NST - Part IA EARTH SCIENCES – 2017-2018
LECTURE LIST

Michaelmas Term

LECTURES 1-4	**INTRODUCTION TO THE EARTH – Dr John Maclennan**
Lecture 1	**Inside the Earth** How we find out what the Earth is made of: a detective story with unusual clues.
Practical 1	*The meaning of rocks and minerals*
Lecture 2	**Geological Time** Coping with the lifetime of the Earth. Putting time in perspective. How we measure it and correlate events.
Field trip	*Ketton quarry field trip:* 10th, 11th, or 12th October Why Peterborough was like the Bahamas.
Practical 2	*Introduction to Geological Maps*
Lecture 3	**Sea levels and ice ages** A story of little creatures and big ice caps. Interactions between land, sea and atmosphere.
Practical 3	*More geological maps*
Lecture 4	**Deforming the Earth** How the secret to the really big things on Earth is contained in the behaviour of small crystals. The creepy Earth.
Practical 4	*And still more geological maps* (Perhaps the best ones. . .)
LECTURES 5-8	**WHAT ARE PLATES? – Dr John Maclennan**
Lecture 5	**Gravity, Isostasy and paleomagnetism.**
Practical 5	*Isostasy*
Lecture 6	**Secrets of the oceans.**

Practical 6	*Paleomagnetism.*
Lecture 7	**Plate tectonics.**
Practical 7	*Plate margins, Euler poles, and geology.*
Lecture 8	**Lithosphere and asthenosphere.**
Practical 8	*Ocean floor topography and heat flow.*

LECTURES 9-14 **WHAT'S THE EARTH MADE OF? AN INTRODUCTION TO ROCKS AND MINERALS – Professor Richard Harrison**

Lecture 9 **The Earth's building blocks**

What is the Earth made of? Chemical composition of the Earth, core, mantle and crust. What is a mineral? Solid solutions. The $[SiO4]^{4-}$ tetrahedron. Bridging and non-bridging oxygens. The 'no rattle limit', coordination number and cation size. Cleavage. Introduction to the common rock forming minerals: olivine, pyroxene, amphibole, mica, quartz, feldspar.

Practical 9 *Hand specimen properties of minerals*

Lecture 10 **Symmetry and the seven crystal systems**

Periodicity of atom structure in crystalline minerals. Unit cell and lattice parameters. Rotational symmetry - diads, triads, tetrads, and hexads. Mirror symmetry. The seven crystal systems. Lattice planes and Miller indices. Indexing crystal faces. Shape and habit. Twinning.

Practical 10 *How to describe and identify minerals and solid solution*

Lecture 11 **Optics 1. Refraction and anisotropic minerals**

The nature of light. Polarised and unpolarised light. Refractive index and Snell's law. Introduction to thin sections and the petrographic microscope. Descriptive terms for habit. Colour. Pleochroic halos, radiation damage. Relief and the Becke line test. Isotropy and anisotropy. Pleochroism. Permitted vibration directions and double refraction in calcite.

Practical 11 *Symmetry, systems, Miller indices and double refraction*

Lecture 12 **Optics 2. Crossed polars and birefringence**
Isotropic materials under crossed polars. Anisotropic materials under crossed polars. Extinction positions. Straight vs. inclined extinction. Optical path difference and birefringence. Conditions for light getting through or not getting through the analyser. The quartz wedge in monochromatic and white light. The Michel-Levy chart.

Practical 12 *Properties of minerals in plane-polarised light: Refractive index and relief.*

Lecture 13 **Optics 3. The optical indicatrix**
How structure and symmetry controls refractive index. How refractive index varies with direction in a crystal. Why cubic minerals are optically isotropic. Uniaxial indicatrix (tetragonal, trigonal and hexagonal). Isotropic sections, optic axis and optic sign. Variation of anisotropy with cut orientation. Biaxial indicatrix (orthorhombic, monoclinic and triclinic). Symmetry control of indicatrix orientation. Orthopyroxene vs clinopyroxene. Straight, inclined and symmetrical extinction. Extinction angles in plagioclase feldspar: relationship to composition and melt temperature.

Practical 13 *Pleochroism and double refraction*

Lecture 14 **Journey to the centre of the Earth**
What's in the core? Hexagonal and cubic close packing. Coordination number and density. Packing efficiency. Fe phase diagram. Effect of light elements and why we still can't answer the question. How hot is the core? High pressure/high temperature experiments. Mantle mineralogy and seismic discontinuities. Minerals in the lower mantle, upper mantle and transition zone. Why mineralogists are glamorous, after all...

Practical 14 *Interference colours, extinction angles and indicatrix orientation*

LECTURES 15-20 **FROM MINERALS TO ROCKS: HOW THE CRUST WORKS – Professor Marian Holness**

Stretching and colliding: Igneous and metamorphic rocks
The practicals for this course are based on observation of thin-sections and hand specimens. Introductory videos for each of the important thin-sections are downloadable from Moodle. It is a good idea to watch the relevant videos before each practical session, although a computer will be available during the session.

Lecture 15	**Generation and ascent of magma**
Practical 15	*Introduction to igneous rocks (1)*
Lecture 16	**Emplacement of magma and volcanic eruptions**
Practical 16	*Introduction to igneous rocks (2)*
Lecture 17	**Formation of the oceanic crust**
Practical 17	*The Oman ophiolite*
Lecture 18	**Destruction of the oceanic crust**
Practical 18	*Subduction zone magmas*
Lecture 19	**Continental collisions: introduction to metamorphic rocks**
Practical 19	*Regional metamorphism of argillaceous rocks*
Lecture 20	**Continental collisions: granites**
Practical 20	*Regional metamorphism of basaltic rocks*

LECTURES 21-24	**EARTH AND OTHER PLANETS – Dr John Maclennan**
Lecture 21	**The puzzle of the continents.** Faults, folds, mountains and basins on the continents, why are continents odd?
Practical 21	*Seismic refraction, crust, mantle, core.*
Lecture 22	**Why does it all happen? How does the Earth work?** Heat, conduction, convection. The Earth as a heat engine.
Practical 22	*Geology of Britain.*
Lecture 23	**Isotope Geochemistry.** Star formation, what isotopes can tell us about planetary evolution.
Practical 23	*Geology of Atlantic Region.*

Lecture 24 **The Solar System.**
Mars, Venus, Moon and moons of other planets.

Practical 24 *(There is no practical)*

Lent Term

LECTURES 25-36 **PALAEOBIOLOGY – Professor Simon Conway Morris**

Lecture 25 **Introduction.** Body fossils, hard parts and soft-part preservation; trace fossils; chemical fossils; bias in the fossil record.

Lecture 26 **Origin and early evolution of the Solar System.** Origin of life. Precambrian life and rise of oxygen. Origins of animals (Metazoa).

Lecture 27 **The taxonomic hierarchy and cladistics.** Introduction of marine invertebrate phyla. Modes of skeletal growth: accretionary, moulting, addition and modification.

Lecture 28 **Introduction to palaeoecology,** living position and feeding habits and their recognition in the fossil record.

Lecture 29 **Introduction to functional morphology**, trilobite vision as a selected example. Taphonomy, the post-mortem history of a fossil. Completeness of the fossil record.

Lecture 30 **Fossils as environmental indicator**s. Foraminifera and reefs as indicators of water depth and temperature. Other fossils as indicators of selected factors.

Lecture 31 **The origin and diversification of land plants**, invasion of land, evolution of life cycles.

Lecture 32 **Fossils in stratigraphy**. Macrostratigraphy. Microstratigraphy and the biostratigraphic zonation of the Phanerozoic. Powers of resolution.

Lecture 33 **Biogeography and plate tectonics.** Distribution of fossil organisms, communities and provinces, modes of dispersal. Plate collision and dispersal. Simpson index of similarity.

Lecture 34 **Evolution**. Microevolution, convergence, macroevolutionary rates and patterns.

Lecture 35 **Evolution of humans and intelligence**.

Lecture 36 **Mass extinction, terrestrial and extraterrestrial mechanisms.** The Cretaceous/Tertiary (KTF) event.

LECTURES 37-42 SEDIMENTARY PROCESSES AND PRODUCTS - Dr Neil Davies

Lecture 37 **Sedimentary rocks: description and classification**
Sedimentary components: mineral grains, lithic fragments, biogenic material, chemical precipitates. Grain size and shape, texture. Classification of clastics, volcaniciclastics and carbonates. Examining sedimentary rocks.

Practical 37 *Grain-size and textures of clastic sediments*

Lecture 38 **Sediment mechanics, structures, facies and environments**
Transport media. Geological fluids and particles. Erosion and transport. Deposition and grading. Bedforms: ripples, dunes, plane bedding, antidunes; bedform stability diagram. Wave ripples. Mass flows. Erosional and deformational structures. Facies, associations and sequences; graphic logs. Palaeocurrents. Geological environments.

Practical 38 *Sand transport, ripples and cross bedding*

Lecture 39 **Continental environments and facies**
Continental environments and global climate. Weathering, erosion and sediment supply. Glaciers and icecaps; tills, moraines etc. Arid environments: deserts, wadis, alluvial fans, playas. Rivers: braided, meandering, flood plains. Lakes: density, salinity and oxicity.

Practical 39 *Aeolian and glacial sediments*

Lecture 40: **Marginal and shallow marine environments and facies**
The marine realm: tides, waves, thermohaline currents, marine ecology. Delta types: river, wave and tide-dominated. Delta cycles. Estuaries: tide and wave dominated. Coastlines: erosional and constructional; clastic and carbonate; arid coastlines, sabkhas. Clastic shelves: tide or storm dominated. Carbonate shelves and platforms; rimmed or ramped. Evaporite basins.

Practical 40 *River sediments and the reconstruction of a delta*

Lecture 41 **Deep marine environments and facies**
Continental slopes and rises. Submarine fans: mass flow processes, proximal to distal variations. Contourites. Pelagic sedimentation: carbonate and siliceous ooze, CCD. Mn-nodules, hydrothermal deposits. Volcanic environments; Air fall, pyroclastic flows, breccias.

Practical 41 *Overview of the variety and classification of sediments*

Lecture 42 **Sedimentary basins: form, fill and value**

Post-depositional processes; soft-sediment deformation, compaction, cementation, diagenesis of clays and organics, carbonate diagenesis, dolomitisation. Basin-forming mechanisms: thermal, stretching, flexure. Tectonic settings of basins. Hydrocarbon systems; source, reservoir and cap rock; maturation, migration and traps.

Practical 42 *Turbidites and abyssal fans*

LECTURES 43-47 **EARTH'S CLIMATE SYSTEM – Professor David Hodell**

Lecture 43 **Overview Of The Modern Climate System.**

Earth's Energy Balance — Greenhouse Effect — Atmosphere and Ocean Circulation

Practical 43 *Ocean sediments*

Lecture 44 **Climate Change: Forcing And Feedback.**

Causes of Climate Change — Positive and Negative Feedback Mechanisms — Solar variability — Albedo feedback — Greenhouse gases — Radiative forcing — Climate Sensitivity

Practical 44 *Limestones*

Lecture 45 **Global Carbon Cycle and Geologic History of CO_2 Variation.**

CO_2 sources and sinks - Anthropogenic emissions - Marine carbonate system - Proxies for reconstructing past CO_2 – Geologic history and controls of atmospheric CO_2 – Future CO_2 in a geologic context

Practical 45 *Carbonate environments*

Lecture 46 **Cenozoic And Quaternary Climate History.**

Tools for paleoclimate reconstruction — Palaeoclimate Proxies — Marine Microfossils — Oxygen isotopes — Cenozoic Cooling and Glaciation — Intensification of Northern Hemisphere Glaciation — Quaternary Glacial-Interglacial Cycles

Practical 46 *Carbonate diagenesis*

Lecture 47 **Unlocking the Mystery of the Ice Ages.**
Causes of Pleistoene Glacial-Interglacial Cycles - Milankovitch Theory of The Ice Ages

Practical 47 *tbc Sandstone petrography and classification/Arran Practical*

Lecture 48 **INTRODUCTION TO ARRAN – Dr Ed Tipper**

Field Trip to Arran
Party A: Thursday 16th March to Friday 24th March 2017
Party B: Thursday 23rd March to Friday 31st March 2017
Party C: Monday 3rd April to Tuesday 11th April 2017

Easter Term

Lectures 49-53 **BRITAIN'S GEOLOGY: SOLVING THE JIGSAW - Dr Nigel Woodcock**

Lecture 49 **The foundations of Britain and Ireland: basement terranes**
The geological time scale: the geological map of Britain and Ireland, Caledonian and Variscan orogens: basement terranes and their histories: Gondwanan and Laurentian origins: Terrane tectonics in western North America and southeast Asia

Practical 49 *Revision: geological maps.*

Lecture 50 **Britain and Ireland through geological history.**
Controls on the British geological record: sea level, atmospheric composition, temperature organic evolution. Linked atmosphere/geosphere mechanisms. Britains's latitudinal drift through time. Palaeocontinental maps. Continental assembly and break-up: supercontinents. The origins of Iapetus.

Practical 50 *Revision: maps and mineral identification.*

Lecture 51 **Closing the Iapetus Ocean: orogeny in action**
The mismatching margins of Iapetus.. A palaeocontinental view of Iapetus closure. Caledonian deformation phases in time and space. Orogenic ('mountain building') mechanisms. Grampian phase: arc-continent collision. Scandian phase: continent-continent collision. Southern Uplands example: Iapetan subduction complex. The problem of the Acadian phase: Iapetus or Rheic linked?

Practical 51 *Revision: fossil identification*

Lecture 52 **Living on a supercontinent; Pangaea**
Palaeocontinental framework. Formation of sedimentary basins during Variscan convergence. The Pangaean Ice Age, causes and effects. The Variscan Orogeny in Britain and Ireland. After the storm: Permo-Triassic deserts.

Practical 52 *Revision: fossils, rocks and maps.*

Lecture 53 **Rifting the Atlantic: Britain back on the margin.**
Palaeogeography of the Atlantic breakthrough. Failed rifts. Mechanics of rift and sag basins. Mesozoic basins around Britain. The North Sea record.

The Thulean plume: uplift and magmatism. Alpine shortening. Quaternary ice sheets in the British Isles.

Practical 53 *Revision: sedimentary rock identification.*

LECTURES 54-56 **GEOLOGY BEYOND THE SOLAR SYSTEM – Dr Oliver Shorttle**

Lecture 54 **Planetary life cycles – the birth and death of planets**
From the big bang to stellar death, planets are fundamentally linked to their astrophysical environment. Here we recap the origin of planetary building blocks and chart the planet formation process from observations of solar system objects and of nearby star forming regions. We will also look at the clues lurking in stellar spectra that record the dramatic end some planets face.

Practical 54 *Radiometric dating of Precambrian terranes.*

Lecture 55 **Discovering other worlds – an exoplanet menagerie**
Over the last decade a revolution in astronomical observation has expanded the horizon of geological processes, out from the handful of rocky bodies in our solar system to the now several thousand planets detected around other stars. Here we will look at the key discoveries in exoplanetary science, the types of planetary systems that have now been identified, and the methods for detecting and characterizing exoplanets.

Practical 55 *Revision: igneous rock description.*

Lecture 56 **Planetary habitability – finding life in the universe**
Life on Earth presents a staggering conundrum, existing in the geological record as far back in time as we can see and persevering uninterrupted over 4 billion years of environmental upheaval. Yet, despite the remarkable resilience of life the conditions for its emergence seem far more fragile. By recapping the basic climatic energy balance covered earlier in the course, we here consider the concept of a planetary habitable zone and with this discuss the likelihood of life existing on planets around other stars.

Practical 56 *Revision: igneous and metamorphic rock identification.*

LECTURES 57-60 **PLANET EARTH: The Bigger Picture – Dr Marie Edmonds**

Lecture 57 **Earthquakes**
Why do earthquakes that routinely kill 50,000 people in Asia only kill 50 in Japan and California? Who is really vulnerable and why? What does the future hold?

Practical 57 *Revision: sedimentary and metamorphic rock description.*

Lecture 58 **Tsunamis**
What happened in the Great Sumatra earthquakes of 2004, 2005, 2007? How are tsunamis generated and why can they travel round the Earth? How do we prepare for them, and what warning systems are possible?

Practical 58 *Revision: Correlation of borehole logs.*

Lecture 59 **Volcanic eruptions and collapses**
Eruption columns, co-ignimbrites, super-eruptions: Tambora, Toba, Yellowstone, the real risk of global catastrophe.
Volcanoes that fall to pieces. Giant landslides.

Practical 59 *Geological maps.*

Lecture 60 **Global energy issues: the role of the Geologist**
It is clear that we have to change the way we use energy, or face serious changes to our environment. What is the role of geology in all this? What are the issues that will need to be addressed by your generation?