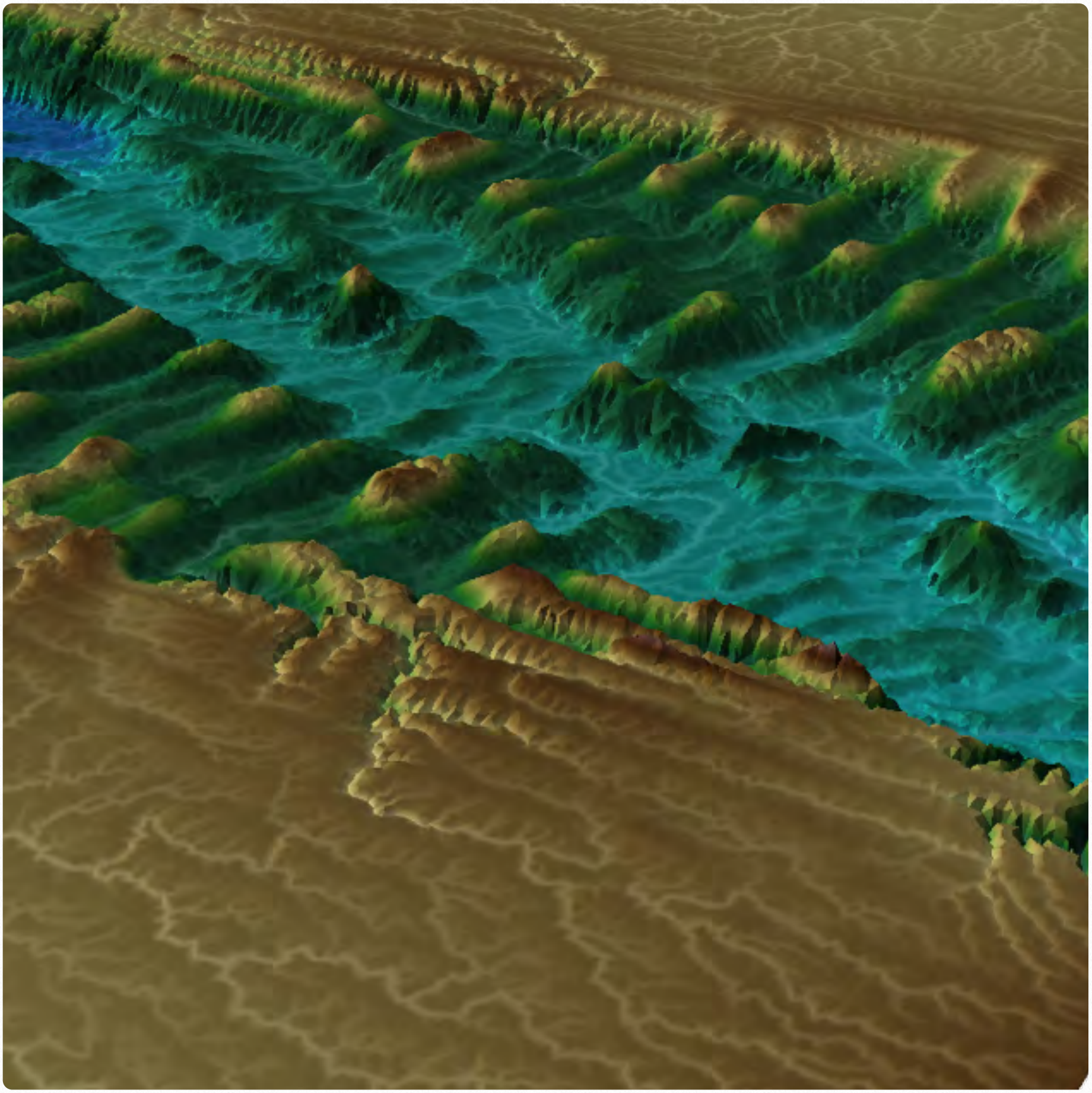
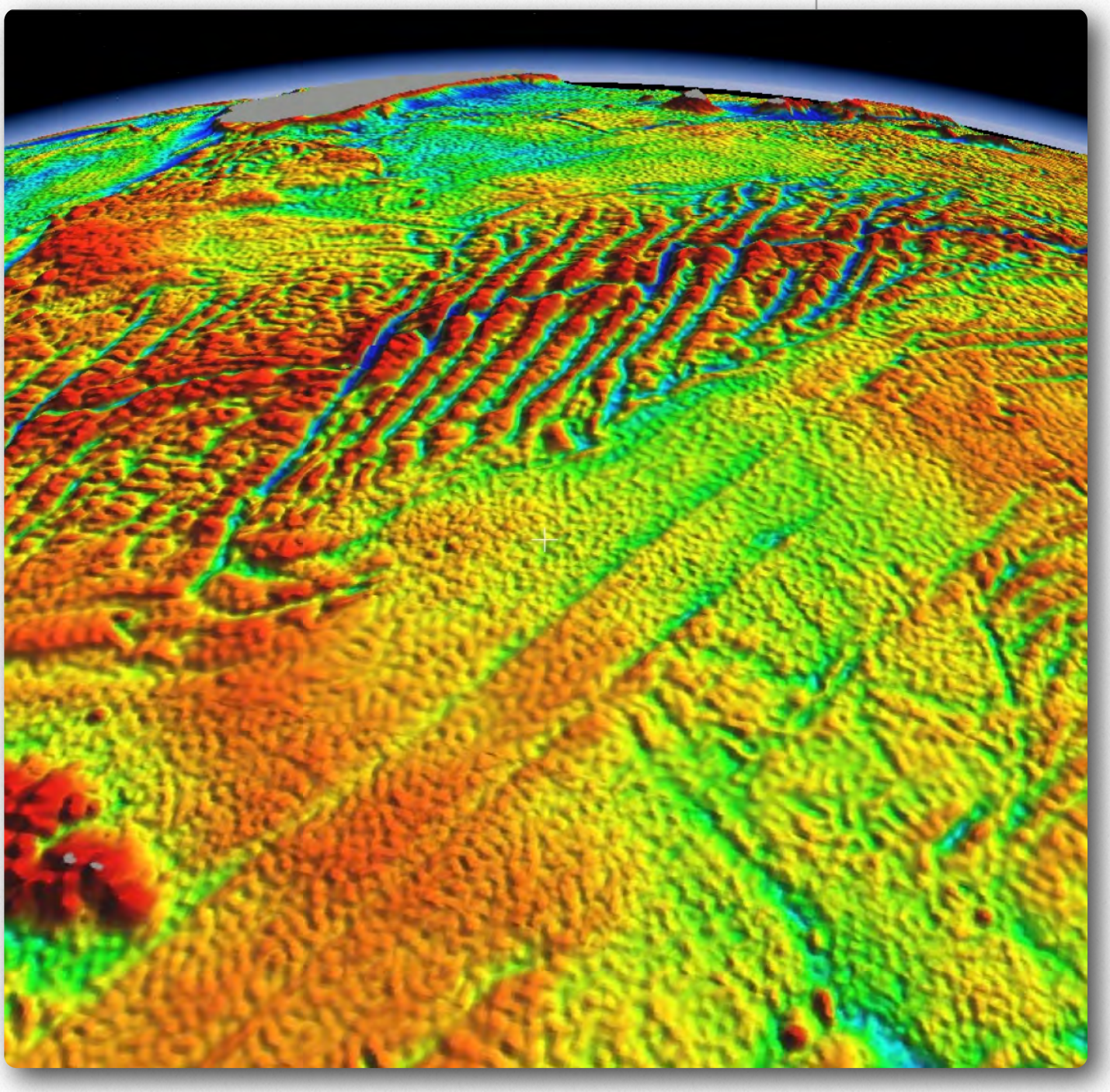
Course Outline

GEOS 3104 - 3804
Geophysical methods



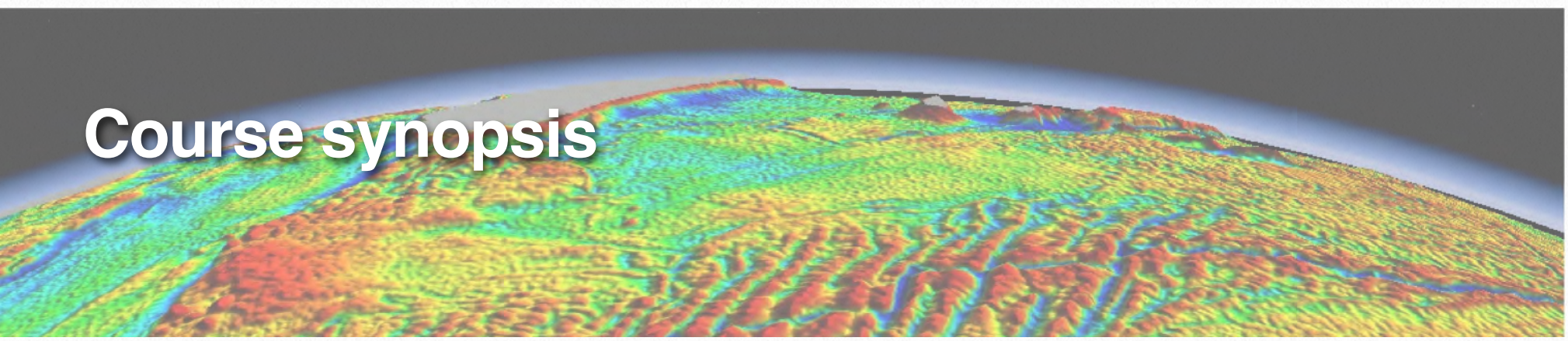
GEOS 3104 - 3804
Geophysical methods

Prof Dietmar Müller - Earthbyte
A.Prof. Patrice Rey - Earthbyte
Dr Tristan Salles - Earthbyte
Dr Simon WIlliams - Earthbyte
Dr Nicolas Flament - Earthbyte
Mrs. Sarah McLeod - Earthbyte



THE UNIVERSITY OF SYDNEY

EarthBYTE
Linking observations to kinematic and dynamic models

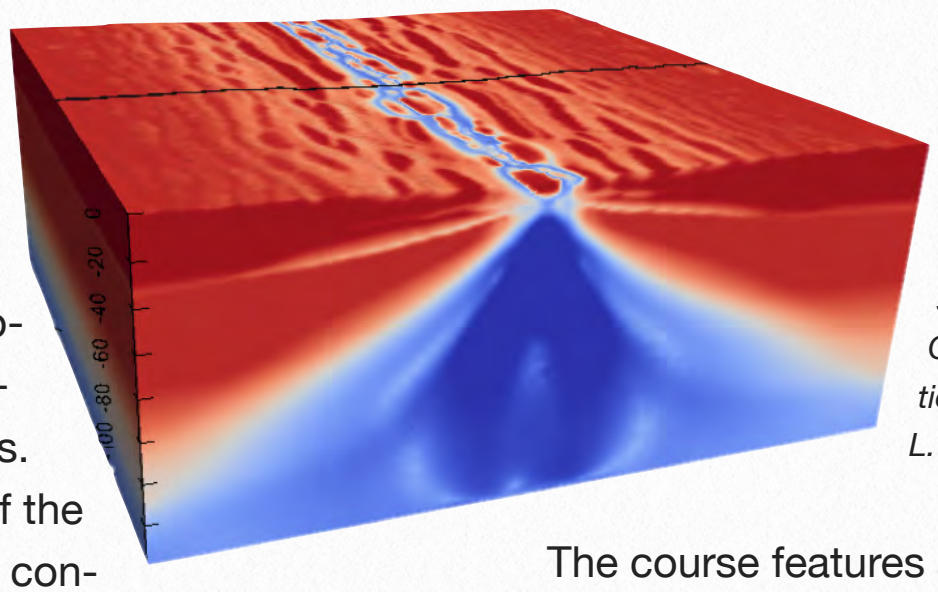


Course synopsis

GEOS3104: The aim of this course is to introduce the geophysical methods used to investigate and understand the Earth's interior. The first module of the course is mainly based on the techniques used for minerals and hydrocarbon exploration and production, covering marine and terrestrial applications. Where appropriate, applications in global geophysics will also be described. This module is relevant for students with interests in land-based and marine resource exploration, as well as environmental applications. The second module of the course introduces the concept of numerical modelling to investigate and understand complex mantle, lithospheric and surface processes. Students are strongly encouraged to bring their laptop to the classroom.

Students wishing to become professional geophysicists are strongly encouraged to expand their geophysics background through completion of an Honours degree.

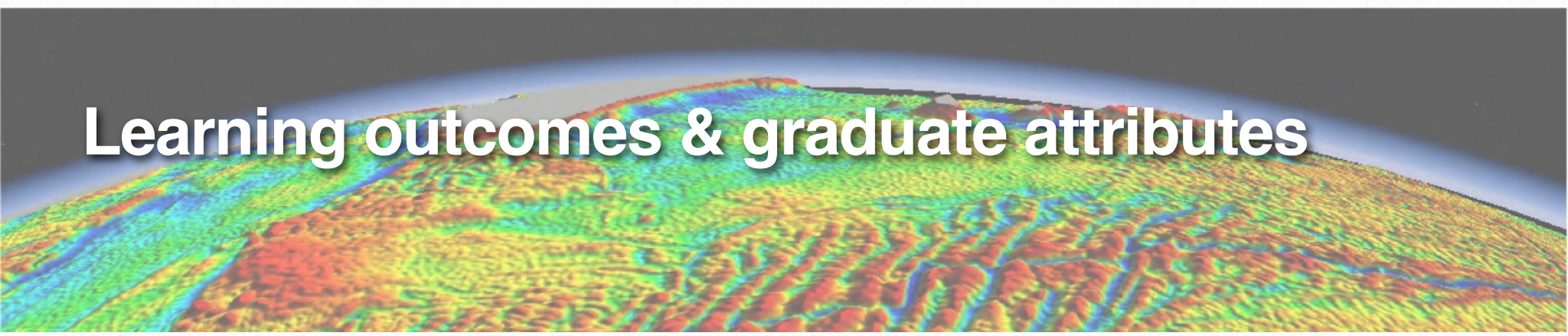
GEOS3804: It has the same objectives and is suitable for students who wish to pursue aspects of the subject in greater depth. Entry is restricted and selection is made from the applicants on the basis of their performance at the time of enrollment. Students who elect to take this unit are required to pursue independent work to meet unit objectives.



During extensional tectonics, the Earth lithosphere breaks and the asthenosphere rises. Decompression melting of the hot asthenospheric mantle beneath Mid-Oceanic-Ridges explains the formation of the oceanic crust. (image @ L. Mondy).

The course features a weekend-long geophysical field practical which is run at the Arthursleigh/Marulan Farm, a University of Sydney property in the Southern Highlands of NSW, approximately 30 mn from Goulburn. Here, the basics of geophysical data acquisition and processing are taught using potential field and seismic refraction methods. Students will be required to contribute financially to transportation and food costs. Details on the timing and technical aspects of the field trip will be provided during the first weeks of the semester.

Learning outcomes & graduate attributes



@ N. Flament

Learning outcomes: Following completion of this unit of study, and provided that students attend all classes and complete all required work, it is expected that students will be able to:

• 1/ Understand the use of seismic waves to explore the Earth interior, and image sedimentary basins for oil and gas exploration.

• 2/ Understand how anomalies in the Earth gravity field relate to distribution of masses at depth, and how mapping gravity anomalies is used in mineral exploration.

•3/ Understand the Earth's magnetic field and its dependence on core dynamics and near surface geology, and how mapping magnetic anomalies is used in mineral exploration

•4/ Acquire and process geophysical data using Matlab and Python.

•5/ Use the Ellipsis software to model complex geodynamic and tectonic processes.

•6/ Understand, characterize and model Earth surface dynamics as a consequence of the interplay between tectonic, climatic and surface processes.

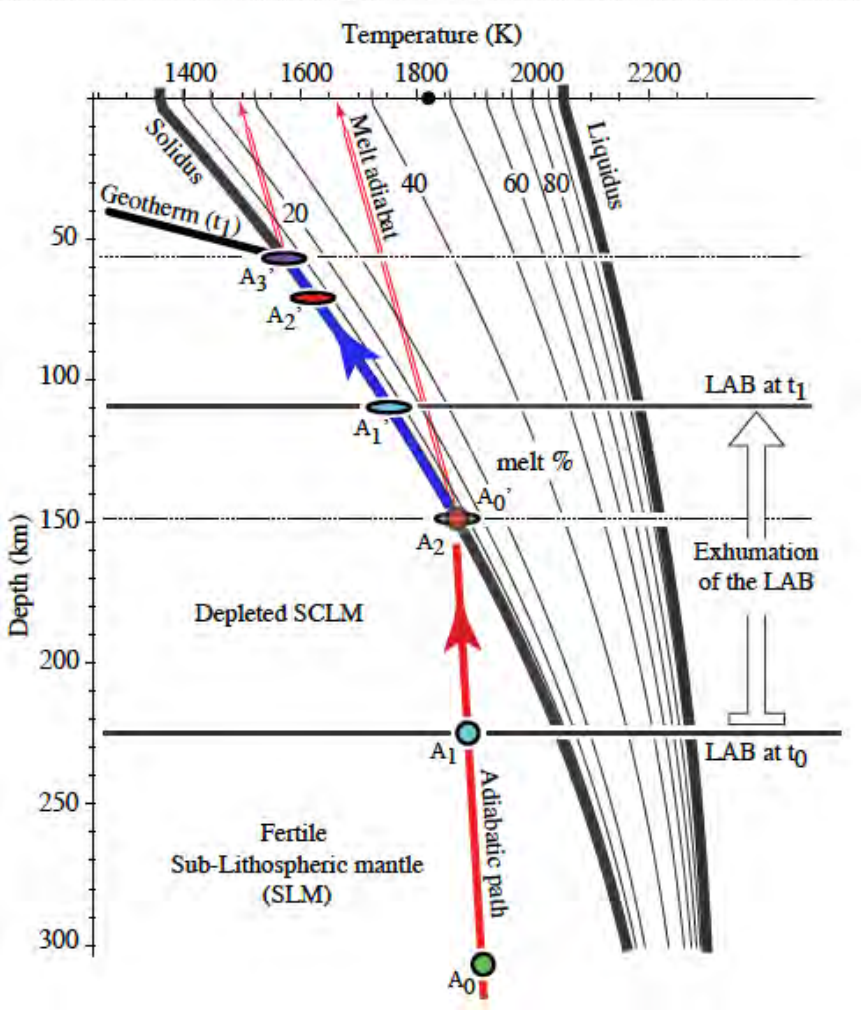
•7/ Understand and model mantle partial melting driven by mantle upwelling and decompression.

•8/ Understand how mantle convection relates to mantle heating (internal or basal), and understand how tectonic plates modulate mantle convection.

•9/ Use computers effectively to process, visualize and analyze data, and perform numerical experiments.

•10/ Work collaboratively in a multicultural team environment.

•11/ Write concise technical reports.

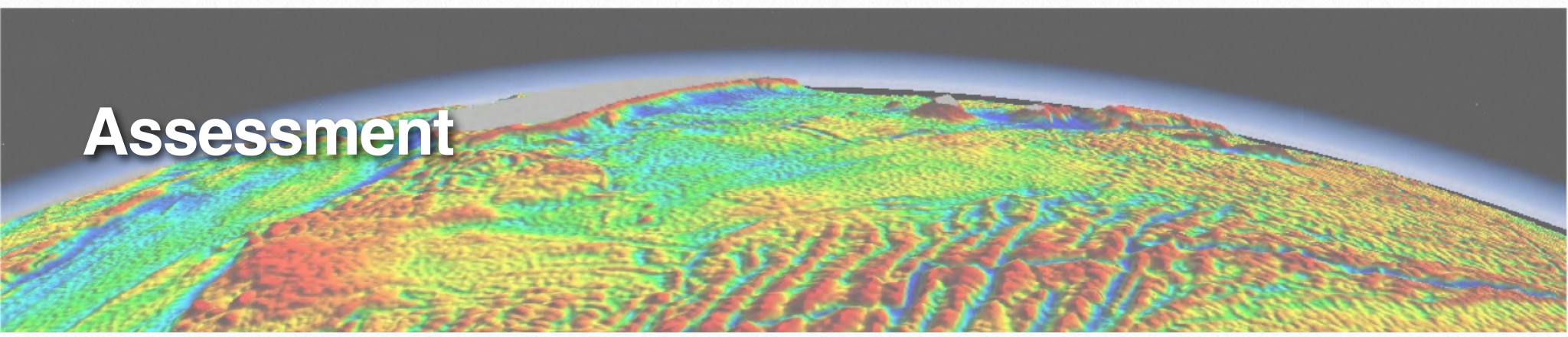


The adiabatic upwelling of the hot asthenospheric mantle triggers decompression melting as the raising mantle intersects its solidus (image @ P. Rey).

Learning outcomes & graduate attributes

Graduate attributes encompass the qualities making students strong contributing members of professional and social communities. They relate to a graduate's attitude or stance towards knowledge, the world, and themselves. These are understood as a combination of five overlapping skills or abilities, the foundations of which are developed as part of specific disciplinary study. For further details please refer to this Science faculty website.

Graduate Attributes (http://www.itl.usyd.edu.au/graduateAttributes/facultyGA.cfm?faculty=Science)		Learning outcomes
A Research and Inquiry		
A1	Apply scientific knowledge & critical thinking to identify/analyse problems, create solutions, & improve practices.	1 to 8
A2	Gather, evaluate and deploy information relevant to a scientific problem.	4, 5, 7
A3	Design and conduct investigations, or the equivalent, and analyse and interpret the resulting data.	4 to 7
A4	Critically examine the validity in scientific argument and discourse, & evaluate the relative importance of ideas.	1 to 8
B Information Literacy		
B1	Use a range of searching tools (such as catalogues and databases) effectively and efficiently to find information.	4 to 8
B2	Access a range of information sources in the science disciplines: books, articles, patents & company standards.	1 to 8
B3	Critically evaluate the reliability and relevance of information in a scientific context.	1 to 8
B5	Use information technology to gather, process, and disseminate scientific information.	4 to 8
C Communication		
C1	Explain and present ideas to different groups of people in plain English.	9 to 11
C2	Write and speak effectively in a range of contexts and for a variety of different audiences and purposes.	10, 11
C4	Present and interpret data or other scientific information using graphs, tables, figures and symbols.	4 to 11
C5	Work within a team, & take individual responsibility within the group for developing and achieving group goals.	10, 11
C6	Take a leadership role in successfully influencing the activities of a group towards a common goal.	10, 11
D Ethical, Social and Professional Understanding		
D1	Demonstrate an understanding of the significance and scope of ethical principles, both as a professional scientist and in the broader social context, and a commitment to apply these principles when making decisions.	10
D2	Appreciate the importance of sustainability and the impact of science within the broader economic, environmental and socio-cultural context.	1
E Personal and Intellectual Autonomy		
E1	Evaluate personal performance & development, recognise gaps in knowledge and learn independently.	4, 10
E2	Demonstrate flexibility in adapting to new situations and dealing with uncertainty.	4, 10
E3	Reflect on personal experiences, and consider their effect on personal actions and professional practice.	4, 10
E4	Set achievable and realistic goals and monitor and evaluate progress towards these goals.	1 to 11
E5	Demonstrate openness and curiosity when applying scientific understanding in a wider context.	1 to 11



Assessment

Compulsory Assessment: Each practical exercise - including field work - must be passed (50%) to pass this unit of study.

** Faculty policy: In cases where a student fails to submit a compulsory task and/o fail to get a Pass, the final marks awarded should be the maximum that the student is entitled to,* ***up to 49****. This attracts an "Absent Fail" grade.*

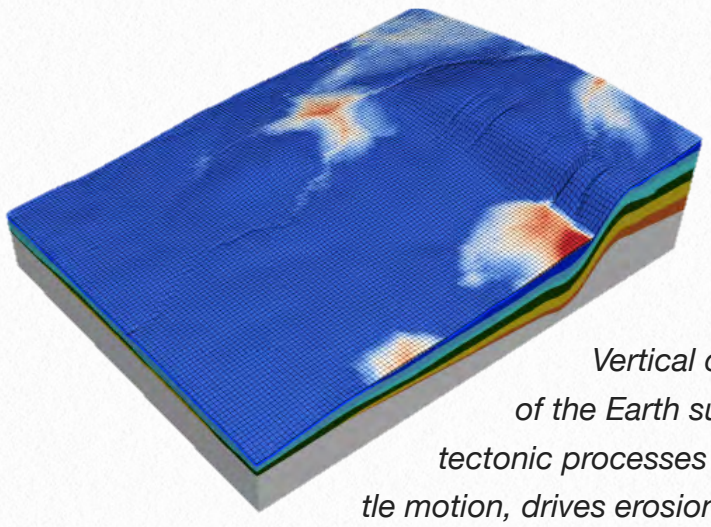
Compulsory Attendance: Attendance to lectures and practicals is compulsory unless there is a clash with other USyd UoS.

The assessment for this course is based on 50% coursework (practical reports are or equal weight) and 50% final exam. Late assignments will be penalized 10% per day (weekends count as 2 days). The final examination will be 2 hours long and will be held during the examination period at the end of semester. To satisfactorily complete the course, you must pass both the coursework (NB: All practical reports have to be completed to a minimum grade of Pass to avoid an *Absent Fail*) and the final exam.

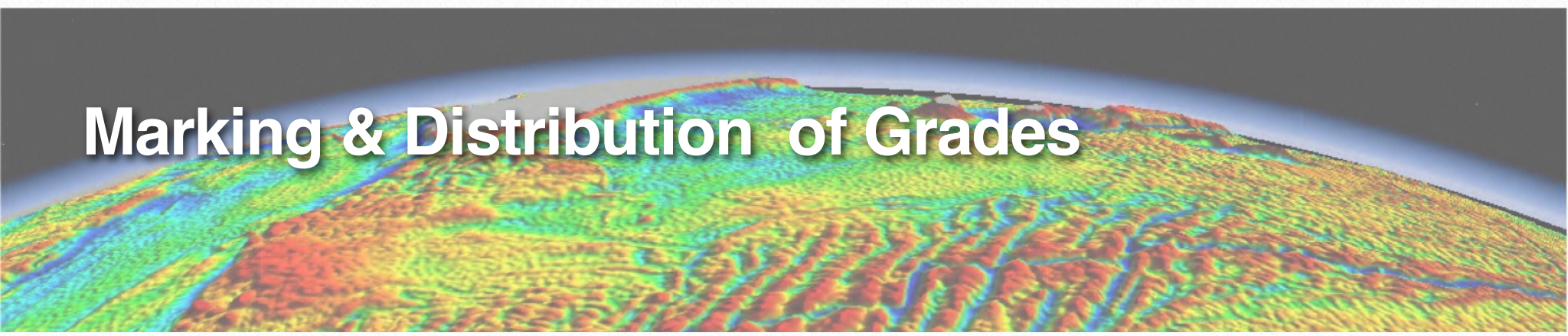
Special Consideration - Students who have a serious illness or who have experienced misadventure which may affect their academic performance in this Unit of Study may request that they be given *Special Consideration* in relation to the determination of their results. It should be noted that brief illness or minor misadventure will not warrant Special Consideration unless it prevents the student submitting an assessment by the due date, or attending an examination as scheduled.

Please note that the application for Special Consideration must be submitted within five (5) working days of the due date of the assessment or examination for which consideration is being sought.

If intending to request Special Consideration you must obtain a Special Consideration Application pack (containing an information sheet, the Application for Special Consideration form, the Professional Practitioners Certificate and the Academic Judgment Form) from the Student Information Office of the Faculty of Science or from the following Faculty of Science website: http://www.science.usyd.edu.au/cstudent/ug/forms/special_cons.shtml



Vertical displacement of the Earth surface, due to tectonic processes or due to mantle motion, drives erosion and sediments transfer from elevated source regions to low elevation sink regions (image @ G. Duclaux).



Marking & Distribution of Grades

Marking and Distribution of Grades: Marks for the assessment tasks and grades awarded for the unit will conform to the University's assessment policies and procedures. A recent change to this policy requires that marks be awarded relative to a set of standards that describe a graduated hierarchy of the levels of achievement. The marks assigned to the various grades pass, credit, distinction, high distinction remain as they were prior to the change in the policy. The grades are described below along with the criteria that will be used to identify the various levels of achievement. Note the acknowledgement of the several sources (e.g. SLS 2014) from which these grade descriptors were modified; given below, see section on plagiarism).

In reference to these grades students should note that:

a) all marked assessment tasks, with the possible exception of practicals, will normally contain an at least one item that will enable the full range of achievement levels to be demonstrated, although students should note that some, and perhaps the majority of the individual items, activities or questions presented in each of the assessment tasks will be intended to establish that students have achieved a pass or credit level of achievement.

b) that distinctions and high distinctions would normally only be awarded to students who have performed at a high level in all assessment tasks – in this context 'performed at a high level in all assessment tasks' means that distinction students will have achieved a credit minimum in all individual items of assessed work and will have achieved a distinction level of achievement (or better) for the majority (>75%) of the assessment tasks. High distinction students will have achieved a distinction minimum in all individual items of assessed work and will have achieved a high distinction level of achievement for the majority (>75%) of the assessment tasks

Fail (Below 50%)

Work may fail for any or all of the following criteria

- No answer or response is provided
- Does not address or otherwise answer the question
- Contains numerous minor errors or presents a significant misconception
- Presents irrelevant material
- No evidence of research or analysis
- Presents a significantly inaccurate or flawed argument
- The answer is incomprehensible or difficult to understand due to significant problems with grammar, expression or structure

Pass (Between 50% and 64%)

Work awarded a passing grade will usually achieve the following minimum standards or present the described characteristics

- An appropriate but superficial answer or response is provided
- Presents relevant material in a superficial manner or in a simplistic descriptive style
- Correctly identifies key point or points (facts) but does not develop an appropriate explanation or argument if this is required
- Contains some minor errors or presents minor inaccuracies and misconceptions
- Little or no evidence of in-depth analysis or deep understanding of the concept

- Answers can be understood but may be poorly worded or somewhat flawed due to poor grammar, expression or structure

Credit (Between 65% and 74%)

Work awarded a credit grade will usually achieve the following minimum standards or present the described characteristics

- An appropriate, accurate and reasonable detailed answer or response is provided
- Appropriate key point or points (facts) and/or concepts clearly presented without significant errors or misconceptions
- Presents relevant material concisely with facts clearly integrated into the explanation
- Accurate quotation and/or source identification when appropriate.
- Evidence of some independent research or critical analysis of concept or problem
- Answers are easily understood with both clear expression and structure if appropriate

Distinction (Between 75% and 84%)

Work awarded a distinction grade will usually achieve the following minimum standards or present the described characteristics

- Accurately answers the question in a convincing, confident manner
- Presents relevant material accurately in a concise manner or with the facts well-integrated into a comprehensive explanation or argument
- Accurate quotation and/or source identification when appropriate.
- Evidence of extensive independent research
- Evidence of extensive critical analysis of concept, and/or innovative perspective on the topic, and/or deep understanding of problem
- Answers are well written, with clear structure and cogent expression

High Distinction (Above 85%)

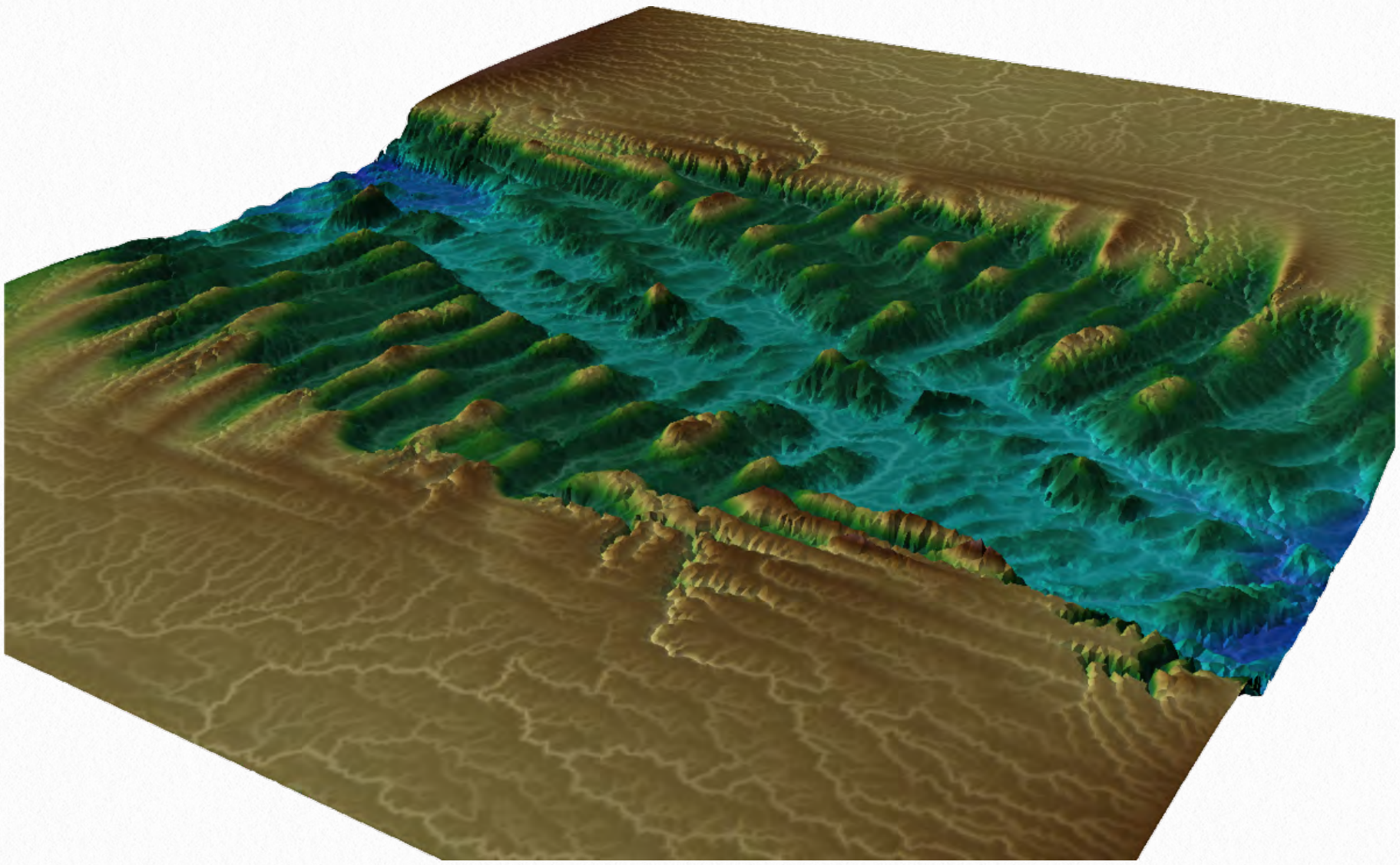
- Work awarded a distinction grade will usually achieve the following minimum standards or present the described characteristics
- Accurately answers the question in an impressive, compelling, or highly persuasive manner
- Presents relevant material accurately in a thoroughly convincing or forceful manner or with the facts well-integrated into an extended and comprehensive explanation or argument
- Accurate quotation and/or source identification when appropriate.
- Evidence of exhaustive independent research
- Evidence of extensive critical analysis of concept, and/or innovative perspective on the topic, and/or deep understanding of problem
- Answers demonstrate striking originality, an innovative approach, or impressive analytical skill
- Answers are exceptionally well written, with excellent structure expression
- Is otherwise exceptional in some way

The completion of all of the assignments in this unit of study will contribute to the Graduate Attributes set by the University of Sydney:

Graduates of the Faculty of Science will be able to create new knowledge and understanding through the process of research and inquiry, use information effectively in a range of contexts, work independently and sustainably, in a way that is informed by openness, curiosity and a desire to meet new challenges, hold personal values and beliefs consistent with their role as responsible members of local, national, international and professional communities,

recognise and value communication as a tool for negotiating and creating new understanding, interacting with others, and furthering their own learning.

With the exception of values and beliefs, which are mainly addressed in lectures relating to mineral deposits, the assessment tasks of this unit are intended to collectively enhance the above graduate attributes.



Synthetic landscape produced by Underworld and Badlands (image @ Tristan & Patrice).

Course schedule

GEOS - 3104/3804 - LECTURE OUTLINE		
WEEK	LECTURES - Two 1-hour lecture per week Tuesday-Thursday: 12.00 to 1.00 pm Madsen Lab 336	LABS - One 3-hour session per week Madsen computer lab. 301 Thursdays - 2 to 5 pm
Module 1: Seismic and Potential Methods - Prof. D. Müller, Dr S. Williams		
Week 1	Intro to geophysical methods/petrophysics	Introduction to Matlab
Week 2	Gravity methods	Gravity anomalies and sedimentary basins
Week 3	Magnetics methods	Continental magnetic data
Week 4	Gravity and magnetics of the oceans	Seafloor magnetic data
Week 5	Global seismology and signal processing	Earthquakes
Week 6	Seismics: data acquisition and processing	Seismic data processing
Week 7	Seismic interpretation and applications	Interpretation of seismic data
Module 2: Geodynamics - A. Prof. P. Rey, Dr N. Flament, Dr T. Salles		
Week 8	Introduction to geomorphic modelling	Surface processes and geomorphic modelling
Week 9	Geomorphic modelling and processing	Surface processes and geomorphic modelling
Week 10	Introduction to solid earth modelling	Modelling lithospheric extension
Week 11	Introduction to mantle processes	Modelling mantle convection
Week 12	Modelling plume and partial melting	Modelling plumes and partial melting
FIELD GEOPHYSICS & DATA ACQUISITION (MARULAN, NSW) 23-25 October, Prof. D. Müller, Dr S. Williams		
Week 13	Field geophysics	Field trip data processing and analysis

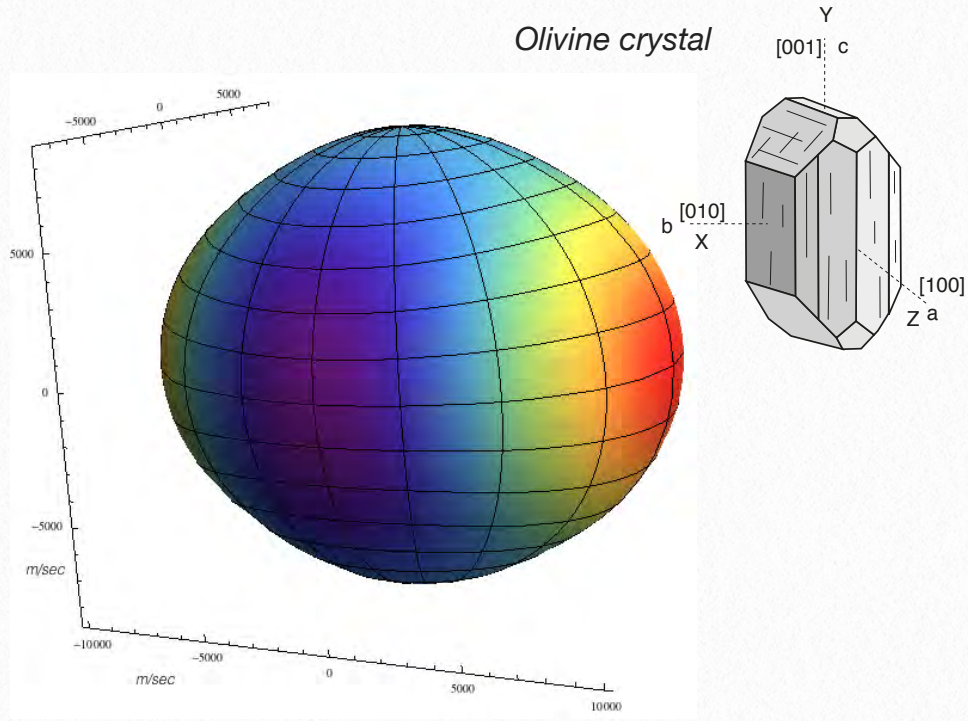
Submitting reports - When submitting your reports via email : 1/ Use your USyd email address. 2/ In the email subject please refer to the UoS and the practical ID (e.g. GEOS-3104 Report Week 7). 3/ Send your reports as PDF (Portable Document Format). PDF was invented to facilitate the sharing of documents across platforms via the Internet. 4/ Reduce the PDF size before sending it. 5/ Instead of naming your report “practical_report” choose this format “UniKey_Lab_nb” e.g “jsmi_Lab_3”. 6/ When using the assignment box, write the date of submission, otherwise penalty will be counted up to the date when your report was collected.

Plagiarism policy

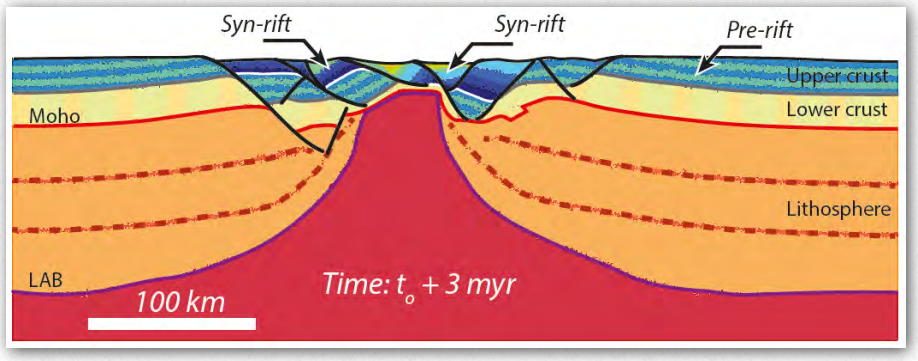
Plagiarism policy - Please ensure you have read the University of Sydney Plagiarism Policy which can be accessed from the following website: http://sydney.edu.au/ab/policies/Academic_Honesty_Cwk.pdf

All hardcopy assignment submissions must include a signed copy of the Student Plagiarism: Coursework - *Policy and Procedure Compliance Statement* form which can be downloaded from the School of Geosciences website: http://www.geosci.usyd.edu.au/undergrad/ug_acahon.shtml

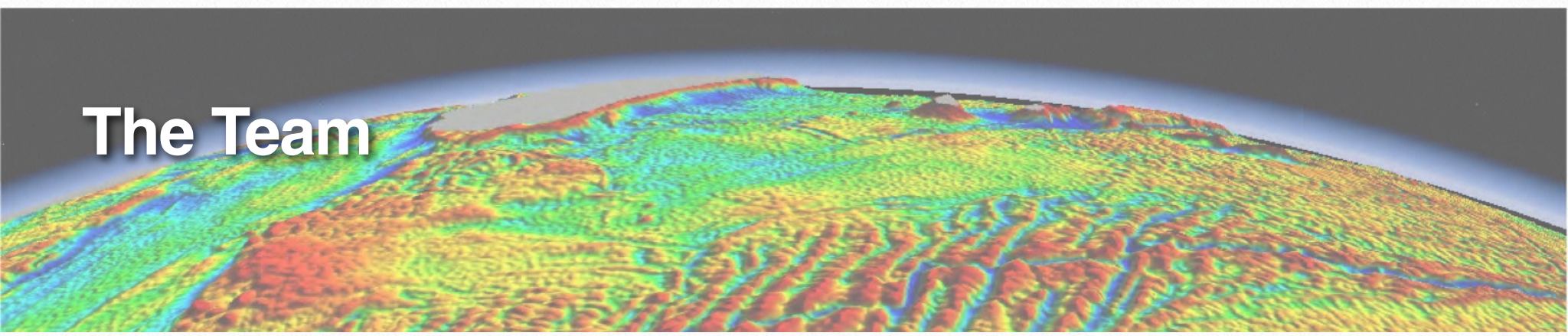
All electronic assignment submissions must include the text provided in the *Student Plagiarism: Coursework - Policy and Procedure Compliance Statement* form. The text must be unchanged except for the students' name(s) and submission date and must appear on the first page of any electronically submitted assignment in order for the assignment to be considered acceptable. The form is available as a word document from the School of Geosciences website: http://www.geosci.usyd.edu.au/undergrad/ug_acahon.shtml



The elastic properties of olivine, which makes at least 60% of the Earth's mantle, largely control the propagation of seismic waves through the Earth interior. This image shows the speed of P-waves propagating inside a crystal of olivine. The fast direction (red) corresponds to the [100] crystallographic axis, whereas the slow direction (purple) is the axis [010] (image @ P. F. Rey).

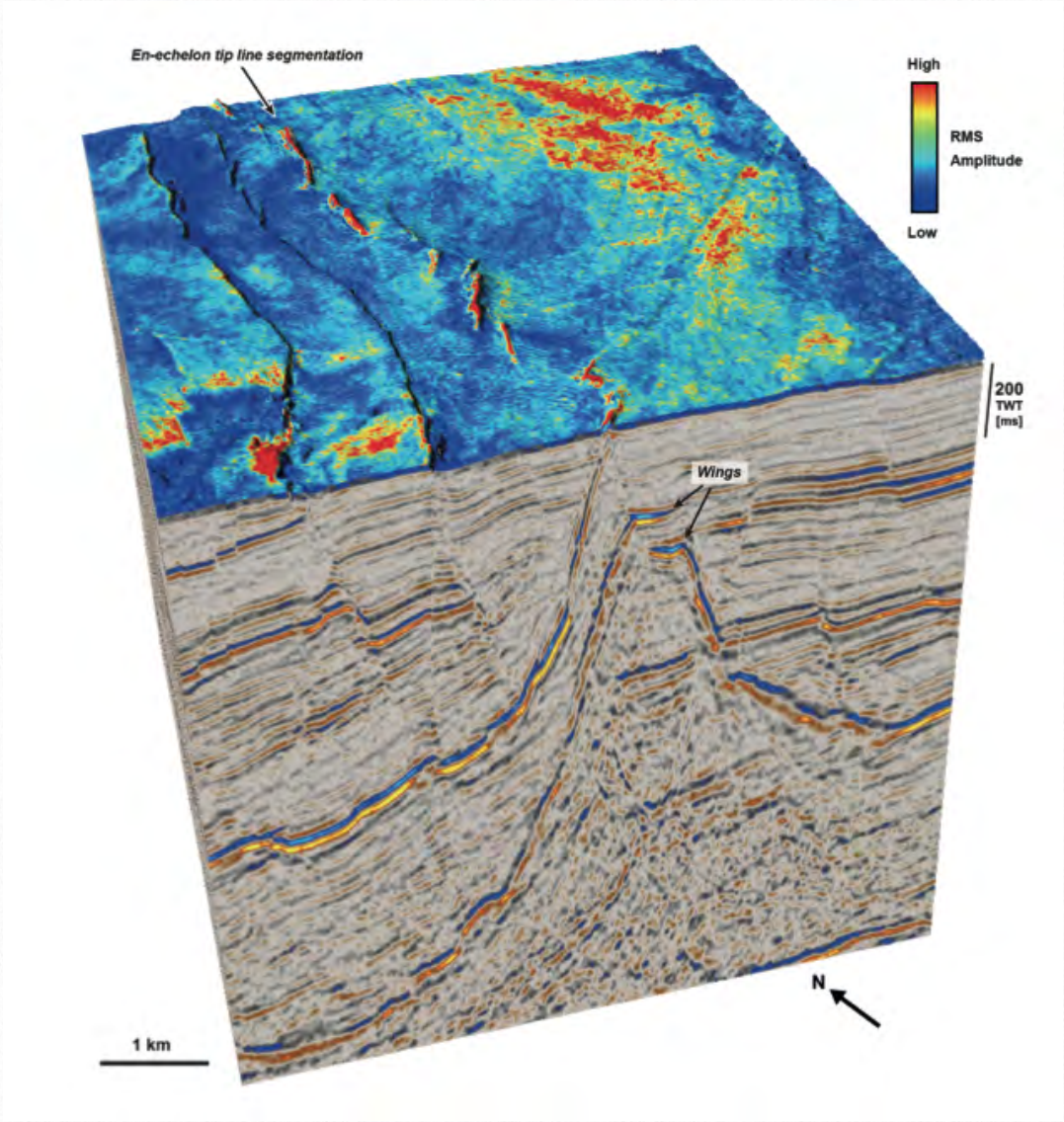


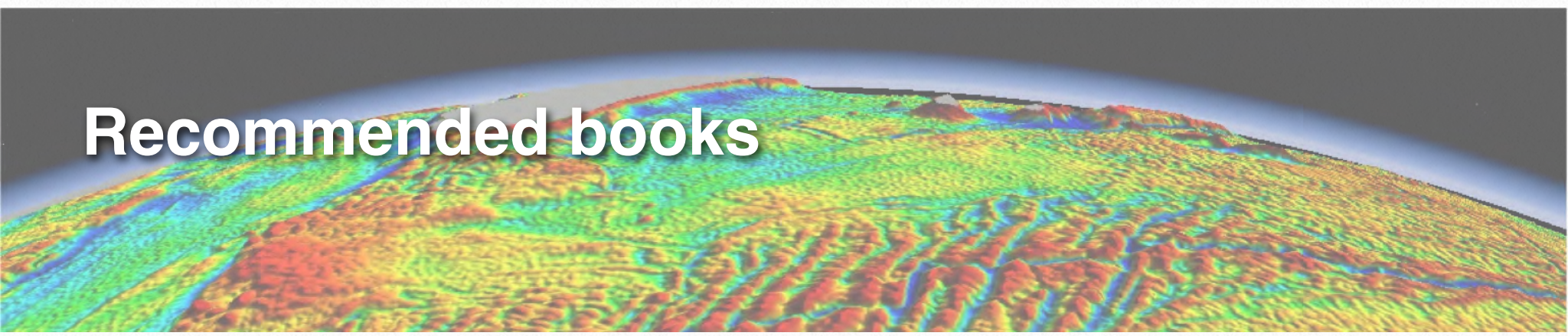
Lithospheric extension is a key process explaining the formation and evolution of continental margins, and related sedimentary basins (image @ Luke Mondy).



Staff Contact Information

Lecturers	Room	Tel	Email
Dietmar Müller	Rm 406 Madsen Bld	9036 6533	dietmar.muller@sydney.edu.au
Patrice Rey	Rm 408 Madsen Bld	9351 2067	patrice.rey@sydney.edu.au
Simon Williams	Rm 404 Madsen Bld	9351 8904	simon.williams@sydney.edu.au
Nicolas Flament	Rm 416 Madsen Bld	9351 7576	nicolas.flament@sydney.edu.au
Tristan Salles	Rm 454 Madsen Bld	8627 4123	tristan.salles@sydney.edu.au
Sarah McLeod	Rm 414 Madsen Bld	9351 8093	sarah.mcleod@sydney.edu.au





Recommended books

Keary, P., & Brooks, M., 1991. An Introduction to Geophysical Exploration: *Blackwell Publishing, 254 p*. {http://books.google.com/books?id=yj7CMOMvxnMC&dq=isbn:0632049294}
This is quite a good (although slightly outdated) textbook on the main geophysical techniques used for hydrocarbon and mineral exploration. It is probably the best currently available resource on geophysical exploration at introductory level. It can be used as a supplementary text to the lectures.

Fowler, C. M. R 2005. The Solid Earth --- An introduction to Global Geophysics: *Cambridge University Press, 685 p*. http://www.cambridge.org/9780521584098
Good, up-to-date introductory level book with good graphics and exercises. The book covers the most important fields of geophysics with applications to tectonics, Earth structure and dynamics. Each chapter provides a comprehensive list of key scientific publications. It can be used as supplementary text to the lectures.

Jones, E.J.W., 1999. Marine geophysics: Chichester: *New York, Wiley, 466 p.*
This volume on marine geophysics has two objectives: to provide a comprehensive review of techniques and to examine what geophysical observations can tell us about the structure and tectonics of the oceans. This book is of interest to marine scientists and advanced undergraduates and postgraduates following courses on, or undertaking research in, geophysics, marine geology, oceanography, physical sciences, remote sensing, marine surveying and offshore engineering.

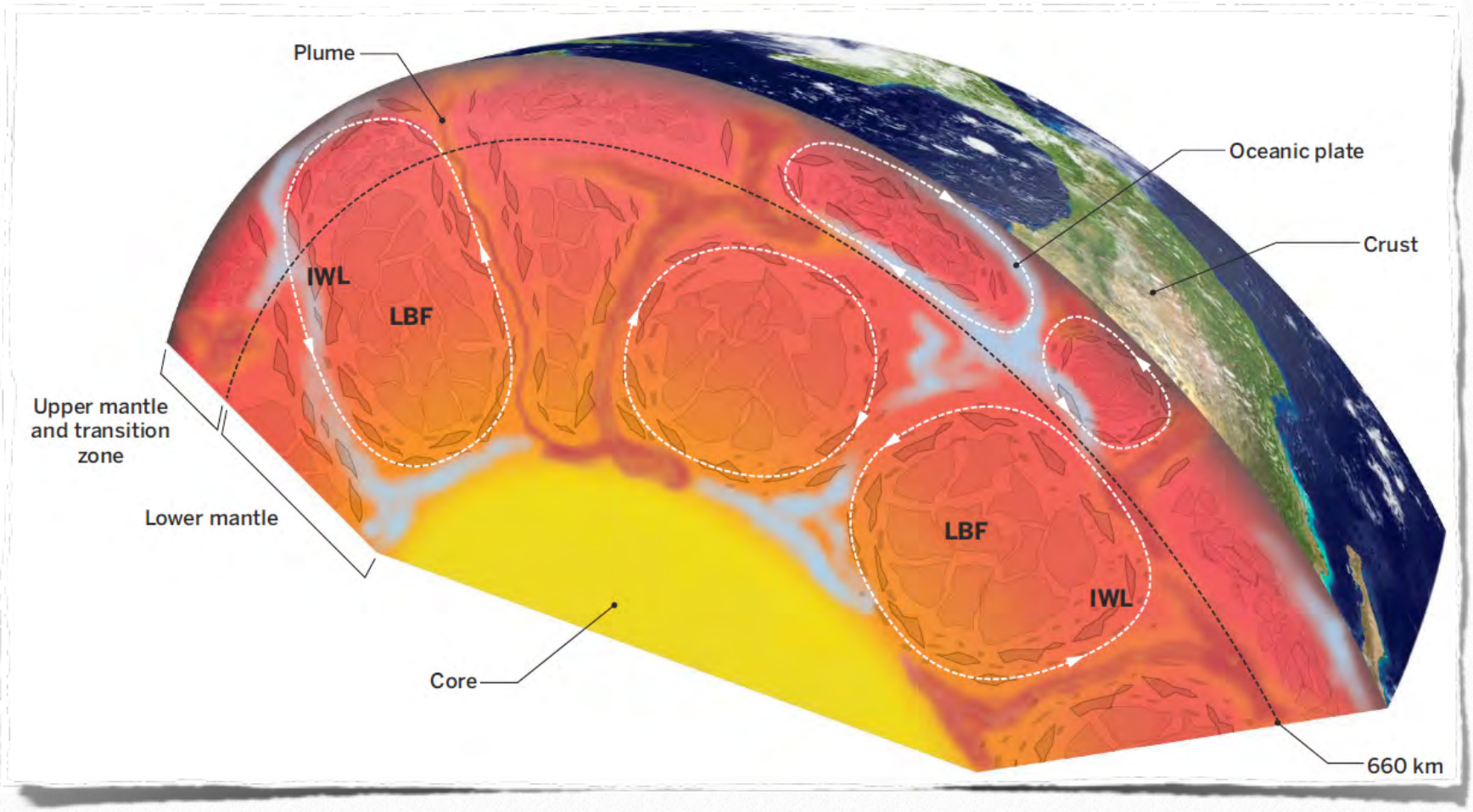
Parasnis, D.S., 1986. Principles of Applied Geophysics: *Chapman and Hall, 402 p.*
A good introductory text book, especially for the geophysical methods used in minerals exploration.

Telford, W.M., Geldhart, L.P. and Sheriff., R.E., 1990. Applied Geophysics: *Cambridge University Press, 770 p*.
A very thorough description of most methods of geophysical exploration.

Sheriff, R.E., and Geldart, L.P., 1995. Exploration seismology: Cambridge; New York, Cambridge University Press, 592 p.

An accessible introduction to Unix. http://www.ee.surrey.ac.uk/Teaching/Unix/index.html

One last thing...



Jiahua Chen, Science 8 Jan. 2016: Subducting slabs bring oceanic plates (blue) into the deep mantle. The slabs deflected at the 660-km discontinuity form layered convection within upper mantle and transition zone. The slabs penetrating into the lower mantle reaching the core-mantle boundary form whole-mantle convection. Plumes (red) rise from the core-mantle boundary, bringing materials that are enriched in incompatible elements relative to the expected mantle average back to the 660-km discontinuity. Some of them penetrate through the discontinuity, whereas others are deflected and may produce secondary upper-mantle plumes. Shear localization induces interconnected weak layers (IWL) along the slabs or plumes as well as the top and bottom of the lower mantle, yielding a less efficient mixing for the central LBF (load-bearing framework) part of the lower mantle (the reason for long-lived geochemical reservoirs). Illustration: C. Bickel/Science