Inside the magma chamber (Cuillins, Isle of Skye)
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1. Geology – what is it all about?

Geology is the science of the Earth. It deals with processes operating inside the Earth and on the Earth’s surface, today and back in time to the planet’s origin some 4.5 billion years ago. These processes may be brief and violent, such as earthquakes and volcanic eruptions, or they may be slow and drawn out, like the rise of majestic mountain ranges. Scientists from all major disciplines are drawn into geology: they work together to figure out just how the Earth and its abundant life came to be the way we find them today. Charles Darwin was, first and foremost, a geologist. Without a sense of ‘deep time’ his astonishing insight into evolution could never have happened. Geology was so central to scientific investigation in Darwin’s age that Trinity College saw fit to recognize the subject’s importance by erecting the splendid Museum Building. This building continues to be the home of geology in Trinity, and geological research is as active there today as it has ever been. Recent work has included the reconstruction of global geography 300 million years ago, ancient global warming, the precise measurement of the age of rocks, and the origin of planets.

The time perspective is important when analysing short-term fluctuations of climate, oceanic circulation and biodiversity as well as understanding the formation of our natural resources, their finite nature and sustainability of our species. The subject matter is utterly fascinating and forms an excellent basis for critical and logical thinking as well as a vocational training. Aside from its fundamental interest, geology has paved the way towards our modern industrialised society by showing how and where to find those resources – water, coal, iron, oil, and rare metals – upon which we so crucially depend. And now, as civilization strives to come to terms with the damage caused by over-exploitation of those resources, it is geologists who, through their understanding of the planet’s past history, are best equipped to seek mitigating solutions to the threat of climate change, and to the risk of losing access to clean water. Geology is science at its broadest and at its most relevant for the future of humankind.
The undergraduate programme in Geology

This booklet deals with modules available to undergraduate students taking the TR071 (Science) course. The four years of modules offered by the staff of Geology form an integrated programme of study for the moderatorship in geology. The honours degree course in geology involves two years when students take several different sciences (including geology), followed by two years when geology is studied alone. All science degrees in Trinity follow this pattern, where knowledge across a range of disciplines is regarded as having great educational benefit. Aspiring geologists register for the Science (Common Entry) programme whose CAO code is TR071.

In September 2009 Trinity moved to a system of two teaching terms of 12 weeks duration, each with a designated study week within them, followed by a term of revision and examinations. Every module is given a credit value that links to the European Credit Transfer System (ECTS), a system that has been designed to permit easy transfer of students throughout universities in Europe with recognisable ‘currency’. This system is also intended as being of value to employers thus permitting mobility of labour. The system is based not on the amount of class contact but on total student workload. One credit is equal to approximately 25 hours of projected student input, which covers class contact, reading, assignments, revision and examinations. Teaching is delivered in modules, mostly of 5 or 10 credit weighting, where 1 credit corresponds to 25 hours of work by a student, including private study time as well as time spent in lectures and practical classes. One year of study amounts to 60 credits. The first year to fourth year modules, which lead to a degree in geology, are listed in the table on the page below. The term in which modules occur is indicated in the module description.

The first year in Trinity is called the Junior Freshman (or JF) year. JF geology is a 10-credit module, which is taught during the second term (i.e. after the Christmas break). This module aims to provide an overview of the subject, and presents many of the ‘big’ issues affecting the planet.
Geology in the second, or Senior Freshman (SF), year is presented as two separate 10-credit modules, one before and one after Christmas. Students take both modules if they are thinking of continuing on to complete a geology degree. The SF modules focus on acquiring the skills necessary to describe, identify and interpret the rocks that comprise the Earth, the fossils found within them, and the minerals from which they are made, and to describe and analyse the three-dimensional geometry of rock units beneath the Earth’s surface.

Many of our modules, particularly the freshman modules, are taken by students whose main interest is in other areas such as biology or physics but for whom some knowledge of the planet is a valuable part of their education. These students are just as welcome as those who continue to study geology for the whole four years.

In the third (junior sophister) year, the programme aims to provide a good grounding in all major aspects of geology whilst the fourth (senior sophister) year allows a considerable amount of choice both in modules taken and also in the nature of material studied for the independent project. Strong emphasis is placed on transferable skills of analysis and presentation and also on integration of information, the latter particularly through an important fieldwork programme.

Some other modules that are taught by staff in geology but which are not part of this overall structure, e.g. Geology for engineers, are detailed on the website or in the appropriate course booklet.

The Department of Geology offers a friendly and stimulating working environment where students are treated as individuals and our overarching aim is that each student has the opportunity to develop themselves to their full potential. In the senior sophister year in particular, many of the modules are research led and deal with problems and data sets that are currently the subject of staff research. Research interests of members of staff and current events are housed on the regularly updated departmental website.
BA (Mod) Geology - Learning outcomes

On successful completion of this programme a student should be able to:

1. identify, formulate, analyse and suggest reasoned solutions to geological problems
2. identify earth materials and interpret three and four dimensional distributions of these materials from incomplete data sets
3. apply scientific procedure to solving problems
4. critically assess previously produced geological data sets and interpretations
5. work effectively as an individual, in teams and in multidisciplinary settings
6. communicate effectively with both the geological community and with society at large
7. update their knowledge and undertake further study with a high degree of autonomy.

David Chew
Course Director
## 2. Programme overview

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(M = mandatory; O = optional)
3. Course Structure and Outlines of Modules

3.1 Junior Freshman Modules

**GL1101 Geology**  
*10 credits*

**Co-ordinator:** Dr Chris Nicholas  
**Prerequisites:** No prior knowledge of geology is required or assumed, but a background in at least one science subject taken at Leaving Certificate level is recommended, along with an inquisitive mind.  
**Semester:** Hilary Term  
**Contact Hours:** 3 hours lectures and 1 hour tutorial per week.

**Module Learning Aims:** The module gives an introduction to our dynamic Planet Earth, explains the natural principles and processes that govern how it works inside and out, and retraces its geological history over the past four and a half billion years.

**Module Content:** From the vastness of the Universe to the microscopic structure of mineral crystals, from galaxy birth over billions of years to volcanic eruptions lasting only minutes; the science of geology sets out to investigate the origin and development of the planet, the natural principles that govern it, the processes that act in, on and around it, and the life that has evolved with it. Many sciences are conducted in the laboratory, but to a geologist the Earth itself is the laboratory. In essence, this module provides a beginner’s guide to Planet Earth.

The module is divided into two main themes developed consecutively during the Semester. Firstly, 'Earth in Space' investigates the origin of the Universe and our Solar System, Earth’s early formation, composition and structure, with a focus on how Earth's internal dynamism constantly changes the landscape upon which we live. The second theme, 'Earth and Life' explores how the planet and the organisms that have lived on it evolved together over billions of years. It investigates how evidence of past life can be preserved in rocks, how key fossil groups evolved, and the geological causes that drove some of them to extinction.
Learning Outcomes: On successful completion of this module students should be able to:

- explain the basic origin and evolution of planet Earth and outline its dynamics
- discuss the major evolutionary episodes in the fossil record and explain how the planet changed over time with life

Assessment details: Theory examination (60%); in-course assessments made up of multiple-choice tests (10%); tutorial work (30%).
3.2 Senior Freshman Modules

**GL2205 Dynamic Earth 1: Rocks and Evolution 10 credits**

Coordinator: Prof. Balz Kamber
Prerequisites: GL1101
Semester: Michaelmas Term
Contact Hours: Four lectures and one three-hour practical per week

**Module Learning Aims:** (1) to promote the understanding of how material is cycled and recycled within the Earth and how rock types record different aspects of this cycling. (2) To provide (a) an understanding of form and function in fossil organisms and their links to living floras and faunas (b) an overall appreciation of the evolutionary record of life on Earth.

**Module Content:** The module initially approaches the solid materials that make up the outer parts of the Earth - the lithosphere - namely rocks and their basic building blocks, minerals. A pathway is taken through the rock cycle from initial formation from mantle material into igneous rocks, their subsequent breakdown at the Earth’s surface and reconstitution into sedimentary rocks and, finally the alteration of these rocks through burial at elevated temperatures and pressures. Techniques of describing and reaching first stage interpretations of rocks and minerals in hand sample are covered.

Equipped with an appreciation of the dynamic natures of the solid Earth, the module then introduces the time dimension of life, which has existed on planet Earth for much of its history. Fossil organisms are the data that record the evolution of life on the planet.

**Learning Outcomes:** On successful completion of this module students should be able to:
- describe and identify common kinds of rock, and the minerals they contain, in hand sample
• describe and classify a broad range of organisms found in the fossil record, and explain the concepts of fossilisation, evolutionary sequences and lineages
• outline the uses of fossils in palaeobiological, palaeogeographic and evolutionary studies, and state the basic principles of taxonomic procedure

Assessment details: Theory examination (60%); practical examination (20%); in-course assessment (20%).

**GL2206 Dynamic Earth 2: Structure and Microscopy 10 credits**

Coordinator: Dr David Chew  
Prerequisites: GL1101, GL2205  
Semester: Hilary Term  
Contact Hours: Four lectures and one 3-hour practical per week

**Module Learning Aims:** (1) To investigate how, why and where rocks undergo deformation. (2) To understand the different plate tectonic environments, and their evolution in time and space (3) To be able to interpret two-dimensional representations of geological data (maps) in three dimensions. (4) To understand the physical and chemical properties of minerals and how minerals can be investigated using the polarised light microscope.

**Module Content:** This module investigates the structure of the Earth from the scale of plate tectonics through to investigation using the polarising microscope. The structural geology lectures cover the principles of rock deformation and the classification of structural features. The tectonics lectures provide an overview of active plate tectonic processes. These various processes are exemplified by a series of practical exercises that aim to develop an understanding of plate tectonics and the visualisation of structures in three dimensions. The module also introduces the principals of crystallography and the theory and practice of using a polarised light microscope to look at minerals in thin sections of rock. The rock-forming minerals are examined in detail in terms of where they are found, what they look like through the
microscope, what chemical elements they contain, and their physical stability.

**Learning Outcomes:** On successful completion of this module students should be able to:

- investigate and explain how, why and where rocks undergo deformation
- describe the different plate tectonic environments, and their evolution in time and space
- interpret two-dimensional representations of geological data (maps) in three dimensions
- describe the physical and chemical properties of minerals and describe how minerals can be investigated using the polarised light microscope.

**Assessment details:** Theory examination (70%); practical examination (15%); in-course laboratory assessment (15%).

Leinster granite, thin slice through a polarizing microscope
3.2.2 Senior Freshman Earth Science Students Only

GL2299 Fieldwork 5 credits

Coordinator: Dr Patrick Wyse Jackson
Prerequisites: GL2205
Semester: Hilary Term
Contact Hours: Seven day residential field course

Module Learning Aims: To be able to systematically investigate Earth materials in the field.

Module Content: This module is based on an extended residential field module. Geological rock types and structures are examined which illustrate topics covered in other freshman geology modules. Quaternary sediments and geomorphological features covered in freshman geography modules are also examined. Emphasis is placed on practical aspects of the earth sciences, especially interpreting and recording data in a systematic way.

Learning outcomes: On successful completion of this module students should be able to:

- identify common sedimentary, igneous and metamorphic rocks in the field
- identify and record basic geological features
- describe and record a range of Quaternary sediments and landforms
- conduct a basic surveying exercise

Assessment details: In-course assessment 100%

155 Ma Ammonites with original shell material
3.3 Junior Sophister Modules

**GL3301: Sedimentary petrology: from sediment to rock  5 credits**

**Coordinator:** Dr Catherine Rose  
**Prerequisites:** GL2205, GL2206  
**Semester:** Michaelmas Term  
**Contact Hours:** Weeks 12-16, seven hours per week

**Module Learning Aims:** The aims are (1) To acquire a basic understanding of how sediment is produced at the Earth's surface and then becomes rock. (2) To be able to relate the information preserved in these sedimentary rocks to physical, chemical and biological processes that occurred during their formation.

**Module Content:** The origin of a wide range of sedimentary rocks is investigated in theory and in the laboratory using hand samples and thin sections.

**Learning outcomes:** On successful completion of this module students should be able to:

- provide technical descriptions of common sedimentary rock types from hand samples and thin sections
- outline appropriate strategies for laboratory investigation of sedimentary rocks
- produce basic interpretations of petrological evidence

**Assessment details:** Theory examination (50%); practical examination (25%); in-course laboratory practical work and seminars (25%)

Saharan erg
GL3306: Palaeontology, palaeoecology and evolution 5 credits

Coordinator: Dr Patrick Wyse Jackson
Prerequisites: GL2205 or BY2204
Semester: Michaelmas Term
Contact Hours: Weeks 12-16, seven hours per week

Module Learning Aims: The aims are to provide (1) an understanding of evolutionary processes; (2) a link between modern and ancient ecosystems; (3) a synopsis of methodologies in taxonomy; and (4) guidelines on how to gather biological data from fossils in the field.

Module Content: This module will focus on two areas: the evolution of life on our planet from earliest times, and the use of fossils as sources of palaeoenvironmental data. In the former topics covered in lectures include the Cambrian explosion, evolution and classification, the evolution of flight, and the biodiversity in the past, present and future. In the second area lectures and practical sessions will concentrate on determining the information available to field geologists from single fossils and from fossil assemblages and will reconstruct past environments from the available data, taking into consideration the reduced information available between the living organism and its fossilised representative. Some of the content of this module will be student-led through presentations.

Learning outcomes: On successful completion of this module students should be able to:

- describe the evolutionary steps displayed in the fossil record
- identify and describe modern ecological parameters that act on the biosphere and apply this information to the fossil record
- select appropriate statistical and qualitative techniques when investigating fossils in the field and in the laboratory
- discuss the basic principles of taxonomic procedures

Assessment details: Theory examination (60%); in-course laboratory practical work and seminars (40%)
GL3317: Geological Structures and Mapping  10 credits

Coordinator:  Dr David Chew
Prerequisites:  GL2205, GL2206
Semester:  Hilary term
Contact Hours:  Weeks 21-26, nine hours per week; Weeks 28-30 6 hours a week

Module Learning Aims: This module aims to develop an understanding of structures in three dimensions by introducing the principal means of presenting structural data, namely maps, cross sections and stereographic projections. The mapping component of the module aims to provide the basic background to geological cartography and how to undertake geological mapping at a variety of scales.

Module Content: This module examines the geometries, kinematics and mechanics of rock deformation. It also deals practically with the representation of three-dimensional structural data using maps, cross-sections and stereographic projections. It also introduces the principles and methodology of geological mapping at a variety of scales including topics such as map projections, coordinate systems and Global Positioning Systems (GPS).

Learning outcomes: On successful completion of this module students should be able to:

- summarise the basics of rock rheology, the concepts of stress and strain, and the processes of brittle and ductile deformation
- classify and identify rock fabrics, faults, fractures and fault zone rocks and describe and classify folds
- give a detailed account of the principal features of compressional, strike-slip and extensional tectonic systems
- confidently present and manipulate data using stereographic projection
- confidently navigate and locate themselves in the field, use compass-clinometers correctly
• produce their own base and geological maps using hand-held GPS, and outline the principles behind their construction.

**Assessment details:** Theory examination (35%), in-course work (65%).

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**GL3318: Mineralogy**

**5 credits**

**Coordinator:** Dr Teresa Ubide  
**Prerequisites:** GL2205, GL2206  
**Semester:** Michaelmas Term  
**Contact Hours:** Weeks 6-10, seven hours per week

**Module Learning Aims:** This module aims to consolidate and extend the skills in using the polarized light microscope developed in the Senior Freshman year, and to reinforce knowledge of the rock forming minerals. It also aims to enlarge knowledge of the chemistry and appearance of hand specimen minerals.

**Module Content:** The module develops the use of the polarizing microscope including use of conoscopic illumination and other techniques for distinguishing between common rock-forming minerals in thin section. It deals with the crystal chemistry, stability and occurrence of these minerals. It introduces a wide range of other minerals in hand specimen, along with their chemistry and economic value.
Learning outcomes:  On successful completion of this module students should be able to:

- make observations in orthoscopic and conoscopic light, to rectify misaligned components of a polarizing microscope, obtaining optimal illumination
- identify the major rock-forming minerals in hand specimen and thin section, and state their chemistry, crystal structure, and geological occurrence
- identify hand specimens of many additional minerals, and state their chemistry, occurrence, and economic uses.

Assessment details:  Theory examination (50%), practical examination (50%).

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Zoned Zircon crystal seen through a polarising microscope

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GL3321:  *Geochemistry and analytical techniques*  5 credits

Coordinator:  Dr Quentin Crowley  
Prerequisites:  GL2205, GL2206  
Semester:  Michaelmas Term  
Contact Hours:  Weeks 6-10, seven hours per week
Module Learning Aims: This module focuses on the theory and application of geochemistry, including major and trace elements as well as stable isotopes. The module covers both the acquisition of geochemical data as well as the principal numeric steps to test geological hypotheses with the data.

Module Content: In terms of analysis, the module introduces many of the currently used methods for quantitative chemical analysis of minerals and rocks (X-ray fluorescence, inductively coupled plasma mass spectrometry and optical emission spectroscopy), for mineral determination (X-ray diffraction) and for imaging rocks and minerals (scanning electron microscopy, transmission electron microscopy, cathodoluminescence). Basic sample preparation techniques and site visits to various working laboratories are included. In terms of data familiarisation, the module covers a logical sequence of steps that guide users of geochemical data towards testing hypotheses.

Learning Outcomes: On successful completion of this module students should be able to:

• describe the evaluate the use of major and trace elements as well as stable isotopes as tracers of geological processes
• describe sample preparation and analysis methods for geochemical studies and outline the types of scientific questions that can be addressed using geochemistry
• explain the principles of several current analytical techniques in geochemistry
• carry out calculations relating to processing analytical data

Assessment details: Theory examination (66%), in-coursework (34%).

GL3322: Crystalline Rocks 1: igneous processes 5 credits

Coordinator: Dr Emma Tomlinson
Prerequisites: GL2205, GL2206
Semester: Hilary Term
Contact Hours: Weeks 21-26, seven hours per week
Module Learning Aims: (1) To broaden and deepen the skills for identification and description of igneous rocks in hand specimen and thin section. (2) To provide an understanding of how igneous rocks are classified. (3) To develop an appreciation of how textural relationships amongst minerals can be used to infer the history of igneous rocks. (4) To demonstrate how magma chemistry dictates the mineralogy of igneous rocks.

Module Content: the module introduces a wide variety of igneous rocks. The rocks are approached on several scales: their tectonic environment, their local occurrence, in the hand specimen as well as under the microscope. The causes of magma diversity are investigated using experiments and phase diagrams.

Learning outcomes: On successful completion of this module students should be able to:

- correctly identify all major igneous rocks and explain their petrogenetic importance
- provide a robust macroscopic and microscopic rock description and correctly interpret mineral textures
- describe how the chemistry of a rock dictates its mineralogy

Assessment details: Theory examination (40%), practical examination (30%), in-course assessments (30%)

GL3323: Crystalline Rocks 2: metamorphic processes and crustal melting  5 credits

Coordinator: Dr Emma Tomlinson
Prerequisites: GL2205, GL2206
Semester: Michaelmas Term
Contact Hours: Weeks 12-16, seven hours per week
Module Learning Aims: (1) To broaden and deepen the skills for identification and description of metamorphic rocks in hand specimen and thin section. (2) To provide an understanding of how metamorphic rocks are classified. (3) To develop an appreciation of how textural relationships amongst minerals can be used to infer the history of a metamorphic rock. (4) To gain knowledge of the role of fluids and partial melting during metamorphism.

Module Content: This module introduces the main types of metamorphic rock in the context of the precursor rock and the geological setting. It examines the effects of pressure, temperature, fluid migration, stress history and partial melting. The rocks are investigated at the scale of their tectonic environment, their local occurrence and in the hand specimen as well as under the microscope.

Learning outcomes: On successful completion of this module students should be able to:

- identify metamorphic rocks in hand specimen and in thin section, and explain their petrogenesis
- independently provide a robust macroscopic and microscopic rock description and correctly interpret mineral textures
- demonstrate how the chemistry of the precursor rock and the physical conditions of metamorphism dictate the mineralogy of a metamorphic rock
- describe how fluids are taken up and released by crustal and mantle rocks during metamorphism at low temperature and at high temperature

Assessment details: Theory examination (50%), practical examination (30%), in-course assessments (20%)
GL3324: Geological Field Skills 1 10 credits

Coordinator: Dr Chris Nicholas
Prerequisites: JS Geology students only
Semester: Michaelmas Term
Contact Hours: 14 Days

Module Learning Aims: To introduce and practice the range of basic geological field skills needed by a geologist today, demonstrate some of the more interesting aspects of Arran's geological history and Scotland as a whole, and to give students experience of problem-solving with others and presenting their own ideas.

Module Content: The Isle of Arran in SW Scotland is often called 'Scotland in miniature' as it has an amazing variety of different rocks squeezed into a relatively small geographical area. Consequently, it is a perfect place to get to grips with geology in the field and to think about rocks on a large scale out of the classroom. This field course will spend time looking at sedimentary, igneous and metamorphic
rocks, and after introducing some of the key basic field techniques needed to extract the most information from rocks in situ, and how to interpret the data, students will then undertake various problem-solving exercises as well as having the chance to try geological mapping on variety of scales.

**Learning outcomes:** On successful completion of this module students should be able to:

- Locate themselves accurately in the field using a compass,
- Confidently use various items of geological equipment to gather and record data from rocks in situ, such as hand lens, hammer, compass-clinometer, and field note book,
- Make an interpretation of the geological origin and formation of any given rock exposure based on their own observational and measured field evidence,
- Confidently undertake basic geological mapping in the field using both topographic base maps and transparent overlay on satellite imagery,
- Synthesise data gathered from a series of rock exposures around an area to piece together its geological evolution and history.

**Assessment details:** In-course assessment 100%
GL3325: Geological Field Skills 2 10 credits
(also taken by Earth Sciences students)

Coordinator: Dr David Chew
Prerequisites: GL2205 and GL2206
Semester: Hilary Term
Contact Hours: Weeks 31-32

Module Learning Aims: To build on the field skills gained in module GL3324, by introducing new techniques, developing and improving geological mapping skills and improving interpretative skills in the field.

Module Content: Undergraduate field courses provide vital experience in practising core subject skills. Much of this module will comprise a two week residential field course to a region of active tectonics. It will comprise a series of exercises in the techniques of geological fieldwork and mapping, and development of an understanding of how the geology of the field area is related to the tectonics of a region.

Learning outcomes: On successful completion of this module students should be able to:

• accurately locate yourself in the field using topographic base maps, satellite imagery and / or GPS
• make essential field observations and measurements, including recognition of major rock types and geological structures
• use a compass-clinometer with familiarity to measure geological structures
• construct a geological map (field slips and interpretative map) and stratigraphic log and accurately record field observations in a notebook, as notes, sketches or tabulated data
• construct a geological cross-section on the basis of a geological map
• identify and interpret a range of sedimentary structures and their depositional environments
• identify diagnostic metamorphic assemblages in the field
• be familiar with a range of volcanic rocks and their modes of deposition and be able to use this information to determine eruptive style
• to evaluate the regional geology and tectonic setting in the context of an active orogenic belt

**Assessment details:** In-course assessment 100%

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### 3.4 Other Junior Sophister Modules - Earth Science Students Only

**GL3320 Microscopy and Crystalline Rocks**

- **5 credits**

- **Coordinator:** Prof. Balz Kamber
- **Prerequisites:** Earth Science Students only
- **Semester:** Hilary Term
- **Contact Hours:** Weeks 30-32, fifteen hours a week

**Module Learning Aims:** (1) To prepare Earth Sciences students for SS Geology module options. (2) To train students in the use of the petrographic microscope. (3) To develop the skills for description and classification of the most important igneous rocks. (4) To develop an appreciation of the various tectonic regimes in which crystalline rocks form.
Module Content: The module starts out with a thorough introduction to the use of the petrographic microscope and the optical properties of the main rock-forming minerals. The module next introduces the most important igneous rocks from a variety of scales: their tectonic environment, their local occurrence, in the hand specimen as well as under the microscope. Finally, the module covers the two most important metamorphic rock series: metapelites and metabasites. They are covered from the point of view of petrography, classification and metamorphic environment.

Learning Outcomes: On successful completion of this module students should be able to:

- describe the basic aspects of cross-polarised light microscopy
- identify, describe and classify all major crystalline rocks and explain the petrogenetic importance of the various rocks

Assessment details: Theory examination (50%), practical examination (30%), in-course assessments (20%)

3.5 Senior Sophister Modules

GL4401 Independent Project 15 credits

Co-ordinator: Dr Chris Nicholas
Prerequisites: JS Geology
Semester: Michaelmas Term
Contact Hours: The project is based on six weeks of geological fieldwork undertaken prior to week 5 of Senior Sophister year.

Module Learning Aims: To reconstruct the geological history of an area based entirely upon field data, their interpretation and supporting petrography of collected samples.

Module Content: The GL4401 'Project' continues to be highlighted by external examiners and potential industry employers as a cornerstone of the moderatorship in
It challenges the student to undertake a 6-week geological field survey of an area that they are initially unfamiliar with. By using their own careful field observations and measured data, they then piece together and interpret the geological evolution of the area. Completed geological maps, cross-sections and stratigraphic schemes for the area are then included as part of an oral presentation and a final report. In support of the field component, the petrology of rock samples collected during fieldwork can be described during the first weeks of the Michaelmas term, accompanied by limited thin sections and/or in-house geochemical analyses.

The module is largely one of independent study, overseen by a project supervisor.

**Learning Outcomes:** On successful completion of this module students should be able to:

- plan and execute an independent geological field survey
- present the scientific findings in a professional manner by means of a written report and oral presentation

**Assessment details:** Six weeks fieldwork (60%); submitted project report and oral presentation (40%).
GL4402  Fieldwork  5 credits

Co-ordinator:  Dr Quentin Crowley
Prerequisites:  JS Geology
Semester:  Hilary Terms
Contact Hours:  Weeks 28-29 (10 days)

Module Learning Aims:  This module aims to integrate all strands of geology by investigating geological problems in the field. Specific aims are to:
• demonstrate how the techniques and concepts you have acquired over your degree programme can be used to build up the geological history of an area,
• advance your field data collection, integration and interpretation skills,
• demonstrate the importance of a multi-disciplinary approach to unravelling the geological evolution of mountain belts, and
• become familiar with an area of young Alpine geology - an orogeny still in progress.

Module Content:  Building upon the six weeks of geological fieldwork undertaken as part of GL4401, this module takes a more applied approach to field geology. The destination and duration of the field excursion may change, but currently comprises a one residential field trip visiting the Betic Chain of SE Spain; a young fold belt with well-exposed regional tectonic structures, volcanic rocks and sedimentary basin-fill.

Learning Outcomes:  On successful completion of this module students should be able to:
• record and interpret data gathered in the field and assess the significance of these data in a regional context
• compare and contrast their own field data with previously published interpretations of field evidence.

Assessment details:  Fieldtrip exercises and notebooks (60%); practical examination (40%)
GL4404  Geological Literature  5 credits

Co-ordinator:  Dr Patrick Wyse Jackson
Prerequisites:  JS Geology
Semester:  Michaelmas Term
Contact Hours:  Weeks 5-10 2 hours per week; Fridays 1-2pm all year

Module Learning Aims:  The aims are to provide (1) an understanding of the range of geological literature and data sources; (2) the means to develop literature reviews; (3) instruction on how to analyse and research papers and produce a critique; (4) an appreciation of early geological concepts and theories.

Module Content:  This module will examine the diverse range of geological literature available, from printed publications to online resources. Using recent examples some geological controversies will be examined, and the salient points of the papers outline, critiqued and discussed. The lectures on the history and philosophy of geology will examine a number of topics focussing on the original ideas, how they were received and how these ideas have been accepted or rejected in modern geological understanding. Theses topics include the dating of the age of the Earth, the construction of the geological column and timescale, the nature of fossils, and the establishment of geophysics as a subject. Much of the module will be student-based learning.
Learning Outcomes: On successful completion of this module students should be able to:

- discriminate between well justified and poorly justified arguments in geological literature, and summarize the material for their own use
- describe the major theories developed by earlier geologists on the formation, age, and internal characteristics of the Earth, and on the formation and meaning of fossils
- identify and discuss current major problems in the earth sciences

Assessment details: Theory examination 100%

GL4406 Global Igneous Petrology 5 credits

Co-ordinator: Dr Emma Tomlinson
Prerequisites: GL3322 or GL3320
Semester: Michaelmas Term
Contact Hours: Weeks 12-16, seven hours per week

Module Learning Aims: To gain a broad understanding of magma generation in the various tectonic environments; to become familiar with advanced analysis of geochemical data; to develop an appreciation of the importance of experimental and numerical studies.

Module Content: This module will provide an introduction to some of the current controversies and problems in igneous petrology. A new topic will be examined each week, starting with an introductory lecture, followed by time for reading and then a symposium session with talks and discussion. Topics may include: (1) Do plumes exist? (2) Do slabs melt? (3) Komatiite: hot or wet? (4) The origin of bimodal volcanism; (5) How to supersize an eruption.

Learning Outcomes: On successful completion of this module students should be able to:
• use petrology, major and trace element chemistry and radiogenic isotope data from igneous rocks to interpret them in a plate-tectonic framework,
• read, assimilate and make critical judgement on published research and to synthesise information from a variety of sources.

**Assessment details:** Theory examination (50%), in-course assessments (50%)

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**GL4411 Organic Petrology, Palynology & Palaeobotany 5 credits**

**Co-ordinator:** Prof. Geoff Clayton  
**Prerequisites:** GL3306  
**Semester:** Hilary Term  
**Contact Hours:** Weeks 30-31, block taught  

**Module Learning Aims:** The aims are (1) To gain a basic understanding of organic petrology, - the study of organic matter in sedimentary rocks. (2) To acquire a basic understanding of the main groups of palynomorphs. These will include acritarchs, spores & pollen, and dinoflagellates. (3) To demonstrate the practical use of these fossils in Geology. (4) To investigate the early radiation of land plants.

Learning Outcomes: On successful completion of this module students should be able to:

- outline the basic principles and practices of organic petrology and the practical use and techniques of study of palynomorphs and fossil plants
- describe the key diagnostic features of the major plant groups

Assessment details: Theory examination (50%), in-course practical & project work (50%)

GL4412 Laboratory Project 5 credits

Co-ordinator: Dr Patrick Wyse Jackson
Prerequisites: JS Geology
Semester: Michaelmas Term
Contact Hours: Although contact hours will appear formally on the timetable, there must be some flexibility depending on the availability of staff and relevant equipment. This module is largely one of independent study.

Module Learning Aims: The aim is to execute a piece of laboratory based geological research and present the acquired data and interpretations in a logical and professional manner.
Module Content: In some cases this research may be based on material collected during the field based project (GL4401). The suitability of projects linked to GL4401 will be assessed by the GL4401 supervisor and the supervisor of the proposed laboratory project in consultation with the head of department and appropriate technical staff. Other projects may be chosen from a list presented at commencement of the first semester. Whilst the module is largely one of independent study, it will be carefully monitored at all stages and all students will be assigned a laboratory project supervisor.

Learning Outcomes: On successful completion of this module students should be able to:

• plan and carry out a laboratory based geological research project
• present the findings of such a project in a professional manner by means of a written report

Assessment details: Submitted project 100%

GL4413 Introduction to Micropalaeontology 5 credits

Coordinator: Prof. George Sevastopulo
Prerequisites: GL3306
Semester: Hilary Term
Contact Hours: Weeks 21-26, six hours per week

Module Learning Aims: The aims are (1) To introduce the subject of micropalaeontology, its scope, methods (including scanning electron microscopy) and potential. (2) To introduce the main groups of microfossils – calcareous nannoplankton, foraminifers, radiolaria, ostracodes and conodonts. (3) To demonstrate the practical use of these fossils in biostratigraphy, palaeoenvironmental analysis, oceanography and thermal maturation studies.
Module Content: This module will cover techniques for description and identification of the main microfossil groups both in theory and in practice. Some practical examples of the uses in biostratigraphy, palaeoenvironmental analysis and oceanography will be covered.

Learning Outcomes: On successful completion of this module students should be able to:
- describe and illustrate microfossils using the Scanning Electron Microscope
- identify individual microfossils to the level of group and use appropriate literature to identify them to the level of genus and species
- apply micropalaeontology to the solution of geological problems

Assessment details: Theory examination (50%); in-course practical and project work (50%)

GL4414 Petroleum Geology and Exploration 10 credits

Coordinator: Dr Chris Nicholas
Prerequisites: JS Geology
Semester: Michaelmas term
Contact Hours: Weeks 6-10, nine hours per week; 5 day residential field course

Module Learning Aims: The aim of this module is to give the student an introduction to the theoretical and practical aspects behind oil exploration in the 21st Century.

Module Content: The last of the world's 'easy' oil discoveries have been made and now there is increasing global economic pressure to explore for hydrocarbons in more and more inaccessible regions, in an attempt to stretch out the planet's last reserves and ease the changeover to renewable energy resources. Therefore, the petroleum industry has now entered a new phase, which targets oil and gas exploration in developing regions, which were previously considered to be uneconomic.
Two main strands are followed during the course of this module. Firstly, the principal theoretical concepts of petroleum generation, migration and accumulation are introduced. Secondly, this theory is illustrated in practice by investigating real-life examples of on going oil exploration in the frontier region of East Africa. In a series of problem-solving practical tasks, the student will use actual industry data to follow the main steps from initial exploration to drilling. Sessions each week will consist of lectures to present new theoretical material followed by practical sessions in which to apply various investigative techniques, including; drilling, electronic well log interpretation and ‘mud-logging’, well correlation and basin modelling, sequence stratigraphy and seismic interpretation. At the end of the module there is a field excursion to the classic coastal exposures of Co. Clare. This excursion is used to demonstrate high-resolution facies analysis and sequence stratigraphic principles in the field in a series of problem-solving exercises.

**Learning outcomes:** On successful completion of this module students should be able to:

- describe how oil and gas is generated and trapped
- interpret seismic sections and discuss the application of sequence stratigraphy
- give a detailed account of the concepts behind petroleum play systems and the recognition of petroleum play elements
- assess risk in prospects prior to drilling
- interpret electronic well logs and provide a discussion of the main structural and petroleum geology aspects of key East African play systems

**Assessment details:** Theory examination (30%); in-course assessment (40%); field course (30%)

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**GL4416  Planet formation and the early Earth  5 credits**

**Co-ordinator:** Prof. Balz Kamber  
**Prerequisites:** JS Geology or GL3320  
**Semester:** Hilary Term  
**Contact Hours:** Weeks 21-26, seven hours per week
Module Learning Aims: (1) To familiarise students with meteorites and early Earth rocks. (2) To develop an understanding of the steps from solid formation in the Solar System to the accretion of rocky planets. (3) To appreciate the differences between early Earth geology and the more familiar Phanerozoic record. (4) To develop an understanding of how meteorites and early Earth rocks can be used to reconstruct the history of the Earth.

Module Content: This module first reviews evidence in meteorites and in the geochemistry of the Earth’s mantle for the formation of solids and planetary embryos in the Solar System. Discussion of planet formation is followed by a chronological introduction to events that shaped the Earth until oxygenation of the atmosphere. The module will introduce students to rocks that are unique to the early Earth with a focus on the most important events that have shaped the planet from the billion of years perspective.

Learning Outcomes: On successful completion of this module students should be able to:

• summarise the difference between primitive and differentiated meteorites and to explain the significance of meteorites for reconstructing the steps towards planet formation
• recognise Archaean rocks and those aspects of Precambrian geology that are different from Phanerozoic geology
• integrate the evidence from the rock record to explain the major events in the physical, chemical and biological evolution of the early Earth

Assessment details: Theory examination (70%), in-course assessment (30%)
GL4419 Economic Geology 5 credits

Co-ordinator: Dr Sean McClenaghan

Prerequisites: JS Geology

Semester: Hilary Term

Contact Hours: Weeks 21-26; Seven hours per week

Module Learning Aims: To gain a broad understanding of the occurrence of the most important types of metal ore deposits. The students learn to identify the most important ore minerals and alteration assemblages and are introduced to core logging. They will become familiar with the petrogenetic environments in which ore deposits form and will be introduced to the economics of mineral exploration.

Module Content: The module introduces the various types of metal ore deposits with an emphasis on base metals, including Irish zinc deposits. For each type of deposit, students will be exposed to the most common ore minerals in hand specimen, and for selected types, drill cores containing relevant rock types. Deposit
types will be explained in the petrologic context that most commonly hosts the ores. Finally, the strategies for mineral exploration and the economics of mineral exploration and production will be explained with case studies.

**Learning Outcomes:** On successful completion of this module students should be able to:

- identify typical ore minerals and alteration associations
- explain how the major types of ore deposits form and identify describe the issues of critical raw metals
- devise strategies for mineral exploration and analyse the economic factors controlling the viability of mineral exploration and production

**Assessment details:** Theory examination (60%), in-course assessments (40%)

Shedding light on the underground geology at Navan Mine!
GL4422  Analysis in Geological, Earth and Environmental Research  5 credits

Co-ordinator:  Dr Robbie Goodhue
Prerequisites:  JS Geology
Semester:  Michaelmas Term
Contact Hours:  Weeks 13-16, seven hours per week

Module Learning Aims:  The module instructs students in geochemical and mineralogical analysis. It (1) introduces the key analytical instruments used for researching natural and man-made materials, before (2) providing a basic understanding of the operation of such instruments, and finally (3) developing the concepts of selecting the most appropriate techniques and limits of methodology.

Module Content:  The module will follow a series of environmental and geological samples from their collection, to obtaining data, to data processing and final interpretation. Emphasis will be placed on how to select a suitable analytical technique, how the sample is prepared and how the instrument is operated and calibrated. Practical sessions will afford students the opportunity to remotely operate several of the analytical instruments housed in TCD Geochemistry and experience of processing some real and ‘live’ data. The techniques considered may include: CF-IRMS, ICP-OES, LA-ICP-MS, XRD, XRF.

Learning Outcomes:  On successful completion of this module students should be able to:

- have an understanding of several key methods used in the modern analysis of samples;
- have learned how to approach analysis;
- have developed a clear appreciation of correct method selection, data analysis, sources of error and principles of sound interpretation.

Assessment details:  Theory examination (70%); in-course assessment (30%).
GL3423: Hydrology and Water Quality 5 credits
Taken by JS Earth Sciences (M) and by JS Environmental Science (M)

Coordinator: Dr Catherine Coxon
Prerequisites:
Semester: Hilary Term
Contact Hours: Weeks 21-26, six hours per week

Module Learning Aims: This course aims to provide students with an understanding of hydrological processes, following the different pathways of water through the terrestrial part of the hydrological cycle. It also aims to familiarise students with the factors affecting groundwater quality, and to develop an understanding of groundwater quality issues in the context of integrated catchment management.

Module Content: The hydrology component of this module includes the following topics: the hydrological cycle and catchment water balances; rainfall and evapotranspiration; soil water and hillslope hydrology; river flow; hydrogeology; groundwater – surface water interaction. The water quality component is focussed primarily on groundwater, with topics including groundwater chemistry and natural groundwater quality problems; groundwater quality issues in rural and industrial settings; groundwater quality monitoring; groundwater vulnerability and protection. The interaction of groundwater and surface water quality is also considered

Learning outcomes: On completion of this course the student should be able to:

- evaluate the role of different hydrological pathways in a range of catchment settings
- carry out calculations relating to catchment water balance, river flow and groundwater movement
- analyse the factors controlling aquifer hydrochemistry and contaminant transport processes;
- assess groundwater quality problems in both rural and industrial settings;
• evaluate groundwater vulnerability to pollution; understand the role of groundwater protection schemes and of integrated catchment management.

**Assessment details:** Theory examination (70%); In-course assessment (30%)

Mer de Glace, alpine denudation
4. Examinations and assessment

The regulations governing examinations are set out in the College Calendar.

Examination timetables are published in advance of the dates of examinations. See the examinations office website for more details (http://www.tcd.ie/Examinations/Timetables/). You must ensure that you are available for the duration of the examinations period as presented in the College Calendar (http://www.tcd.ie/calendar/).

**NOTE**: It is your responsibility to establish the dates, times and venues of examinations. No reminders will be sent to you.

The College employs anonymous marking where practically possible. Results will be published by student number. The marking criteria used when marking examination scripts are presented in the relevant section below.

**COURSE WORK**

The form of course work will vary between modules. Details concerning the assessment requirements, value, marking criteria, and deadline/process for submission will be circulated by the module co-ordinator or lecturer when the assessment task is set.

Throughout your degree, your progress will be evaluated by examination and course work. Details concerning examination procedures are documented in the *College Calendar* and you are advised to familiarise yourselves with these at the earliest opportunity.

In the case of supplemental examinations, any marks gained from continuous assessment are carried forward to the supplemental examination.
Submission of Assessed Work

It is your responsibility to ensure that you accurately note the deadline and procedure for submission of assessed work. When work is handed in, a register of its receipt is kept. The register includes the date of submission and the student's signature. For work that is submitted electronically, you must obtain acknowledgement from the member of the academic staff responsible that the submission has been received. Unless otherwise stipulated, all written work must be word-processed. You must keep a paper and electronic copy of all work submitted for assessment.

Deadlines and Penalties for Late Submission

You must ensure that you are available to submit course work by the deadline. In the event of late submission of any course work, a penalty of -5% per day will be applied to the mark for that piece of work up to a maximum of five days after which a zero mark will be given. In cases where illness or other circumstances prevent the submission of work by a deadline, a certificate from a medical practitioner or a letter from the Tutor should be obtained setting out the circumstances. Certificates should, insofar as is possible, refer to the time period during which the illness or other condition prevailed. Certificates seeking an extension of a deadline should be submitted as early as possible (and preferably before the deadline is reached) to the relevant member of staff who may then grant an extension. If an extension is granted, the penalty for late submission will come into effect at the end of the extension period.

PLAGIARISM

Plagiarism is interpreted by the University as the act of presenting the work of others as one’s own work, without acknowledgement. Plagiarism is considered as academically fraudulent, and an offence against University discipline. The University considers plagiarism to be a major offence, and subject to the disciplinary procedures of the University.
Plagiarism can arise from deliberate actions and also through careless thinking and/or methodology. The offence lies not in the attitude or intention of the perpetrator, but in the action and in its consequences.

Plagiarism can arise from actions such as:

a. copying another student’s work;
b. enlisting another person or persons to complete an assignment on the student’s behalf;
c. quoting directly, without acknowledgement, from books, articles or other sources, either in printed, recorded or electronic format;
d. paraphrasing, without acknowledgement, the writings of other authors.

Examples (c) and (d) in particular can arise through careless thinking and/or methodology where students:

- fail to distinguish between their own ideas and those of others;
- fail to take proper notes during preliminary research and therefore lose track of the sources from which the notes were drawn;
- fail to distinguish between information which needs no acknowledgement because it is firmly in the public domain, and information which might be widely known, but which nevertheless requires some sort of acknowledgement;
- come across a distinctive methodology or idea and fail to record its source.

All the above serve only as examples and are not exhaustive.

Students should submit work done in co-operation with other students only when it is done with the full knowledge and permission of the lecturer concerned. Without this, work submitted which is the product of collusion with other students may be considered to be plagiarism.
It is clearly understood that all members of the academic community use and build on the work of others. It is commonly accepted also, however, that we build on the work of others in an open and explicit manner, and with due acknowledgement. Many cases of plagiarism that arise could be avoided by following some simple guidelines:

- Any material used in a piece of work, of any form, that is not the original thought of the author should be fully referenced in the work and attributed to its source. The material should either be quoted directly or paraphrased. Either way, an explicit citation of the work referred to should be provided, in the text, in a footnote, or both. Not to do so is to commit plagiarism.

- When taking notes from any source it is very important to record the precise words or ideas that are being used and their precise sources.

- While the Internet often offers a wide range of possibilities for researching particular themes, it also requires particular attention to be paid to the distinction between one’s own work and the work of others. Particular care should be taken to keep track of the source of the electronic information obtained from the Internet or other electronic sources and ensure that it is explicitly and correctly acknowledged.

It is your responsibility to ensure you do not commit plagiarism. If in doubt, you should seek advice from a lecturer, tutor or supervisor on avoiding plagiarism.

NB: Assignments may be checked using anti-plagiarism software.
### Marking Criteria

<table>
<thead>
<tr>
<th>Class</th>
<th>Mark Range</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>85-100</td>
<td>Exceptional project report showing broad understanding of the project area and excellent knowledge of the relevant literature. Exemplary presentation and analysis of results, logical organisation and ability to critically evaluate and discuss results coupled with insight and originality.</td>
</tr>
<tr>
<td></td>
<td>70-84</td>
<td>A very good project report showing evidence of wide reading, with clear presentation and thorough analysis of results and an ability to critically evaluate and discuss research findings. Clear indication of some insight and originality. A very competent and well presented report overall but falling short of excellence in each and every aspect.</td>
</tr>
<tr>
<td>II-1</td>
<td>60-69</td>
<td>A good project report, which shows a reasonably good understanding of the problem and some knowledge of the relevant literature. Mostly sound presentation and analysis of results but with occasional lapses. Some relevant interpretation and critical evaluation of results, though somewhat limited in scope. General standard of presentation and organisation adequate to good.</td>
</tr>
<tr>
<td>II-2</td>
<td>50-59</td>
<td>A moderately good project report, which shows some understanding of the problem but limited knowledge and appreciation of the relevant literature. Presentation, analysis and interpretation of the results at a basic level and showing little or no originality or critical evaluation. Insufficient attention to organisation and presentation of the report.</td>
</tr>
<tr>
<td>III</td>
<td>40-49</td>
<td>A weak project report showing only limited understanding of the problem and superficial knowledge of the relevant literature. Results presented in a confused or inappropriate manner and incomplete or erroneous analysis. Discussion and interpretation of result severely limited, including some basic misapprehensions, and lacking any originality or critical evaluation. General standard of presentation poor.</td>
</tr>
<tr>
<td>Fail</td>
<td>20-39</td>
<td>An unsatisfactory project containing substantial errors and omissions. Very limited understanding, or in some cases misunderstanding of the problem and very restricted and superficial appreciation of the relevant literature. Very poor, confused and, in some cases, incomplete presentation of the results and limited analysis of the results including some serious errors. Severely limited discussion and interpretation of the results revealing little or no ability to relate experimental results to the existing literature. Very poor overall standard of presentation.</td>
</tr>
<tr>
<td>Fail</td>
<td>0-19</td>
<td>A very poor project report containing every conceivable error and fault. Showing virtually no real understanding or appreciation of the problem and of the literature pertaining to it. Chaotic presentation of results, and in some cases incompletely presented and virtually non-existent or inappropriate or plainly wrong analysis. Discussion and interpretation seriously confused or wholly erroneous revealing basic misapprehensions.</td>
</tr>
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CONDUCT AND SAFETY

Under the Health and Safety at Work Act (1989), you are responsible for your own safety and that of your fellow students. The person in charge must be informed immediately if any student falls ill during class, in a laboratory practical or on fieldwork. If the student needs medical attention, inform the doctor of when and where the illness took place. In the case of accidents, however trivial, always inform the lecturer, laboratory supervisor, or departmental safety officer Dr Robbie Goodhue. Please make a mental note of the position of fire extinguishers and of the clearly marked emergency exits from lecture rooms. If the fire alarm sounds, please leave the building in an orderly fashion by one of the marked exits. Assemble on the Fellows Square area. When in the building, do not run or act in a foolish manner and avoid cluttering benches, floors and walkways with personal effects. Bicycles should not be brought into the building. Impeding exits jeopardises safety.

You are not permitted to smoke or bring food and drink into laboratories, lecture and seminar rooms, or the Geology Museum or Library.

If you suffer from any health problem, such as colour blindness, epilepsy, asthma, fainting fits, haemophilia, general allergies, immunodeficiency, diabetes, balancing disorders, or any other health problem likely to affect your work, you must - Inform your doctor of your intention to undertake laboratory and field work and seek relevant advice. Notify your tutor. Inform project / practical supervisors and field-module leaders.

Fieldwork Safety - it is a requirement that you complete the relevant Health Questionnaire, Fieldwork Safety and Risk Assessment forms. In addition to following the instructions of fieldtrip leaders, please also pay particular attention to the following:

- Always wear suitable clothing and, if in doubt, ask the leader prior to the trip.
- Always leave an account of your movements and expected return time with a responsible person.
- Check on the weather forecast prior to any trip.
• Where necessary, use helmets and eye protection, which will be made available for relevant trips.
• Never enter caves alone or without an authorised leader and proper lighting.
• Exercise particular caution around water.
• Never visit pubs and clubs in unfamiliar places alone, and never leave drinks and valuables unattended.

.................in the distance is Arran

.................Arran