ranalli: chapter 9.1&9.3, Passchier and Trouw
		12.00-2.00		SPLect 2a &: Rheology concepts II & Annealing mechansims, Dynamic recrystallization, and dislocation creep		Ranalli: Passchier and Trouw, chapter 1- 3, 9.1&9.4

9-Mar	Mo	2.00-4.00	E5A 210		Optical Microscopy (microstructures), Exercise 1 (paper), Define first presentation topics	
		4.00-5.00		*NDLect 1: How the microscope works		
12-Mar	Thurs	9.00-10.00	E5A 210	SPLect 3a: Rheology Concepts III		Ranalli: chapter 9.1&9.3
		10.00-11.00	E5A 210	*SPLect 3b: shear sense indictators, CPO		Passchier and Trouw 4.13, 5
		11.00-2.00	E5A 210		Optical Microscopy (microstructures), Exercise 2 (paper), First presentations (5 min)	
16-Mar	Mo	2.00-4.00	E5A 210	SPLect 4a & 4b: Rheology Concepts IV - diffusion, metamorphism and deformation		Passchier and Trouw
		4.00-5.00	E5A 210		Optical Microscopy (microstructures), Exercise 3 (paper), Define second presentation topics	
19-Mar	Thurs	9.00-11.00	E5A 210	SPLect 5: Rheology Concepts V (summary) - dissolution precipitation, fringes, veins		Passchier and Trouw
		11.00-2.00	E5A 210		Optical Microscopy (microstructures), Second presentations (5 min)	
23-Mar	Mo	2.00-3.00	E5A 210		Discuss SEM/ EBSD/ Thermocalc Projects, install EBSD program (BRING laptops to install program)	
		3.00-5.00	E5A 210	*SPLect 6A/B/C: Bringing it all together & deformation mechanisms in different minerals, gb hierarchy		Passchier and Trouw

26-Mar	Thurs	9.00-11.00	E5A 210		Optical Microscopy (microstructures)	Passchier and Trouw
		11.00-2.00	E5A 210	EBSD course	EBSD & Thermocalc courses; Questions about projects	
28th March - 25th April					Sandra away	
30-Mar	Mo	2.00-5.00	E5A 210	EBSD course (to be handed in 6th April - to Nathan)		
2-Apr	Thurs	9.00-10.00	E5A 210	*NDLect 2: Mineral assemblages, phase diagrams, P-T grids, pseudosections and compatibility diagrams		Powell, 1978: Chapters 1 & 2
		10:00-11:00	E5A 210	*NDLect 3: Changes to mineral assemblages, modes and mineral chemistry		Powell, R. & Holland, T.J.B., 2008. On thermobarometry. Journal of Metamorphic Geology, 26, 155–179.
		11.00-2.00	E5A 210	*NDLect 4: Heterogeneity in metamorphic rocks, equilibrium volume and reaction textures	Define Third presentation (10 min Thermocalc)	EBSD & Thermocalc courses; Questions about projects
6-Apr	Mo	2.00-3.00	E5A 210	*SPLect 7: TechniquesI I: Numerical Simulations - overview and ELLE		
		3.00-5.00	E5A 210	*SPLect 8: Techniques II: Analog Modelling and Image analysis (SPO)	Finish Optical Microscopy (microstructures)	Passchier and Trouw
9-Apr	Thurs	9.00-11.00	E5A 210		Thermocalc Practical	Holland, TJB, & Powell, R, 1998. An internally-consistent thermodynamic dataset for phases of petrological interest. Journal of Metamorphic Geology 16, 309–344.
		11:00-12:00	E5A 210	*NDLect 5: Compositional zoning, solid solution and chemical diffusion		
		12.00-1.00	E5A 210	*NDLect 6: Fluids, open vs closed systems and retrogression		
16-Apr	Thurs	9.00-11.00	E5A 210	NDLect 7: Metamorphic Microstructures	Thermocalc Practical	Holland, TJB, & Powell, R, 1998. An internally-consistent thermodynamic dataset for phases of petrological interest. Journal of Metamorphic Geology 16, 309–344.

		11:00-12:00	E5A 210	NDLect 8: Microstructure of Deformed rocks		
		12.00-2.00	E5A 210		Optical Microscopy (metamorphic textures)	
20-Apr	Mo	2.00-5.00	E5A 210		Optical Microscopy (metamorphic textures)	
23-Apr	Thurs	9.00-10.00	E5A 210		Thermocalc project	
30-Apr	Thurs	9.00-10.00	E5A 210		Thermocalc Presentations	Submit Thermocalc exercise
		10:00-11:00			Discuss timing projects etc.	
4/05/2015	Mo	9-5:00	SEM booked	group I		
7/05/2015	Thurs	9-5:00	SEM booked	group II		
11/05/2015	Mo	5:00 PM		project due group I		
14/05/2015	Thurs	5:00 PM		project due group II		
Thinsections:		Please leave in E5A 210 in allocated box - so everybody can look at them. If you need photos, go to E5A 210 when there is no classes, or you can go to the office next door (Nigels office, ask PhD students for entrance / how to work things				
		* audio lectures				

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/

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.

Extensions and Penalties:

Whenever possible requests for an extension should be submitted prior to an assignment's due date. Late assignments will be date stamped and a penalty of 10% initially and then 5% per day (Monday to Friday) will be deducted from the total mark.

Academic Honesty and Plagiarism

Plagiarism involves using the work of another person and presenting it as one's own. If you use the work of another person without clearly stating or acknowledging the source, you are falsely claiming that material as your own work and committing an act of **PLAGIARISM**. This is a very serious violation of good practice and an offence for which you will be penalised. You should read the University's policies and procedures on plagiarism. These can be found at: http://www.mq.edu.au/policy/docs/academic_honesty/policy.html

The policies and procedures explain what plagiarism is, how to avoid it, the procedures taken in cases of suspected plagiarism, and the penalties if you are found guilty. Penalties may include a deduction of marks, failure in the unit, and/or referral to the University Discipline Committee.

As such, the project assignment must have a signed "Faculty of Science" (FoS) assignment cover sheet attached. These sheets are available from the Science centre or from the FoS WEB page.

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 - 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:

Assessment tasks

- Thinsection Description II
- Pseudosections
- Project

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

- Recognize a large variety of deformation and metamorphic microstructures
- Quantitatively record and analyse deformation and metamorphic microstructures
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- Understand the basics of tools such as numerical modelling, EBSD analysis, thermodynamic modelling and image analysis

Assessment tasks

- Thinsection Description I
- Thinsection Description II
- Pseudosections
- Project

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

- Recognize a large variety of deformation and metamorphic microstructures
- Quantitatively record and analyse deformation and metamorphic microstructures
- Relate microstructures to the rheology and history of the specimen analysed
- Interpret microstructures in terms of possible geodynamic settings
- Understand and describe accurately the basics principles of phase equilibria, metamorphic textures and reaction textures

Assessment tasks

- Thinsection Description I
- Thinsection Description II
- Pseudosections

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

- Recognize a large variety of deformation and metamorphic microstructures
- Quantitatively record and analyse deformation and metamorphic microstructures
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Assessment tasks

- Thinsection Description I
- Thinsection Description II
- Pseudosections
- Project

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 outcome

- Understand and describe accurately the basics principles of phase equilibria, metamorphic textures and reaction textures

Assessment tasks

- Thinsection Description I
- Thinsection Description II
- Pseudosections

- Project