

EARTH SCIENCES PART II – 2017-2018

LECTURE LIST

Skills Course - Dr Alex Copley

Thursday 5 Oct

2pm Introduction to part II [Dr Alex Copley, Harker Rm]

3pm Library sign-up [Sarah Humbert]

Monday 9 Oct

12-1pm Library, online resources, group 1 [Sarah Humbert]

3.15-4.15pm Mapping Project [Dr Alex Copley, Harker Rm]

4.15-5.30pm Mapping project display with Part III students [Dr Alex Copley, 1A Lab]

Tuesday 10 Oct

2-5pm Graphics software and map drafting, plus practical [Dr Owen Weller, Harker Room and Galson Lab]

Wednesday 11 Oct

12-1pm Library, online resources, group 2 [Sarah Humbert]

2-4pm Stereonet, Georient, SedLog, TSCreator [Dr Owen Weller, Harker Room and Galson Lab]

Thursday 12 Oct

3-4pm Reading, writing, and exam skills [Dr Alex Copley, Harker Room]

Monday 16 Oct

12-1pm Introduction to GIS [Simon Passey, Harker Room]

2-5pm GIS practical [Magda Biszczuk, Galson Lab]

Thursday 19 Oct

2-4pm Statistics lecture and practical [Dr David Al-Attar, Harker room]

Other sessions:

Late October/Early November

Photomicroscope training with Iris Buisman

Tuesday 23 January

1.30-5pm Petroleum Geology [Andy Bell – Shell]

Note: This session is a key part of your general geological education, and forms part of the Geolsoc accreditation of the degree, so attendance is compulsory.

C1: Geophysics and Tectonics

Lectures and practicals on Tuesday and Thursday mornings (9am-12pm), and one stand-alone lecture per week at 12 noon on Fridays. Lectures that are followed by a practical are labelled with [P].

Alex Copley, Nicky White, Nick Rawlinson, John Rudge, David Al-Attar.

Lectures 1-9: Dr Alex Copley

5 October

1. Earthquake seismology [P]

How to estimate earthquake locations, depths, and focal mechanisms.

6 October

2. Faulting in large earthquakes: seismology, geomorphology, surface ruptures

What happens in big earthquakes? Combining seismology, field observations, aftershock, and geomorphology.

10 October

3. Earthquake scaling laws and fault strength [P]

The rules controlling earthquakes and faulting. The controversy about the strength of faults.

12 October

4. Space geodesy: InSAR and the earthquake cycle [P]

Mapping surface motions using satellites. How InSAR works, the earthquake cycle, inter-, co-, and post-seismic motion.

13 October

5. Space geodesy: GPS and large-scale velocity fields

How GPS works, construction of velocity fields, tectonic applications.

17 October

6. Large earthquake case studies – subduction zones and Nepal [P]

Combining geology and geophysics to understand subduction zone and continental megathrusts (in Sumatra, Japan, and Nepal).

19 October

7. Mineral creep [P]

How minerals deform by diffusion and dislocation creep. Deformation maps, and theoretical and observational estimates of lower lithosphere viscosity.

20 October

8. Plate driving forces

The forces that control the motion of the plates and the deformation on their edges.

24 October

9. Plate structure and rheology [P]

Thermal, seismological, flexural, and petrological insights into the rheology of the plates.

Lectures 10-14: Professor Nicky White

26 October

10. Gravity [P]

Gravitational field of the Earth. Free-air and Bouguer gravity corrections and anomalies. Isostatic calculations. Satellite gravity data. Gravity and mantle convection.

27 October

11. Topographic analysis

Topographic wavelength. Relationship with gravity. Flexural rigidity, flexural parameter and elastic thickness. Spatial and frequency domain methods for estimating elastic thickness. Oceanic and continental examples. How do foreland basins form?

31 October

12. Controlled source seismology: refraction [P]

Snell's law and ray tracing. First arrivals and travel-time diagrams. Layer-cake modelling. Forward and inverse models. What does continental crust look like?

2 November

13. Controlled source seismology: reflection [P]

Sub-critical reflections. How are seismic reflection experiments carried out at sea and on land? The key steps of signal processing: stacking, deconvolution and migration. Two-, three-, and four-dimensional seismic imagery and what it means.

3 November

14. Geophysical analysis of the Icelandic plume

Measuring residual depth anomalies in the North Atlantic Ocean. Geophysical extent of Icelandic plume and its size. Transient thermal anomalies. Towards a fluid dynamical understanding of the Icelandic plume.

Lectures 15-18: Professor Nick Rawlinson

7 November

15. Seismic wave propagation [P]

On the generation and propagation of seismic waves in realistic media

9 November

16. The global seismic wavefield [P]

Global body wave phases, surface waves, normal modes, and what they look like on a seismogram

10 November

17. Geophysical inverse problems

Basic concepts in geophysical inverse theory and case studies involving different types of data

14 November

18. Earth imaging [P]

The structure and dynamics of the Earth's interior from large geophysical datasets

Lectures 19-22: Dr John Rudge

16 November

19. The Fluid dynamics of convection [P]

Conservation laws. Scaling and the thermal time constant. Rayleigh number. Planform of convection. Laboratory and numerical experiments.

17 November

20. Mapping mantle convection

Surface observations. Gravity anomalies and residual depth. Continental methods.

21 November

21. Layered or whole mantle convection? [P]

Geochemical arguments for layering (e.g. argon). MORBs vs OIBs. Focal mechanisms in subducting slabs. Tomography.

23 November

22. Other planets [P]

Magellan gravity and topography observations of Venus. Estimates of T_e and planform of convection. Why plate tectonics?

Lectures 23-24: Dr David Al-Attar

24 November

23. Post-glacial sea level change 1: Applications to Earth's viscosity structure

How sea level is defined, and why it varies in space and time. Viscoelastic materials and the Maxwell time. Observations and methods used to constrain mantle viscosity. Implications for mantle dynamics.

28 November

24. Post-glacial sea level change 2: Applications to past and present climate change [P]

Spatial and temporal patterns of sea level change associated with deglaciation. Ice sheet reconstructions. Estimates of present day ice mass loss from Greenland and Antarctica. Sea level fingerprints and Melt Water Pulse 1A.

Seminars

13 Oct, 10 am

Camilla Penney, The active tectonics and earthquake hazard of the Makran subduction zone

27 Oct, 10 am

Jacky Austermann, Interactions of dynamic topography and paleo climate

10 November, 10 am

Marte Kloeking, Estimating mantle temperature and dynamic uplift from basalt geochemistry and shear wave velocity anomalies in western North America

24 November, 10 am

James Jackson, Earthquakes and Tsunamis in the Eastern Mediterranean

Field trip

1-9 December: 9-day field trip to study the active tectonics of central Greece, and its controls on sedimentation and volcanism.

C2: Ancient Life and Environments

Lectures and practicals [P] are scheduled for Monday and Wednesday mornings (9–12am), plus a stand-alone lecture on Fridays at 2pm (on occasion followed by a research seminar [S]).

Sasha Turchyn, Neil Davies, Nick Butterfield.

Lectures 1-11: Dr Sasha Turchyn

6 October

1. Geochemistry and sedimentology in tidal environments

9 October

2. Tidal sedimentary environments 1 [P]

11 October

3. Tidal sedimentary environments 2 [P]

13 October

4. Tidal sedimentary environments 3 [S]

16 October

5. Sedimentary diagenesis 1 [P]

18 October

6. Sedimentary diagenesis 2 [P]

20 October

7. Biogeochemistry in modern environments (+ departure for Norfolk field trip)

23 October

8. Suffolk field trip [P]

25 October

9. Sediments to sedimentary rocks [P]

27 October

10. Geochemistry in ancient Environments 1 [S]

30 October

11. Geochemistry in ancient Environments 2 [P]

Lectures 12-23: Professor Nick Butterfield

1 November

12. Early records of life on Earth [P]

3 November

13. The evolving Proterozoic Earth system 1

6 November

14. The evolving Proterozoic Earth system 2 [P]

8 November

15. Early evolution of eukaryotes [P]

10 November

16. Cryogenian to Ediacaran Earth and evolutionary history

13 November

17. Ediacaran palaeobiology [P]

15 November

16. The Cambrian Explosion [P]

17 November

19. The Burgess Shale and other taphonomic windows [S]

20 November

20. The Great Ordovician Biodiversification Event [P]

22 November

21. Reefs and reef-building organisms [P]

24 November

22. Coevolution, ecosystem engineering & the modern marine biosphere [S]

27 November

23. Astrobiology

Lecture 24: Dr Neil Davies

29 November

24. Terrestrialization [P]

Seminars

13 October, Gilad Antler – The sulphur-iron interplay and its role in the fate of carbon in anoxic environments

27 October, Will McMahon – Precambrian fluvial environments: from river to rock record

17 November, Jennifer Hoyal-Cuthill – Raman spectroscopy of Cambrian fossils

24 November, Aaron Hunter – Cambro-Ordovician radiation of echinoderms

Field Trips

20–22 Oct, Norfolk field trip

23 Oct, Suffolk field trip

C3: Petrology

This 24-lecture course is designed to introduce you to a range of fundamental ideas and concepts that will provide you with a sound basis for petrological Part III projects and courses. It includes 6 lectures on topics in metamorphic and igneous petrology, reinforcing and expanding pre-existing skills. It includes Schreinemaker's analysis, pelite bulk composition diagrams, siliceous dolomites and CO₂-H₂O fluids, granulites, melting, and oxidation-reduction. The next 3 lectures will develop your petrographic skills and teach you how to decode the record of rock history preserved in thin sections of both metamorphic and igneous rocks. Magma chambers are covered in 5 lectures, with a discussion of fluid dynamical processes occurring during solidification of basaltic and andesitic magma (including the effects of convection, liquid immiscibility, progressive fractionation, degassing, ore formation, and the triggering, dynamics and effects of explosive eruptions). A basic geochemical toolbox will be delivered over 5 lectures, building on the whole-Earth geochemistry you have already covered in 1B and demonstrating the range of geochemical techniques used in a wide range of exciting topics such as core formation, mantle reservoirs of noble gases, non-traditional stable isotope geochemistry and U-series dating. The final 4 lectures will show how synthesizing fluid dynamics, geophysics and geochemistry can be used to answer some of the big questions of mantle convection and Earth history.

Lectures will be held on Monday, Wednesday, and Friday mornings (9am). Where stated, practical sessions and seminars follow the lecture.

Tim Holland, Marian Holness, Marie Edmonds, Ed Tipper, Oliver Shorttle, Davide Novella.

Professor Tim Holland

This part of the course will reinforce and expand their understanding of thermodynamics, with application to metamorphic and igneous petrology.

19 January

1. Pelitic rocks 1

Constructional features as building blocks for phase diagrams. P - T - X section, projects. Phase rule and variance, singular points etc. Schreinemaker's.

Group Supervision: Introduction to the microscopes, revision of optical microscopic techniques. (MBH)

22 January

2. Pelites 2

Grids, pseudosections, PTt history.

Practical

24 January

3. Siliceous dolomites

T - X (CO₂) and mixed volatile equilibria. Fluid-rock interaction. Swiss Alps.

Practical

26 January

4. Granulites 1

High-*T* equilibria, reducing water activity, mechanisms

Isotope Coffee: Part III students give presentations

29 January

5. Granulites 2

Melting equilibria (dry and wet). Crust and mantle melting. Dehydration melting and granulite formation.

Practical

31 January

6. Eclogites

Eclogites in basic, pelitic and granitic compositions. High-pressure formation and exhumation from western and eastern Alps.

Practical

Professor Marian Holness

This set of lectures will teach them how to interrogate and interpret thin sections, giving them the background knowledge to obtain microstructural information on rock history with application to metamorphic and igneous petrology. The last two lectures introduce the physics and chemistry of mafic layered intrusions, using microstructure as the key to understand mass transport and solidification in magma chambers.

2 February

7. Crystal nucleation and growth

Classical nucleation theory (revision), heterogeneous vs homogeneous nucleation. Crystal size distributions, Ostwald ripening, nucleation inhibition in small pores, eutectic crystallization.

Seminar: Owen Weller

5 February

8. Crystal shape

Diffusion vs interface limited growth, dendrites, spherulites, sector zoning.

Practical: Thin sections (igneous and metamorphic)

7 February

9. Textural equilibrium

Equilibrated microstructures (both solid and fluid-bearing), effect of anisotropy, effect of surface chemistry, implications for mass transport in the mantle (Fe-rich vs silicate melts)

Practical: Thin sections (igneous and metamorphic)

9 February

10. Microstructural evolution in cumulates

Revision of cumulus concept, in situ growth vs crystal settling, permeability of mush layer,

compaction and the limitations of the “trapped liquid” concept. How to create an adcumulate.
Group supervision: Petrographic descriptions (MBH)

12 February

11. Mafic Layered Intrusions

Skaergaard, background and general introduction. Discussion of the controversies, including effects of liquid immiscibility, compaction, comparison of the behavior of crystal mushy layers on the roof, walls and floor. Could include comparison with Rum (open system chamber feeding an active volcano).

Practical: Skaergaard thin sections, illustrating all the points covered in the previous 4 lectures.

Dr Marie Edmonds

This set of lectures follows on from the last two of MBH’s course. It develops ideas of the physical and chemical behavior of magma in the crust, incorporating fluid dynamics and geochemistry.

14 February

12. Storage and transport of magma in the crust

Architecture and longevity of crustal magma reservoirs; intrusive/extrusive magma budgets. Link to Marian’s lectures wrt compaction processes, entrainment of mushes into erupting magmas, fluid dynamics of magma reservoirs. Magma mixing and recharge and generation of andesites.

Practical: Andesites (thin sections): magma mixing, mafic recharge

16 February

13. Crustal fluids

Magma degassing and implications of volatiles for magma differentiation, phase equilibria. Dynamics of bubbles in magma reservoirs. Partitioning of elements into fluids. Transport of metals to ore deposits.

Practical: Pinatubo, 1991 – eruption triggering and timescales, outgassing, impacts, hazards.

19 February

14. Volcanic eruptions

Fluid dynamics of eruptions; impacts. Role of volcanoes in global geochemical cycling.

Seminar: Jerome Neufeld – Understanding the fluid dynamical behavior of igneous rocks through analogue experiments. (NB in the Wolfson Lecture Theatre, Bullard)

Dr Ed Tipper

Here the students will be given a basic geochemical toolbox, building on the whole-Earth geochemistry they did in 1B and demonstrating the range of geochemical techniques using a wide range of exciting topics.

Wednesday 21 February

15. Bulk silicate earth and core formation

Chondritic or non-chondritic (^{142}Nd and to include some geochron), core formation, O and S, Si in the core based on Si isotopes. Age of the core based on Hf-W (to expand on what is already

covered at GSB and recap on the fairly brief overview that is given on extinct systems at the beginning of GSB). age of the Moon based on Hf-W.

Practical

Friday 23 February

16. An Overview of Noble Gas Geochemistry and Cosmochemistry: To potentially include:

Origin of Noble Gases in the Terrestrial Planets

Noble Gas Isotope Geochemistry of Mid-Ocean Ridge and Ocean Island Basalts: Characterization of Mantle Source Reservoirs. Tracing Fluid Origin, Transport and Interaction in the Crust.

Group supervision: Ed Tipper

Monday 26 February

17. Stable isotope Geochemistry

Fundamentals of stable isotope fractionation and the origin of equilibrium and kinetic isotope fractionation factors (to cover quantum mechanical and simple harmonic oscillator aspects) and their applications in high temperature systems (ranging from fluid flow to fingerprinting to application of multiple isotope Rayleigh distillation problems).

Practical

Wednesday 28 February

18. Non-traditional stable isotope geochemistry

Fundamentals of Si, Fe, Mg, Li isotope geochemistry in High-T systems.

Practical

Friday 2 March

19. U-Series geochemistry and dating.

Quick reminder of concordia etc. (revision from GSB) but more related to time-scales of magma chamber processes (could link into other lectures quite nicely), disequilibria in MORB etc.).

Seminar: Helen Williams - Iron and zinc stable isotope constraints on slab dehydration and devolatilisation processes.

Dr Oliver Shorttle and Dr Davide Novella

Showing how synthesizing fluid dynamics, physics and geochemistry can be used to unravel the Big Picture of mantle spatial variability and the extent and processes involved in melting it.

Monday 5 March (Oli Shorttle)

20. Mantle melting - Physical basis - solid flow field, energy balance during melting, prediction of melt fractions and volumes, thermal consequences of presence of heterogeneities.

Practical

Wednesday 7 March (Oli Shorttle)

21. Mantle melting - Geochemical predictions - Quantitative relationship between T_p , lithospheric thickness, mantle flow and bulk melt composition. Influence of short-lengthscale heterogeneity on aggregated melt composition. Relationship between isotopic and trace element composition of

basalt and underlying mantle.

Practical

Friday 9 March (Davide Novella)

22. Volatiles in the mantle - Storage capability of deep mantle minerals. Observational constraints on mantle volatile contents. Influence of volatiles on phase diagrams and melting behaviour. Redox melting.

Seminar: Mike Stock

Monday 12 March (Oli Shorttle)

23. Melt transport - Rates and observational constraints. Mechanisms - Porous flow, solitary waves, channelisation, reaction, rheological feedback.

Practical

Wednesday 14 March (Oli Shorttle)

24. Mixing in mafic and ultramafic systems - Understanding the record melt mixing during transport and storage. Again, consequences for understanding mantle heterogeneity. Mixing of chemical heterogeneities by mantle convection.

Practical

C4: Earth's Climate System

Lectures will be held on Monday, Wednesday and Thursday afternoons (2 pm). Practical sessions are as indicated in the course synopsis below. There will also be four invited seminars, times and dates to be confirmed.

David Hodell, Luke Skinner, Eric Wolff.

18 January

David Hodell Course introduction: Marine sediments as paleoclimate archives - what makes a good record?
Practical 1: Smear Slide Description and Pelagic Sediment Classification (IA Lab)

22 January

David Hodell Palaeotemperature proxies
Practical 2: Sediment Coarse Fraction Description– Foraminifera and Ice rafted detritus (IA Lab)

24 January

David Hodell Oxygen isotopes, ice volume, and temperature
Practical 3: Oxygen isotope Age Models and Sediment Physical Properties (Galson Lab)

25 January

David Hodell Intensification of Northern Hemisphere Glaciation at the base of the Quaternary

29 January

David Hodell Orbital forcing and the Milankovitch theory of glacial-interglacial climate change
Practical 4: Orbital Forcing and Introduction to Spectral analysis (Galson Lab)

31 January

David Hodell Problems with the Milankovitch theory
Practical 5: Spectral analysis of U1308 data (Galson Lab)

1 February

David Hodell Origin of the 41-kyr cycle and The Middle Pleistocene Transition

5 February

David Hodell Cyclostratigraphy and the Geologic Time Scale
Practical 6: Cyclostrat Practical (Galson Lab)

7 February

David Hodell Paleotracers of Deep-water Circulation, Nutrient and Water Mass Chemistry Proxies ($\delta^{13}\text{C}$, Cd/Ca, Nd...)
Practical 7: TBD

- 8 February
David Hodell Dynamic Paleocirculation Proxies (Pa/Th and ^{14}C and sortable silt)
 Practical 8: Interpreting Ocean Circulation Records from the Atlantic and Pacific
- 12 February
David Hodell Case study: Quaternary history of Deepwater Circulation
 Practical 9: TBD
- 14 February
See below Seminar
- 15 February
Eric Wolff Ice sheets and ice cores
 Practical 10: visit to the BAS ice core labs
- 19 February
Eric Wolff Orbital and millennial events in ice cores, and links to other archives
 Practical 11: Dating ice cores and synchronising them to other archives
- 12 February
Eric Wolff The cryosphere and ice dynamics
- 22 February
Luke Skinner Trends, rhythms and ‘surprises’ in Earth’s climate history (timescales and patterns of change over time)
 Practical 12: Dynamical systems (I) (Galson lab)
- 26 February
Luke Skinner Millennial climate change: the atmosphere, ocean and hydrological cycles
 Practical 13: Dynamical systems (II) (Galson lab)
- 28 February
Luke Skinner Millennial climate change: the cryosphere (polar temperatures, sea-level, sea ice)
- 1 March
Luke Skinner Mechanisms of rapid change: freshwater forcing, ocean heat transport and the bipolar seesaw
 Practical 14: The Stommel model and hysteresis (Galson lab)
- 5 March
Luke Skinner Mechanisms of rapid change: wind, sea-ice, without ‘hosing’
 Seminar: TBD

7 March

Luke Skinner Biogeochemical impacts: Nitrogen cycle and methane
Seminar: TBD

8 March

Luke Skinner Biogeochemical impacts: carbon cycle (I)
Practical 15: biogeochemical box model solutions

12 March

Luke Skinner Biogeochemical impacts: carbon cycle II
Practical 16: biogeochemical GCM solutions

14 March

Luke Skinner The bigger picture: the role of abrupt climate change in longer-term climate evolution

Seminar Speakers (times/dates tbc):

1. Chronis Tzedakis – A simple rule to determine which insolation cycles lead to interglacials
2. Dorthe Dahl-Jensen – Greenland ice cores tell tales of past sea level changes
3. Andrey Ganopolski – Modeling and understanding of Quaternary climate cycles
4. Rachael Rhodes – Atmospheric methane variability in the last Glacial Period

C5: Mineralogy

Lectures will be held on Tuesday and Thursday mornings (9 am) and Friday afternoons (2 pm). Most lectures are accompanied by a practical session. There will also be four invited seminars.

Richard Harrison, Emilie Ringe, Simon Redfern, Michael Carpenter.

Lectures 1-6: Professor Richard Harrison. Mineral Magnetism

This course describes the theory and applications of fine-particle magnetism in natural systems. We explore how a knowledge of small magnetic particles helps to answer a diverse range of questions, including how meteorites retain information about the magnetic field strength of the early solar system, how magnetic proxies are used as tracers of environmental processes, and how magnetic minerals are exploited by biological systems for navigation. The lectures are accompanied by practicals that reinforce the core concepts covered (including a 'field trip' to the Granta pub to collect magnetotactic bacteria!) and a seminar that puts the methods learned into the context of current research. The course provides the necessary core material to take the Part III option "Magnetism of Earth and Planetary Materials".

18 January

1. How to Build a Magnetic Mineral Part 1

19 January

2. How to Build a Magnetic Mineral Part 2

23 January

3. To Saturation and Back Again: Magnetic Hysteresis

25 January

4. Nature's Hard Disk: Recording Natural Magnetic Remanence

26 January

5. Using magnetic minerals to trace Earth's changing climate

30 January

6. A Bug's Life: Magnetic Minerals in Biological Systems

26 January

Seminar: Dr James Bryson

Title to be confirmed

Lectures 7-12: Dr Emilie Ringe. Diffraction

This course describes how diffraction techniques, including X-ray, neutron, and electron diffraction, can reveal the atomic and grain structure of minerals. Building on symmetry concepts, we first explore the rules governing diffraction and learn how to think in reciprocal space. We then examine how diffraction data is used to understand not only crystal structure, but also orientation, grain size, strain, etc. The lectures are accompanied by practicals on X-ray and electron diffraction with a special emphasis on data interpretation and applications, as well as a seminar that explores current research topics.

1 February

7. Diffraction and scattering

2 February

8. Bragg's law and reciprocal space

6 February

9. Structure factors and systematic absences

8 February

10. X-ray diffraction

9 February

11. Electron diffraction

13 February

12 Interpreting diffraction patterns

9 February

Seminar. Prof. Richard Harrison.

X-ray holography: diffractive imaging of nanoscale magnetism in meteorites

Lectures 13-18: Professor Simon Redfern. Lattice Dynamics

We pick up from the Diffraction course. Now we know how we know “where the atoms are” in a mineral – but many of the properties of rocks and minerals are down to how the atoms move – the dynamics of the lattice. In this course we learn how to calculate the forces between atoms, and how those forces are responsible for the way that atoms move, when considered in terms of classical Newtonian mechanics. Finally, we will learn how to use computational methods to calculate the physical properties of minerals at the extreme conditions of the Earth's deep interior, and how such calculations provide insights into planetary processes.

15 February

13. Introduction to Lattice Dynamics

16 February

14. Lattice Dynamic Models

20 February

15. Lattice Dynamics of Silicates

22 February

16. Lattice Dynamics of Monatomic Crystals Part 1

23 February

17. Lattice Dynamics of Monatomic Crystals Part 2

27 February

18. Lattice Dynamics of Multi-atom Crystals

23 February

Seminar. Dr. Xiaolei Feng.

Predicting the structure properties of solids from first principles.

Lectures 19-24: Michael Carpenter. Phase transitions

Any change in atomic, magnetic or electronic structure that occurs in crystalline materials is almost invariably accompanied by lattice distortions (strain). This has implications for the thermodynamics of phase transitions and can result in very substantial (10's of %) changes in elastic properties. In this course, the fundamentals of elastic properties of minerals will be introduced using tensors and their relationship to symmetry. These will be illustrated using specific examples of phase transitions in minerals and functional oxides.

1 March

19. Physical properties of crystals I: tensors, strain and thermal expansion

2 March

20. Physical properties of crystals II: the piezoelectric effect

6 March

21. Introduction to Landau theory of phase transitions

8 March

22. Octahedral tilting transitions in perovskites and introduction to elasticity measurements

9 March

23. Elastic properties of perovskites

13 March

24. Ferroelasticity

9 March

Seminar, Seb Haines

Title to be confirmed

Seminars

Seminars on current research topics in Mineral Sciences will be provided fortnightly on Fridays at 2/4pm, interspersed on alternate weeks with practical material.

Supervisions

Supervisions are arranged in groups of 2-4 and given towards the end of each set of lectures.