GEOS922

Microstructures to Large Scale Processes: Rheology, Metamorphism and Fluids

S1 Day 2015

Dept of Earth and Planetary Sciences

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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
Co-convener
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Contact via nathan.daczko@mq.edu.au
E7A509

Unit Convenor
Sandra Piazolo
sandra.piazolo@mq.edu.au
Contact via sandra.piazolo@mq.edu.au

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 http://students.mq.edu.au/student_admin/enrolmentguide/academicdates/

Learning Outcomes

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

**Assessment Tasks**

<table>
<thead>
<tr>
<th>Name</th>
<th>Weighting</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinsection Description I</td>
<td>15%</td>
<td>April 12th</td>
</tr>
<tr>
<td>Thinsection Description II</td>
<td>15%</td>
<td>April 12th</td>
</tr>
<tr>
<td>Pseudosections</td>
<td>20%</td>
<td>29 April 2014</td>
</tr>
<tr>
<td>Project</td>
<td>50%</td>
<td>13 May 2014</td>
</tr>
</tbody>
</table>

**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.

This Assessment Task relates to the following 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

**Thinsection Description II**

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

These will be small topic-based presentations 5-10 min on second part of practical work.
This Assessment Task relates to the following 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

Pseudosections
Due: 29 April 2014
Weighting: 20%
Presentation of calculated Pseudosections which is part of the Thermodynamics Part of the course

This Assessment Task relates to the following Learning Outcomes:
  • 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)

This Assessment Task relates to the following Learning Outcomes:
  • Recognize a large variety of 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

Delivery and Resources
Textbook, Webpages and Technology Used.

The textbooks for the unit are:

- Metamorphic phase modeling software - Thermocalc: [http://www.metamorph.geo.uni-mainz.de/thermocalc/](http://www.metamorph.geo.uni-mainz.de/thermocalc/)
- Elle Microstructure Modelling software - [http://www.materialsknowledge.org/elle/](http://www.materialsknowledge.org/elle/)
- Image Analysis Program (for Mac) NIH Image - [http://rsb.info.nih.gov/nih-image/about.html](http://rsb.info.nih.gov/nih-image/about.html)

**Unit Schedule**

<table>
<thead>
<tr>
<th>Date</th>
<th>Weekday</th>
<th>Time</th>
<th>Location</th>
<th>Lectures (all recorded in 2013) *Listen to recorded lecture only (no live performance)</th>
<th>Practicals / Laboratory work</th>
<th>Readings / Online EBSD course / Online Thermocalc course</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Mar</td>
<td>Mo</td>
<td>2.00-4.00</td>
<td>E5A 210</td>
<td>SPLect 1a: Intro to Rheology</td>
<td></td>
<td>Ranalli: chapter 1, chapter 2, chapter 3</td>
</tr>
<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Room</td>
<td>Topic</td>
<td>Book References</td>
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<tr>
<td>5-Mar</td>
<td>Thurs</td>
<td>9.00-11.00</td>
<td>E5A 210</td>
<td>SPLect 1b: The atomic basis for deformation mechanisms</td>
<td>Ranalli: chapter 9.1 &amp; 9.3, Passchier and Trouw</td>
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<tr>
<td></td>
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<td>12.00-2.00</td>
<td></td>
<td>SPLect 2a &amp;: Rheology concepts II &amp; Annealing mechanisms, Dynamic recrystallization, and dislocation creep</td>
<td>Ranalli: Passchier and Trouw, chapter 3, 9.1 &amp; 9.4</td>
<td></td>
</tr>
<tr>
<td>9-Mar</td>
<td>Mo</td>
<td>2.00-4.00</td>
<td>E5A 210</td>
<td>Optical Microscopy (microstructures), Exercise 1 (paper), Define first presentation topics</td>
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<tr>
<td></td>
<td></td>
<td>4.00-5.00</td>
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<td>*NDLect 1: How the microscope works</td>
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<tr>
<td>12-Mar</td>
<td>Thurs</td>
<td>9.00-10.00</td>
<td>E5A 210</td>
<td>SPLect 3a: Rheology Concepts III</td>
<td>Ranalli: chapter 9.1 &amp; 9.3</td>
<td></td>
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<td></td>
<td></td>
<td>10.00-11.00</td>
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<td>*SPLect 3b: shear sense indicators, CPO</td>
<td>Passchier and Trouw 4.13, 5</td>
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<tr>
<td></td>
<td></td>
<td>11.00-2.00</td>
<td>E5A 210</td>
<td>Optical Microscopy (microstructures), Exercise 2 (paper), First presentations (5 min)</td>
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<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Location</td>
<td>Topic</td>
<td>Presenter</td>
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<td>16-Mar</td>
<td>Mo</td>
<td>2.00-4.00</td>
<td>E5A 210</td>
<td>SPLect 4a &amp; 4b: Rheology Concepts IV - diffusion, metamorphism and deformation</td>
<td>Passchier and Trouw</td>
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<td></td>
<td></td>
<td>4.00-5.00</td>
<td>E5A 210</td>
<td>Optical Microscopy (microstructures), Exercise 3 (paper), Define second presentation topics</td>
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<tr>
<td>19-Mar</td>
<td>Thurs</td>
<td>9.00-11.00</td>
<td>E5A 210</td>
<td>SPLect 5: Rheology Concepts V (summary) - dissolution precipitation, fringes, veins</td>
<td>Passchier and Trouw</td>
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<td></td>
<td></td>
<td>11.00-2.00</td>
<td>E5A 210</td>
<td>Optical Microscopy (microstructures), Second presentations (5 min)</td>
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<tr>
<td>23-Mar</td>
<td>Mo</td>
<td>2.00-3.00</td>
<td>E5A 210</td>
<td>Discuss SEM/EBSD/Thermocalc Projects, install EBSD program (BRING laptops to install program)</td>
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<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Location</td>
<td>Lecture Title</td>
<td>Instructor(s)</td>
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<tr>
<td>26-Mar</td>
<td>Thurs</td>
<td>9.00-11.00</td>
<td>E5A 210</td>
<td>*SPLect 6A/B/C: Bringing it all together &amp; deformation mechanisms in different minerals, gb hierarchy</td>
<td>Passchier and Trouw</td>
<td></td>
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<tr>
<td>26-Mar</td>
<td>Thurs</td>
<td>11.00-2.00</td>
<td>E5A 210</td>
<td>EBSD course</td>
<td>EBSD &amp; Thermocalc courses; Questions about projects</td>
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<tr>
<td>28th March - 25th April</td>
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<td>Sandra away</td>
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<tr>
<td>30-Mar</td>
<td>Mo</td>
<td>2.00-5.00</td>
<td>E5A 210</td>
<td>EBSD course (to be handed in 6th April - to Nathan)</td>
<td>Powell, 1978: Chapters 1 &amp; 2</td>
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<td>10:00-11:00</td>
<td>E5A 210</td>
<td>*NDLect 3: Changes to mineral assemblages, modes and mineral chemistry</td>
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<tr>
<td>Date</td>
<td>Time</td>
<td>Location</td>
<td>Lecture/Workshop</td>
<td>Notes</td>
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<tr>
<td>6-Apr</td>
<td>2.00-3.00</td>
<td>E5A 210</td>
<td>*SPLect 7: Techniques I: Numerical Simulations - overview and ELLE</td>
<td>*EBS &amp; Thermocalc courses; Questions about projects</td>
<td></td>
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<tr>
<td>9-Apr</td>
<td>9.00-11.00</td>
<td>E5A 210</td>
<td>*SPLect 8: Techniques II: Analog Modelling and Image analysis (SPO)</td>
<td>Finish Optical Microscopy (microstructures); Passchier and Trouw</td>
<td></td>
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<td>11.00-2.00</td>
<td>E5A 210</td>
<td>*NDLect 4: Heterogeneity in metamorphic rocks, equilibrium volume and reaction textures</td>
<td>Define Third presentation (10 min Thermocalc)</td>
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<tr>
<td>11:00-12.00</td>
<td>E5A 210</td>
<td>*NDLect 5: Compositional zoning, solid solution and chemical diffusion</td>
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</tbody>
</table>

**Unit guide** GEOS922 Microstructures to Large Scale Processes: Rheology, Metamorphism and Fluids

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
<th>Lecture/Practical</th>
<th>Reading/Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-Apr</td>
<td>Thurs</td>
<td>9.00-11.00</td>
<td>E5A 210</td>
<td>NDLect 7:</td>
<td>Metamorphic Microstructures</td>
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<td>Thermocalc Practical</td>
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<td>20-Apr</td>
<td>Mo</td>
<td>2.00-5.00</td>
<td>E5A 210</td>
<td></td>
<td>Optical Microscopy (metamorphic textures)</td>
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<tr>
<td>23-Apr</td>
<td>Thurs</td>
<td>9.00-10.00</td>
<td>E5A 210</td>
<td></td>
<td>Thermocalc project</td>
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<tr>
<td>30-Apr</td>
<td>Thurs</td>
<td>9.00-10.00</td>
<td>E5A 210</td>
<td></td>
<td>Thermocalc Presentations</td>
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<td></td>
<td></td>
<td>Submit Thermocalc exercise</td>
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<td>10:00-11:00</td>
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<td></td>
<td>Discuss timing projects etc.</td>
</tr>
<tr>
<td>4/05/2015</td>
<td>Mo</td>
<td>9-5:00</td>
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<td>SEM booked</td>
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<td></td>
<td>group I</td>
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<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Description</td>
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<tr>
<td>7/05/2015</td>
<td>Thurs</td>
<td>9-5:00</td>
<td>SEM booked group II</td>
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<td>11/05/2015</td>
<td>Mo</td>
<td>5:00 PM</td>
<td>project due group I</td>
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<tr>
<td>14/05/2015</td>
<td>Thurs</td>
<td>5:00 PM</td>
<td>project due group II</td>
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</tbody>
</table>

**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

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**Policies and Procedures**

Macquarie University policies and procedures are accessible from [Policy Central](http://mq.edu.au/policy/docs/). Students should be aware of the following policies in particular with regard to Learning and Teaching:


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](http://mq.edu.au/policy/docs/) 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
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 Enquiry Service
For all student enquiries, visit Student Connect at 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
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 - 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 - 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
- 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

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

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
- 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
• 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