GCE

Examinations from 2009

First AS Award: Summer 2009

First A Level Award: Summer 2010

Geology

Contents

WJEC AS GCE in Geology
WJEC A Level GCE in Geology

2009 & 2010

First AS Award - Summer 2009
First A level Award - Summer 2010

GCE Geology

Subject/Option Entry Codes			English medium	Welsh medium
Advanced Subsidiary (AS) "Cash in" entry		*2211*	01	W1
A Level (A)"Cash in" entry		*3211*	01	W1
GL1 :	Foundation Geology	1211	01	W1
GL2 :	Investigative Geology			
	GL2 (a)	1212	01	W1
	GL2 (b)	1212	02	W2
GL3 :	Geology and the Human Environment	1213	01	W1
GL4 :	Interpreting the Geological Record	1214	01	W1
GL5 :	Geological Themes			
	Theme 1 and Theme 2	1215	01	W1
	Theme 1 and Theme 3	1215	02	W2
	Theme 1 and Theme 4	1215	03	W3
	Theme 2 and Theme 3	1215	04	W4
	Theme 2 and Theme 4	1215	05	W5
	Theme 3 and Theme 4	1215	06	W6
GL6 :	Geological Investigations	1216	01	W1

Availability of Assessment Units				
Unit	**January 2009**	**June 2009**	**January 2010 & each subsequent year**	**June 2010 & each subsequent year**
GL1	✓	✓	✓	✓
GL2		✓		✓
GL3	✓	✓	✓	✓
GL4				✓
GL5				✓
GL6				✓

Qualification Accreditation Numbers

Advanced Subsidiary: 500/2758/X
Advanced: 500/2485/1

SUMMARY OF ASSESSMENT

This specification is divided into a total of 6 units, 3 AS units and 3 A2 units. Weightings noted below are expressed in terms of the full A level qualification.

AS

GL1 17.5% 60 marks (105 UM)	
Foundation Geology Structured data-response questions. All questions compulsory.	
GL2 15 % Internal assessment 60 marks (90 UM)	
either	**GL2(a)** A practical exercise based on a simplified geological map, with specimens, photographs and other data. Questions enable the application of investigative skills (both field and laboratory), to determine the geological background and solve geological problems of a hypothetical area. Administered and marked by the centre.
or	**GL2(b)** A report of a field investigation to determine the geological background and solve geological problems of an area visited by the Centre
GL3 17.5 % 1hr 15min Written Paper 50 marks (105 UM)	
Geology and the Human Environment Two compulsory structured data-response questions and a choice of one essay from three.	

A LEVEL

GL4 17.5 % 2 hour Written Paper 100 marks (105 UM)
Interpreting the Geological Record Integrated structured questions, interpreting a variety of data, including geological maps.
GL5 17.5 % 2 hour Written Paper 80 marks (105 UM)
Geological Themes A choice of two papers from the four themes. Each paper has compulsory structured data-response questions followed by a choice of one essay from three.
GL6 15 % Internal assessment 60 marks (90 UM)
Geological Investigations Two geological investigations with a minimum of 50% field evidence and a maximum of 50% laboratory work, the latter being optional.

GEOLOGY

1 INTRODUCTION

1. 1 Criteria for AS and A Level GCE

This specification has been designed to meet the general criteria for GCE Advanced Subsidiary (AS) and A level (A) and the subject criteria for AS/A Geology as issued by the regulators [July 2006]. The qualifications will comply with the grading, awarding and certification requirements of the Code of Practice for 'general' qualifications (including GCE).

The AS qualification will be reported on a five-grade scale of A, B, C, D, E. The A level qualification will be reported on a six-grade scale of A*, A, B, C, D, E. The award of A* at A level will provide recognition of the additional demands presented by the A2 units in term of 'stretch and challenge' and 'synoptic' requirements. Candidates who fail to reach the minimum standard for grade E are recorded as U (unclassified), and do not receive a certificate. The level of demand of the AS examination is that expected of candidates half way through a full A level course.

The AS assessment units will have equal weighting with the second half of the qualification (A2) when these are aggregated to produce the A level award. AS consists of three assessment units, referred to in this specification as GL1, GL2 and GL3. A2 also consists of three units and these are referred to as GL4, GL5 and GL6.

Assessment units may be retaken prior to certification for the AS or A level qualifications, in which case the better result will be used for the qualification award. Individual assessment unit results, prior to certification for a qualification, have a shelf-life limited only by the shelf-life of the specification.

The specification and assessment materials are available in English and Welsh.

1.2 Prior learning

The specification is equally accessible to all irrespective of age, gender and ethnic, religious or cultural background.

No prior learning in geology is required. The specification builds on knowledge, understanding and skills acquired in GCSE subjects or equivalent.

Grade C in GCSE/Key Stage 4 Mathematics, or equivalent, would benefit students following this course. Candidates will be expected to: manipulate geological data presented as formulae; understand units used for geological quantities and measurements; interpret geological numerical data presented in a variety of forms. **The mathematical competences required are detailed in the Appendix.**

1.3 Progression

The six part structure of this specification (3 units for AS, and an additional 3 for the full Advanced) allows for both staged and end-of-course assessment and thus allows candidates to defer decisions about progression from AS to the full A level qualification.

The specification provides a firm basis for further study in geology and a pathway to a geological career. It has wider educational relevance, however, by exploiting the rich potential of geology to underpin cultural, social and recreational activities throughout life: the specification develops scientific insights into the natural environment, deepens understanding and appreciation of landscape and scenery, provides a 'deep time' framework and addresses a broad range of environmental and sustainability issues.

In addition, the specification provides a coherent, satisfying and worthwhile course of study for candidates who do not progress to further study in this subject.

1.4 Rationale

The scope of geology

Geology is the branch of science concerned with the structure, evolution and dynamics of the Earth and with the exploitation of the mineral and energy resources that it contains in a sustainable way. Geology is ideally suited to fulfil the educational purpose of demonstrating the relevance of science to society.

Geology applies physical, chemical and biological principles to the investigation of the Earth, but also involves a distinctive scientific methodology, invoking internal and external Earth processes to explain the evolution of the planet through geological time. The application of geology to human activities and needs is widely addressed in the specification, providing for relevance and the development of a broad range of Key Skills.

Broad aims and general objectives

The structure of the specification allows for the design of individual courses appropriate to candidates' programmes of study. This structure permits a broad, coherent coverage of geology whilst retaining a clear view of the subject's identity. To exemplify the importance and relevance of geology to everyday life, technological applications and social, economic and environmental issues permeate the specification.

The AS specification is designed to provide a course ideally suited to broaden an AS programme by complementing a science course or providing a contrasting course within the humanities. The specification units extend a science course by study of the application of scientific principles to the investigation of the Earth and by the use of scientific techniques and skills to develop enquiries. AS Unit GL3 identifies the importance of geology to society, and includes enquiry-based investigation of issues and the presentation of written reports, which can enrich a humanities programme.

1.5 The Wider Curriculum

Spiritual, moral, ethical, social, legislative, economic and cultural issues

The study of geology engages students directly in a range of issues. The subject area provides scope to discuss the concepts of proof, truth and certainty within the context of scientific models and hypotheses relating to the origin, form and structure of the Earth and the development of life on Earth (GL1, GL4).

Study of the formation of the Earth, the vastness of geological time and the fossil record of organic evolution, leads to a deeper understanding of the significance of life and, specifically, the place of human life in a planetary and universal context (GL1, GL4). The interdependence of individuals, local and voluntary communities is well illustrated in the geological context of natural hazards (GL3).

Sustainable development

The specification facilitates development of values and attitudes regarding protection and responsible stewardship of the environment (GL3, GL4). Climate change is addressed in GL4. A problem-solving and critical approach is encouraged throughout (particularly GL2, GL6).

Study of natural resources includes consideration of the social and environmental consequences of mineral exploitation (GL5). Studies confront economic and moral dilemmas concerning the balance to be struck between need (economic, social and political) and conservation (of resources and environment).

Study of natural phenomena such as earthquakes and volcanoes encourages a deep appreciation of the natural world and an awareness of individual and societal attitudes, values and actions in response to natural environmental issues (GL3, GL5).

Cwricwlwm Cymreig and the European Dimension

The specification addresses the Cwricwlwm Cymreig and the European Dimension by developing, through appropriate examples, students' knowledge and understanding of the geology of Wales and Europe.

Health and Safety considerations

The specification places a high awareness of Health and Safety considerations in undertaking both fieldwork and practical work in the laboratory.

FIELDWORK REQUIREMENT

Assessment Objective 3 reflects the central importance of field-based study in geology. The specification assesses field-based study through the AS Investigative Geology Unit GL2 and A level coursework, but credit is given in the marking of examination papers for appropriate use of knowledge and understanding and exemplars derived from fieldwork.

It is recommended that all A level candidates should have devoted a minimum of six days, AS candidates a minimum of three days, to geological work in the field. Only a proportion of this time should be devoted to assessed coursework.

The Geologists' Association Code of Conduct for Geological Fieldwork (available from the Geologists' Association, Burlington House, Piccadilly, London W1J 0DU) provides guidance on safe fieldwork practices.

1.6 Prohibited combinations and overlap

Every specification is assigned a national classification code indicating the subject area to which it belongs. Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code will only have one grade (the highest) counted for the purpose of the School and College Performance Tables. The classification code for this specification is 1770.

This specification does not overlap significantly with any other, although there are minor elements of overlap, for example, with Geography and Science. There are no prohibited combinations.

1.7 Equality and Fair Assessment

AS/A levels often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

In *GCE Geology* practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Regulations and Guidance Relating to Candidates who are eligible for Adjustments in Examinations.* This document is available on the JCQ website (www.jcq.org.uk).

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they have taken and there would be an indication on their certificate that not all of the competences have been addressed. This will be kept under review and may be amended in future.

2 AIMS

This AS and A level specification in Geology, through a series of largely independent but inter-related course units which may be combined either to complement and broaden AS/AL courses of study in the sciences or to contrast with and enrich AS/AL courses of study in the humanities,

aims to encourage students to:

(a) develop their interest in, and enthusiasm for geology, including developing an interest in further study and careers in geology and related subjects.

(b) appreciate how society makes decisions about scientific issues and how geology contributes to the success of the economy and society and its environmental protection.

(c) develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works* by:

- becoming aware of how advances in knowledge, understanding and technology, including information technology and instrumentation, are used in geology;
- developing an understanding of the link between theory and experiment;
- promoting the development of geological investigative skills in the field and the laboratory;
- acquiring skills needed to investigate geological processes and events in new and changing situations.

(d) develop essential knowledge and understanding of different areas of geology and how they relate to one another.

(e) experience a course with wide scope for cross-curricular work, exploiting the strong links between geology and other subjects including environmental education, and providing many contexts for the development of Key Skills.

3 ASSESSMENT OBJECTIVES

Candidates must meet the following assessment objectives in the context of the content detailed in Section 4 of the specification.

AO1: Knowledge and understanding of science and of *How Science Works*

Candidates should be able to:

(a) recognise, recall and show understanding of scientific knowledge;

(b) select, organise and communicate relevant information in a variety of forms.

AO2: Application of knowledge and understanding of science and of *How Science Works*

Candidates should be able to:

(a) analyse and evaluate scientific knowledge and processes;

(b) apply scientific knowledge and processes to unfamiliar situations including those related to issues;

(c) assess the validity, reliability and credibility of scientific information.

AO3: *How Science Works*

Candidates should be able to:

(a) demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods;

(b) make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy;

(c) analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

Weightings

Assessment objective weightings are shown below as % of the full A level.

Unit Weighting	%	AO1%	AO2%	AO3%
GL 1	17.5	8	7.5	2
GL 2	15	2	2	11
GL 3	17.5	7	8.5	2
GL 4	17.5	5	7.5	5
GL 5	17.5	6	10.5	1
GL 6	15	2	2	11
Total	100	30	38	32

4 SPECIFICATION CONTENT

The specification content is contained in columns 1 and 2 of the following tables. *The Possible Learning Experiences* column is **not** part of the content, but exemplifies suitable teaching contexts and approaches for delivery of the content of columns 1 and 2.

Links to opportunities for Key Skills development are also listed in the *Possible Learning Experiences* column. The links are for illustration only and are not mandatory. Students are free to apply Key Skills to any part of the specification.

AS

The AS Geology course comprises:

UNIT GL1 Foundation Geology - the content is shown below.

UNIT GL2 Investigative Geology - the content is the asterisked statements in the *Techniques and Skills* column of the **GL1 Unit**.

UNIT GL3 Geology and the Human Environment - the content is shown in **GL3**.

UNIT GL1: FOUNDATION GEOLOGY

The **Foundation Geology** unit is organised into three basic scientific topics:

Matter: the global structure of the Earth and the composition of its crust.

Energy: the Earth's energy sources and the resultant internal and external geological processes.

Time and Change: the geological record of change and the relative and absolute dating of geological events.

This unit aims to develop:

- the basic geological knowledge, understanding and skills to underpin the other units of the course.
- the geological skills of observation and interpretation of simplified geological maps, sections logs, photographs and specimens.

Basic concepts only are addressed in the Foundation Geology unit: later units develop these concepts.

NB: Asterisked techniques and skills in this unit will also be assessed in Unit GL2: Investigative Geology.

I MATTER

Key Idea 1: The Earth has a concentrically zoned structure and composition

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) The Earth has a layered structure: crust, mantle, outer and inner core. Each layer has a distinctive composition and/or physical state. Relevant information is derived from meteorite (stony, iron) compositions, seismology and geomagnetism.	Analysis of seismological evidence for the internal structure of Earth: P and S body waves, surface waves, travel time curves, shadow zones, velocity-depth models of Earth structure, density distribution with depth. Simple analysis of geomagnetic evidence for core composition and processes.	Interpretation of earthquake seismograms. Investigation of densities of representative samples of Earth layers: granite, gabbro (crust), peridotite (upper mantle), iron (core). Experiments illustrating geomagnetic field using a bar magnet and simple measurement of field elements using, e.g., compass or dip circle.
(b) The crust is a thin layer of distinctive composition overlying the mantle; continental and oceanic crust can be recognised and distinguished by their differing thicknesses, composition and structure.		Interpretation of geophysical data on crustal structure (seismic, gravity, magnetic) from continental and oceanic areas.

Key Idea 2: The Earth's crust is composed of rocks which have distinctive mineralogies and textures

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) (i) The Earth's crust is composed of just eight main elements. Silicates represent the commonest rock-forming minerals.	Recognition of the relative abundance of O, Si, Al, Fe, Ca, Na, K and Mg in the crust and the role of the silicates as rock-forming minerals.	Development and use of a mineral classification table to identify a range of minerals.
(ii) Minerals are naturally occurring inorganic chemical compounds or elements. Minerals have distinct chemical compositions, atomic structures and physical properties by which they may be identified.	*Investigation of diagnostic properties of minerals: form, habit, twinning, cleavage, fracture, hardness, density, streak, lustre, colour, degree of transparency, reaction with cold dilute (0.5M) hydrochloric acid.	
	Recognition, using appropriate tests, of the following rock-forming minerals (as specified on the mineral data sheet) from their diagnostic properties: quartz, calcite, feldspars, augite, hornblende, olivine, micas, haematite, galena, pyrite, chalcopyrite, fluorite, barite, halite, gypsum, garnet, chiastolite/andalusite.	
(b) (i) Rocks are composed of aggregates of minerals. (ii) Igneous, sedimentary and metamorphic rocks display differences of composition and texture that reflect their mode of origin.	*Observation and investigation of hand specimens of a variety of rocks in order to: (i) identify and interpret component minerals, (ii) interpret textures (grain size; crystalline/clastic; foliation; mineral alignment/bedding/ crystalline banding) and, hence,	Experimental production of a range of rock textures by: slow and fast cooling from melts (e.g., using salol); sedimentation in vessels to produce layering; compaction (e.g., of sponge or latex foam marked with grain or crystal outlines).
	(iii) deduce the mode of origin of the rock as igneous, metamorphic or sedimentary. *Observation and interpretation of photomicrographs of rocks as an aid to interpreting minerals and rock textures. # A mineral data sheet is available for use in the examination.	Use of a rock classification table to identify common types. Investigation of minerals and rock textures using thin sections and polished surfaces.

II ENERGY

Key Idea 1: The formation and alteration of rocks involve both internal and external energy sources

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Internal energy: (i) Volcanoes, hot springs and surface heat flow provide evidence for internal heat; the main source is radioactive decay. Heat is transferred by conduction and convection; removal of heat from the mantle by convection keeps temperatures (except locally) below melting point.	Interpretation of evidence for temperature variation with depth and simple analysis of the geothermal gradient (geotherm).	Experiments in heat transfer by convection and conduction.
(ii) Tectonic forces generate surface relief, resulting in downslope movement of rock material under the influence of gravity.		Investigation of the possible factors influencing downslope material movement.
(b) External energy: solar heating of the Earth's surface drives the water cycle and influences weathering and erosional processes.		Investigation of various types of weathering and erosion in the field and laboratory, giving simple consideration to the energy systems involved.

Key Idea 2: Igneous, sedimentary and metamorphic rocks are linked through the "rock cycle"

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Igneous rocks are the products of cooling of magma in bodies of various sizes and shapes. Volcanism is the surface expression of igneous activity.	*The recognition of plutons, dykes, sills and lava flows by interpretation of maps, sections and photographs. Observation and investigation of igneous rocks to deduce the cooling history of a magma. (i) grain size: coarse, medium, fine (ii) grain shape: euhedral, subhedral, anhedral (iii) texture: equigranular, porphyritic, vesicular, glassy (iv) structure: pillow structure, aa/pahoehoe surfaces, columnar joints. Identification in hand specimen of the following igneous rocks from their composition, texture and other diagnostic features: Silicic: granite Mafic:, gabbro, dolerite, basalt Ultramafic: peridotite	Field investigations of igneous, sedimentary or metamorphic rocks. Video/DVDs of volcanic activity. Use of rock classification tables to identify a range of rock types.

(b) (i) Physical and chemical weathering of rocks at the Earth's surface produces a range of new minerals and solutions together with residual, resistant minerals, that provide the raw materials for new rocks.	*Interpretation of maps, photographs and graphic logs showing the following sedimentary features: bedding, cross-bedding, graded bedding, lamination, desiccation features, ripple marks, sole structures (load/flame, flute cast). *Identification in hand specimen of the following sedimentary rocks from their composition, texture and other diagnostic features: sandstones (orthoquartzite, arkose, greywacke), shale, limestones (shelly, oolitic, chalk), conglomerate, breccia.	(i) Investigations of different effects of weathering on local building stones.
(ii) Surface materials are transported by a range of erosional agents and deposited as sediments. Different sedimentary environments may be identified by diagnostic sedimentary structures, rock textures, mineralogy and fossil content. A basic study of fluvial, marine, and aeolian sediments demonstrates these differences.	*Investigation of contrasts between fluvial, marine and aeolian sediments.	(ii) Video/DVDs of erosional and sedimentary processes e.g. Snowdon from the Sea OU video
(iii) Sedimentary rocks may also result from the accumulation of organic material (limestone, coal) or by precipitation of solid material out of solution (evaporites).		(iii) Precipitation experiments.
(c) Metamorphism involves mineralogical and/or textural change of pre-existing rocks in response to changes in temperature and/or pressure. Contact (thermal) and regional metamorphism produce distinctive mineralogical and textural changes: non-foliated in contact metamorphism: foliation (slaty cleavage, schistosity and gneissose banding) in regional metamorphism.	*Interpretation of the following metamorphic features using simplified geological maps and photographs: contact aureoles, metamorphic foliations. *Identification in hand specimen of the following metamorphic rocks from their composition, texture and other diagnostic features: marble, metaquartzite, spotted rock, hornfels, slate, schist, gneiss.	Modelling of the effect of compression and shear stress on layers of plastic 'rock'.
	# A mineral data sheet is available for use in the examination.	Laboratory simulations of igneous, sedimentary and metamorphic processes.

Key Idea 3: The Earth's internal heat is the underlying cause of the lithospheric plate motions that control global geological processes

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) (i) The uppermost part of the mantle and the overlying crust form a rigid outer shell to the Earth known as the lithosphere, underlain by a weaker upper mantle zone known as the asthenosphere. The asthenosphere is a seismological low velocity zone.		
(ii) The lithosphere consists of several plates in relative motion. Three types of plate boundary exist; divergent (constructive), convergent (destructive) and conservative. There is a relationship between seismicity, volcanicity and plate boundaries.	(ii) Interpretation of global maps of volcanoes and seismicity.	(ii) Simple experiments to simulate plate movements, including modelling of transform faults.
(iii) Forces driving plates are of thermal origin, involving convective motions affecting the lithosphere, asthenosphere and deeper mantle.		
(b) Some rocks contain a record of the direction of the Earth's magnetic field at the time of their formation, known as remanent magnetism. This is linked to ferromagnetism in some iron minerals and their Curie temperatures. Palaeomagnetism can be used to determine changes of latitude as different continents moved through geological time, indicating continental drift. Ocean floor magnetic anomalies indicate sea floor spreading.	Investigation of magnetic properties of rocks and minerals.	Simple modelling of the Earth's magnetic field using magnets and compasses: demonstrations to show the variation of magnetic inclination with latitude.

(c) The various elements of the rock cycle may be linked directly to plate tectonic processes:
(i) Igneous - basaltic magmatism at oceanic spreading centres due to partial melting of upper mantle; basaltic and andesitic magmatism at island arcs due to partial melting of subducted oceanic crust and overlying mantle rocks.
(ii) Sedimentary - erosional processes and depositional environments influenced by tectonic movements.
(iii) Regional metamorphism in subduction zones and orogenic belts at plate boundaries.

III TIME AND CHANGE

Key Idea 1: Study of present day processes and organisms enables us to understand changes in the geological past

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Much of the rock record can be interpreted in terms of geological processes that are operating today applying the Principle of Uniformitarianism: the present is the key to the past.		Comparison of the products of modern and ancient volcanic and sedimentary processes.
(b) Fossils are evidence of former life preserved in rocks. They provide information on the nature of ancient organisms.	*Appreciation of the basic distinctions between the following fossil groups based on their hard parts: **brachiopods**: shell shape and symmetry, pedicle and brachial valves, pedicle opening, foramen, hinge line, muscle scars; **bivalves**: shape and symmetry of valves, number and size of muscle scars, hinge line, teeth and sockets, gape, pallial line and sinus, umbones; **ammonites**: suture line, coiled and chambered shell; **corals**: colonial, solitary, septa; **trilobites**: cephalon, glabella, genal spines, eyes, thorax, number of thoracic segments, pygidium. **graptolites**: stipes, thecae. **plants**: leaf, stem, root..	
(c) Preservation can give rise to a wide range of fossil materials: actual remains, hard parts, petrification by mineral replacement (calcification, silicification, pyritisation), carbonisation, moulds/casts, trace fossils (tracks and trails, burrows, coprolites).		
(d) Fossils may occur as “life” assemblages (preserved without transport) or “death” assemblages (preserved after transport), or as derived fossils incorporated in later sediments.	*Analysis of modern and fossil assemblages.	Field investigation of fossil assemblages in a variety of sedimentary rocks.

Key Idea 2: Geological events can be placed in relative and absolute time scales

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Geological events can be placed in relative time scales using criteria of relative age: evolutionary change in fossils, superposition of strata, unconformities, cross-cutting relationships, included fragments, 'way-up' criteria.	*Interpretation of age relations of rocks and rock sequences using maps and sections.	Investigative fieldwork to interpret field relations and relative ages in a small area.
(b) Some rocks and minerals can be dated radiometrically to give an absolute age. This involves radioactive decay and the principles of radiometric dating; radioactive series and radioactive half-life; radiometric dating (as exemplified by the K/Ar and ^{14}C methods).	Simple analysis of principles of radiometric dating using decay curves and the half-life concept.	Case studies of radiometric dating of rocks.
(c) Fossils play an important role in relative dating and stratigraphic correlation. The factors contributing to good zone fossils are: wide and plentiful distribution, ready preservation, rapid evolutionary change, a high degree of facies independence, easy identification of index fossils. The utility of graptolites and cephalopods as zone fossils assessed in relation to the above factors.	*Observation and identification of appropriate morphological features and their changes through time: **Graptolites** - number and position of stipes, thecal shape in the Early Palaeozoic. **Cephalopods -** suture lines in Late Palaeozoic and Mesozoic (goniatite, ceratite and ammonite).	Use of data on fossil assemblages to date and/or correlate successions.
(d) The geological column provides a means of (i) placing geological events in their correct time sequence and (ii) defining the absolute age of some events.	*Interpretation of the ages of geological events using the geological column.	Studying regional geological features in order to place local geology within a broader context.

Key Idea 3: The rock record provides evidence for geological change and can be interpreted using geological maps

Understanding and Knowledge	*Techniques and skills*	*Possible learning experiences*
	*The recognition on geological maps and descriptions of:	Geological fieldwork or web-based virtual fieldwork.
(a) (i) Folds and faults as products of tectonic stresses.	(i) Horizontal beds, dipping beds, strike and dip. Folds: limb, hinge, axis, anticline, syncline, axial plane trace, symmetrical and asymmetrical folds. Faults: (i) dip-slip: normal, reverse, thrust; throw - amount, relative movement of footwall/hanging wall. (ii) strike-slip: transcurrent. Fault displacement (= net slip).	
(ii) Unconformities as hiatuses in the geological record. The formation of unconformities by Earth movements and sea level changes. The use of unconformities in dating Earth movements.	(ii) Unconformities with or without angular discordance.	(ii) Laboratory and/or modelling experiments to produce different kinds of unconformity.
	(iii) Intrusive and extrusive bodies (dyke, sill, pluton, lava flow); metamorphic aureoles; mineral veins; superficial deposits (alluvial, glacial).	
(b) The nature of outcrop patterns formed by the intersection of geological structures with a topographic surface as displayed on simplified geological maps.	*Use of geological maps, block diagrams, boreholes, cross-sections and photographs to interpret the geology of an area. *Constructing geological sections from simplified geological maps. *Ordering the geological sequence of events in an area from the study of a simplified geological map and/or section.	

UNIT GL2: INVESTIGATIVE GEOLOGY

USING THE MATERIAL FROM UNIT GL1 this unit assesses:

- **appropriate geological techniques and skills acquired in Unit GL1**

  The detailed content of the geological techniques and skills, including basic field skills, are found (asterisked) in column 2 of Unit GL1.

  Examples
  How do I determine, and what is, the identity of minerals/rocks/fossils? Why do minerals/rocks/fossils differ across the area?
  How may igneous/metamorphic bodies/sedimentary features/structures be recognised/described? What is the nature of the junctions between rock sequences found in the area? (Prediction – concordant, discordant, or unconformity?)
  What are the relative ages of ………?
  An investigation of the environments of deposition in the area.

- **an investigative approach to learning**

  The investigative skills are based on the same criteria as the A2 level geological investigations**:**
  Planning
  Implementing
  Analysing evidence & drawing conclusions
  Evaluating evidence and procedures

  Examples
  Planning – how do I set about determining the identity of ………..?
  - identification of correct materials to investigate in order to answer the question – do I use field observations, hand specimens, photographs, maps, fossils?
  Implementing – observations and measurements
  Analysing and Conclusions – e.g. identifications, cross-sections, sedimentary logs
  Evaluation – how sure can I be that this is a correct identification?
  level of certainty of age or feature

- **Investigations may include one or more of the following techniques and skills from GL1:**

  Nature of the minerals (diagnostic tests, [mineral data sheet available])
  Origin of the rocks (mineralogy, texture)
  Fossils (identification)
  Environments of deposition (graphic logs)
  Field structures: recognition and interpretation of bedding, sedimentary structures/fold/faults/joints/igneous bodies/metamorphic aureole – (field sketching, photographs)
  Cross-section (construction)
  Making or interpreting a geological map during or prior to fieldwork.
  Development of a table of geological events based on field evidence of an area. (i.e. geological Column)

The assessment of GL2 is through Internal Assessment - for detailed guidelines, see **Section 8**

UNIT GL3: GEOLOGY AND THE HUMAN ENVIRONMENT

This unit aims to develop:

- knowledge and understanding of natural geological hazards and those caused by human activity, and the means of predicting, monitoring and controlling them;
- an evaluation of the impact of geology in environmental planning and civil engineering projects;
- skills of analysing and evaluating geological data related to site development and hazard assessment.

Key Idea 1: Natural geological hazards can be classified according to the geological processes involved

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Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) **Volcanic hazards**. Hazards result from (i) blast/explosion, (ii) ash fall, pyroclastic flows (nuées ardentes), and gases (iii) lava flows and (iv) debris flows and mudflows (lahars). The nature of the hazard depends on the composition, viscosity and gas content of the magma.	Use geological data from an appropriate case study of each of the following: (a) a major volcanic eruption (b) a major earthquake (c) a mass movement event to compare and contrast the nature of the geological hazards.	1883 Krakatoa; 1980 Mt St Helens; 1991 Pinatubo; late 1990s Montserrat.
(b) **Earthquake hazards**. There is a relationship between earthquakes and active fault zones. The magnitude of an earthquake event is measured on the Richter scale. The intensity of earthquake damage around an event is measured on the modified Mercalli scale and is related to earthquake size, depth, distance, local ground conditions and building standards.		1906 San Francisco; 1964 Alaska; 1985 Mexico; 1996 Kobe; 2004 Indian Ocean.
Tsunamis can cause devastation in coastal areas following an undersea earthquake or volcanic eruption.		1883 Krakatoa; 1999 Philippines; 2004 Indian Ocean.
(c) **Mass movement hazards**. The mechanism and triggering of rock avalanches, landslides and debris flows are linked to angle of slope, lithology, weathering, load, groundwater regime, rainfall, shrinkage/expansion, ground vibration.		1915 Folkestone Warren; 1988 Anatolia; 1999 Beachy Head.

Key Idea 2: Attempts are made to predict and control hazardous geological events, in order to reduce the risk of loss of life or property damage, with only limited success

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) A wide variety of monitoring techniques is used in an attempt to predict hazardous geological events. (i) **Volcanoes.** Indicators of magma movement include: ground deformation, gravity and thermal anomalies, gas emissions and seismic activity.	An investigation of the monitoring of: (i) a major volcanic eruption (ii) an earthquake (iii) a mass movement event evaluating the degree of success in hazard prediction.	(i) Volcano: Mt St Helens. Volcanic hazard maps.
(ii) **Earthquakes.** Methods used to predict earthquakes include monitoring changes in: seismic activity, groundwater levels and pressure, tilting and ground movement, radon gas emissions, electromagnetic signals, electrical resistivity, animal behaviour, and the presence of earthquake lights.		(ii) Earthquake: Californian attempts at earthquake prediction based on detailed monitoring of precursor events. Earthquake hazard maps.
(iii) **Mass movement**. Sites of potential slope failure can be monitored by: mapping, surveying, measurement of creep, strain, groundwater pressures.		
(b) The risk of damage to property or loss of life is related to population density, building type and density and human activity (social and economic) in the area of the hazard.	Describe the social and economic influences of hazard prediction.	
(c) The destructive effects of volcanoes, earthquakes, and mass movements can to some extent be managed and controlled in order to reduce risk. **Volcanoes** - attempts to control of lava speed and direction. **Earthquakes** - attempts to control stress release along faults and reduce impact of ground accelerations. **Mass Movement** - slope stabilisation, drainage control, retaining structures.		Volcanoes: diversion of lava flows, control of lava speed and direction (e.g., Etna). Earthquakes: Californian experiments in controlled release of stresses along fault zones. Mass movements: stabilisation of slopes, drainage control measures, use of retaining structures
(d) Benefits are associated with some natural hazards: Volcanic activity - geothermal energy, fertile soils.		Students should be encouraged to think why people have chosen to live in seismically active areas.

Key Idea 3: Geologically related hazards can result from human activity

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) **Waste disposal**. Problems of ground contamination, including groundwater pollution and methane gas production, can be controlled by good geological site selection and engineering practice. Use of former landfill sites for development can pose problems of ground instability and subsidence. There are special problems with the disposal of highly toxic and radioactive waste.	Analysis, using a variety of geological data, of the suitability of one actual or potential landfill or underground site for waste disposal.	Investigation of toxic and radioactive waste disposal, e.g., Sellafield, Cumbria. Housing development on former landfill sites. Pollution of water supplies by landfill and mining activity.
(b) **Water supply**. Overuse of aquifers can result in local exhaustion of the water supply as well as contamination (including saltwater incursions in coastal areas), and surface subsidence. Groundwater pollution: in developing groundwater resources local sources of groundwater pollution must be identified and controlled.	Investigation of the physical causes of surface subsidence and saltwater contamination due to overpumping.	Investigation of flow rates through aquifers/rock samples.
(c) **Mining**. Problems associated with the extraction of rock and minerals – stability of working faces, rock falls, ground subsidence, gas explosions, flooding, surface/groundwater pollution, waste tipping.	Analyse the relative importance of these different problems with reference to data from one mine.	Case study of a major open pit or underground mine.

Key Idea 4: Engineering activities interfere with the natural environment and need to take account of geological factors

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Civil engineering work needs to take account of geological factors to avoid: (i) problems of ground instability associated with dip of strata. folding, faulting, rock cleavage and joint patterns. (ii) interference with the hydrological system: surface and underground drainage patterns (porosity, permeability, water table, aquifers). (iii) interference with the coastal system: coastal erosion and deposition, longshore drift.	Simple geometrical analysis of rock slope stability involving friction angle and orientation of rock discontinuities.	Dams, embankments, roadways, bridges, buildings. Cuttings, pits, quarries, tunnels and mines, underground installations. Sea defences, retaining walls.
(b) In building major structures geological factors and geological rock properties must be taken into account: **Dams and reservoirs** - valley shape and rock structure – foundation strength; porosity and permeability; zones of structural weakness and high permeability. **Cuttings and rock tunnels** - rock strength; stable and unstable patterns of geological structures (bedding, jointing, faulting, cleavage). **Buildings** - foundation strength; depth to water table and rockhead; problems of radon gas in buildings – sources and pathways to surface, surface geology of high-risk areas.	Analysis of the suitability of sites using a variety of geological and geotechnical data.	(i) soil or rock slope failure: experiments to determine the effects of different factors on stability, e.g., pore fluid pressure, shape of fragments, slope angle. Simple experiments to determine coefficients of sliding friction of various surfaces. (ii) surface and underground drainage: simple investigation into the different geotechnical properties (strength, bearing capacity, porosity, permeability) of differing rocks. Flood risk assessment; radon hazard maps.

Issues that might be further developed in Unit GL6 Geological Investigations:

Geological, environmental, planning and/or other issues related to local quarrying/mining activity.
Engineering geological field investigation based on a local construction project (major building, motorway, tidal barrage, remedial work).
Investigation of local potential or actual landfill sites and their geological setting.
Investigation of geotechnical properties of rocks.

A Level

The A2 Geology course comprises:

Unit GL4 Interpreting the Geological Record

Unit GL5 Geological Themes - a choice of two out of four themes

Unit GL6 Geological Investigations

UNIT GL4: INTERPRETING THE GEOLOGICAL RECORD

E1: ROCK FORMING PROCESSES

This sub-unit aims to develop:

- an extended concept of the rock cycle to deepen knowledge with understanding of igneous, sedimentary and metamorphic rocks and their processes of formation;
- extended skills in identifying and interpreting rocks using their compositions, textures and other diagnostic features.

Key Idea 1: Different environments and processes of magma formation and evolution generate different types of igneous rocks

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Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Melting of rock material at depth to form magma occurs in a number of different plate environments:	Evaluation of the role of temperature, pressure and water content in determining melting points of rocks. Concept of partial melting of rock (mixture of minerals).	
(i) beneath divergent (constructive) plate margins - partial melting of mantle rocks generates basaltic magma;	(i) interpretations of models of magma chambers under ocean ridges and rises.	
(ii) near to convergent (destructive) plate margins - partial melting of subducted oceanic lithosphere and overlying lithospheric wedge generates andesitic magma;		
(iii) in mantle plumes (hotspots) - partial melting of mantle rocks generates basaltic magma;	(iii) investigation of global distribution of mantle plumes from maps.	(iii) Hawaii as a mid-plate plume; Iceland as a plume beneath a divergent (constructive) plate boundary. Experimental simulation of a mantle plume.
(iv) in deeply buried lower continental crust during orogeny – melting and assimilation of crustal material generates granitic magma.	(iv) simple calculation of depth of formation of granite magma by crustal melting by interpretation of graphs showing continental geotherm and melting temperatures of wet and dry lower crustal material.	

(b) Mechanisms of emplacement and extrusion of magmas depend on magma density, viscosity and fluid pressure: rise due to buoyancy forces; rate of rise controlled by viscosity; forcible intrusion into surrounding rock if fluid pressure exceeds confining pressure; importance of gas content.		Contrast of types of volcanicity in Iceland, Hawaii, Mt St Helens, Pinatubo. Simple experiments to simulate the role of gas phases.
(c) Igneous rock composition and texture depend on magma composition, cooling rate and crystallisation processes. Differentiation: continuous and discontinuous reaction series (Bowen); gravity settling to give cumulates.	Investigation of magma crystallisation and differentiation processes using phase diagrams (plagioclase feldspars, olivine).	Investigation of igneous rocks and their textures using thin sections.
(d) Magma can become contaminated by incorporation of rock material during rise and emplacement, leading to change of composition and physical properties: xenoliths.		Xenoliths of country rock in igneous bodies; investigation of xenolith shapes and textures in hand specimens or the field.

Key Idea 2: The mineralogy and texture of sedimentary rocks are controlled by processes of weathering, erosion and deposition

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Immature sedimentary rocks are characterised by a wide range of mineral compositions and/or lithic clasts; mature sedimentary rocks have restricted mineralogies dominated by mineral species resistant to weathering and erosional processes.		
(b) Mature sedimentary rocks exhibit a restricted range of essential minerals due to processes of:		
(i) weathering, (heating/cooling, freeze/thaw, hydrolysis, carbonation, solution and oxidation) which breaks silicate rocks down into quartz, muscovite, clay minerals, soluble salts, iron oxides and resistant heavy minerals;		(i) Laboratory investigation of weathering processes. Track the effects of weathering on some common rock-forming minerals (e.g. quartz, feldspar, calcite).
(ii) erosion, which sorts the insoluble and soluble raw materials of weathering by a variety of physical and chemical processes and further breaks down the insoluble fraction - abrasion, corrosion, saltation/suspension of particulate grains (effect of composition, weight, density and shape of grains);		(ii) & (iii) Simple laboratory experiments to sort sedimentary particles by various erosional and depositional processes.
(iii) deposition, which selectively concentrates products in particular environments - grain size related to energy of depositional environment; dominance of quartz and muscovite in coarse fraction and clay minerals in fine fraction; flocculation; precipitation; concentration of biogenic material in particular environments.	(iii) analysis of grain size in fluvial environments. Identification of biogenic components in sedimentary rocks.	(iii) Laboratory investigation of flocculation. Concentration of biogenic material in shelly limestones, peat, and coal.
(c) Sedimentary rocks exhibit differences in texture: grain angularity, sphericity, size, sorting, which reflect: (i) the nature of rocks from which they were derived; (ii) conditions of climate, weathering, erosion and deposition operating during their formation; (iii) post-depositional factors.	Investigation of textures of sediments from different depositional environments and sources.	Investigation of sorting characteristics using sieving. Beach sediments, fluvial sediments, scree deposits.

Key Idea 3: The mineralogy and texture of metamorphic rocks are determined by the composition of the parent rock and the conditions of metamorphism

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Igneous and sedimentary rocks contain minerals that are stable or metastable at the temperature and pressure of their formation. Changes in temperature and/or pressure during metamorphism lead to the growth of new minerals with different stability fields.	Analysis of simple pressure - temperature - time paths involved in contact and regional metamorphism. Simple analysis of phase diagrams showing stability fields of selected metamorphic minerals: kyanite/ sillimanite/ andalusite.	
(b) The mineralogical changes during metamorphism depend on the composition of the parent rock. Contact and regional metamorphism of mudstone lead to the growth of new minerals indicative of the type and grade of metamorphism: low to high grade metamorphism.		Arrange rocks (e.g. clay, slate, schist) in order of increasing metamorphic grade and comment on the features that support this.
(c) Contact, regional and dynamic metamorphism result in characteristic textural changes associated with recrystallisation, ductile flow and shear deformation.	Study of texture diagrams to identify and analyse the following metamorphic textures: granoblastic; porphyroblastic; mylonitic.	

E2: ROCK DEFORMATION

This sub-unit aims to develop:

- an extended understanding of the physical relationship between the type of stress and the resultant rock structures;
- skills in laboratory investigation of rock deformation;
- skills in recognising and interpreting structural data presented in a variety of forms.

Key Idea 1: Geological structures are formed when rock material undergoes ductile deformation or fracture.

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Rock deformation results when rocks undergo permanent strain in response to applied tectonic stresses. (b) Faulting results when applied tectonic stresses exceed the fracture strength of a rock. Fault type is determined by the orientation of the principal stresses.	Analysis of simple stress-strain curves showing elastic/brittle and ductile/plastic behaviour; elastic limit, yield point and fracture point. Analysis of the relationship between fault type (normal, reverse/thrust, strike-slip) and the orientation of the principal stress components σ_{min}, σ_{int} and σ_{max} .	(i) Experiments to relate to stress to strain. Hooke's Law experiments. (ii) Simple experiments to produce folds, faults and shear zones in differing materials (plasticine, silicone putty, sand and flour layers, toffee) by the application of stress. (iii) Computer modelling of rock structures. (iv) Film/video demonstration of rock deformation processes.
Technical terms to describe fault elements: slickensides: fault gouge, fault breccia. (c) Folding results when compressional stresses exceed the yield strength of a rock.	(b) & (c) Recognition and interpretation of structural features through study of photographs, diagrams, sections, geological maps.	
Technical terms to describe: (i) fold elements – antiform, synform; anticline, syncline; plunge (of axis), axial planar cleavage; (ii) fold shapes - amplitude, wavelength, interlimb angle, open, tight, isoclinal, upright, inclined, overturned, recumbent.		Use of pencil, eraser and printer paper/telephone directory to simulate fold development.
(d) Structural reactivation: earlier-formed faults can be reactivated during later tectonism; folds may be refolded. Structural inversion: reactivation of normal faults in compression or reverse faults/thrusts in extension.	(d) Recognition of evidence for fault reactivation in geological maps and photographs.	Investigation of seismic sections from areas of structural reactivation, e.g., Wessex basin.

E3: PAST LIFE AND PAST CLIMATES

This sub-unit aims to develop:

- an extended knowledge and understanding of the nature, potential, and limitations of the fossil record;
- skills of observation and interpretation of fossil characteristics;
- skills in investigating the succession of life through geological time as evidenced by diversity in the fossil record;
- knowledge and understanding of past global climate change.

Key Idea 1: Fossil morphology is related to function and to particular modes of life, and fossils may be used to interpret former environments

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Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) Fossil groups may be classified on the basis of morphology.	Development of a classification from provided data. Elementary classification into: phylum, class, order, genus, species. Identification of differences within the named fossil groups, using the morphological features listed in GL 1. **Generic and specific names will not be examined.**	Classification of fossil specimens based on knowledge of living forms.
(b) Morphology is related to mode of life/function in representatives of all major groups of fossils.	(i) Invertebrates: analysis of function/mode of life from morphology of recent or fossil specimens, and interpretation of former environments. **Bivalves and Brachiopods.**	(i) Field investigation of modern environments, e.g., river banks, coastal environments. Examination of fossil assemblages from local rocks and discussion of possible environments.
	(ii) Vertebrates: analysis from secondary data. **Dinosaurs**: size and shape, dentition (carnivorous vs herbivorous), pelvis, vertebrae, ornamentation (horns, plates).	(ii) Museum visits.
	(iii) Land plants: analysis of recent and fossil specimens. Spore-bearing plants vs seed-bearing plants.	

(c) There are problems in relating morphology to function in extinct groups of organisms. Recognition of the value of exceptional preservation.	Interpretation of function and mode of life of **trilobites** and their living environment based on the morphology of fossil specimens.	Burgess Shale fauna; Wenlock Limestone; Cambrian Alum Shale of Sweden.
(d) The fossil record is: (i) biased, in favour of marine organisms, with body parts resistant to decay, that lived in low energy environments, and suffered rapid burial; (ii) incomplete, as natural processes can distort or destroy fossil evidence (predation, scavenging, diagenesis, bacterial decay, weathering, erosion).	Investigation of a modern environment to determine the factors which favour fossil preservation.	Simple laboratory experiments to test hypotheses about the preservation of organic and inorganic remains. Relationship between type of plant tissue, waxy or woody vs non-woody tissue, and preservation.

Key Idea 2: Fossils provide evidence for the increasing diversity of life through geological time

Knowledge with Understanding	*Techniques and skills*	*Possible learning experiences*
(a) The fossil record provides evidence of changes in floras and faunas through geological time and the development of higher life forms:	Interpretation of evolutionary diagrams.	Museum visits to compile data to demonstrate these evolutionary changes.
(i) Precambrian life: life possibly evolved early in Earth history (3.8 billion years ago). The Ediacaran fauna represents the oldest diverse set of multicellular, soft bodied organisms (565 Ma)		An investigation of the divergent views concerning Ediacaran classification: linked to modern groups (corals/jellyfish) or a separate kingdom? Late Precambrian fossil embryos linked to early evolutionary trees.
(ii) The Cambrian Explosion: the development of mineralised skeletons led to a wide variety of advanced marine invertebrates by the early Cambrian.	Analysis of the possible causes of faunal diversification at the Precambrian-Cambrian boundary.	
(iii) Life in the ocean diversified in stages identified by separate fauna: a basic understanding of the difference between Cambrian, Palaeozoic and modern faunas).	Interpretation of simple diversity curves (Sepkoski's curves)	

(iv) the Phanerozoic was marked by the migration of organisms on to the land during the Palaeozoic. Vertebrate development of amphibians from fish, reptiles from amphibians and mammals and birds from reptiles. Colonisation by land plants.	
(b) Diversity increased through the Phanerozoic punctuated by many declines caused by mass extinction events. Mass extinctions may result from a variety of factors including: 1. asteroid impact (Alvarez); 2. increase in volcanicity (flood basalts); 3. changes in land/sea; 4. rapid climate change. Mass extinctions are exemplified by the end-Permian (P-T) and Cretaceous-Tertiary (K-T) boundary events.	Evaluation of contrasting hypotheses regarding mass extinctions
(c) There are alternative interpretations of evolutionary patterns based on the fossil record. Gradual change (gradualism) vs stability interrupted by sudden change (punctuated equilibrium).	Evaluation of alternative interpretations of evolutionary patterns.

Key Idea 3: A combination of global factors contributes to climate change through geological time

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) The distribution of continents and mountain belts affects oceanic and atmospheric circulation, influencing past and present global climate.	Analysis of **present day** oceanic and atmospheric circulation in relation to climatic effects.	Rise of Himalayan Mountains and influence on monsoonal rains.
(b) Milankovitch cycles are regarded as a contributory cause of ice ages.	Analysis of data used to predict **past** climatic regimes.	Simple analysis of web-based climate model data used to predict **past** climatic regimes. Analysis of ice core evidence
(c) Changes in atmospheric composition of greenhouse gases (especially - CO_2 and methane) result from natural processes (volcanic activity, rock weathering, methane hydrates) throughout geological time.	Evaluation of contribution of naturally produced CO_2 and methane to climate change with time	Internet research into atmospheric effects of a major volcanic eruption
(d) There have been climate changes throughout geological time. The current rate of change appears to differ from those in the past.	Analyses of graphs showing different rates of climate change.	

Key Idea 4: Evidence of global climate change is obtained from the fossil record, sedimentary rocks and ocean sediments.

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
(a) The fossil record provides evidence of different climatic zones, as exemplified by: (i) land plants and (ii) corals	Investigation of the evidence for climatic extremes in the rock record.	Investigation of a modern carbonate environment: Great Barrier Reef; Great Bahama Bank.
(b) Sedimentary sequences provide evidence of depositional environments related to particular climatic zones. (i) Carboniferous (icehouse) ancient glacial deposits (ii) Cretaceous (greenhouse) tropical deposits	Assessment of the validity of the evidence for the “Snowball Earth” hypothesis.	
(c) Oxygen isotope ratios ($^{18}O/^{16}O$) in fossil shells are indicative of the temperature of ancient ocean waters.	Simple analysis of oxygen isotope curves.	

E4: GEOLOGICAL MAP INTERPRETATION

The Foundation Geology unit introduces interpretation of subsurface geological structure using simplified geological maps. In this sub-unit, map interpretation skills are developed further by investigating outcrop patterns on real geological maps.

This sub-unit aims to develop:

- extended skills in interpreting structural information contained in geological maps;
- skills in extracting information from geological maps related to a range of geological applications;
- an awareness of the environmental and sustainable issues involved with geological applications.

Key Idea 1: Outcrop patterns on geological maps can be used to identify and interpret structural elements

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Knowledge with Understanding	*Techniques and skills*	*Possible learning experiences*
Outcrop patterns of dipping strata and faults in relation to topography: direction of closure of V-shaped outcrops in valleys as an indication of dip direction; close parallelism of geological boundaries and topographic contours as a sign of near horizontal dip; linear geological boundaries crossing topographic relief as an indication of steep dip.	(i) Interpretation of relationships between structural features, outcrops and topography on geological maps. (ii) Identification of fold types using outcrop patterns on geological maps. (iii) Estimation of fault types and displacements using offsets of geological boundaries across faults. (iv) Identification of unconformities based on field relationships displayed on geological maps.	Use of block diagrams, films, videos and/or computer models to demonstrate the relationship between the outcrop pattern on an irregular surface and the underlying structure. Comparing geological maps with images on Google Earth.

Key Idea 2: Geological maps contain information relevant to a wide range of geological applications

Knowledge and Understanding	*Techniques and skills*	*Possible learning experiences*
Geological maps provide an essential database: (i) of detailed information about the distribution of rocks at the surface that can be used to interpret or predict subsurface geological conditions.	Use of geological maps at various scales to: (i) identify from outcrop patterns and other data on geological maps; 1. conformable and unconformable sedimentary formations; 2. metamorphic sequences and igneous bodies (and any associated metamorphic effects); 3. structural features. (ii) interpret related gravity and magnetic data presented on some geological map sheets.	
(ii) for geological applications: 1. design of construction projects; 2. identification of geological hazards; 3. location of resources - groundwater, fossil fuels; alternative energy sources; 4. identification of environmental issues from extraction of these resources; 5. assessment of suitability for sustainable waste disposal.	1. assess the potential of surface sites for a range of engineering projects on the basis of the prevailing geology; 2. identify geological hazards (landslides, subsidence) at defined surface sites on the basis of the prevailing geology; 3. interpret subsurface geology in connection with: groundwater (water table; springs; aquifers; artesian wells); coal; oil; natural gas and geothermal energy; 4. identify the environmental issues specific to extraction of resources from the map area; 5. assess the suitability for sustainable waste disposal in an area on the map.	Investigation of groundwater issues in a local area using the GIS system from the BGS interactive maps.

Issues that might be further developed and used for GL6 Geological Investigations:

Investigations to interpret rock textures and/or compositions relating to mode of origin.
Field or laboratory investigations of factors determining fossil preservation.
Field investigation of fossil changes through a rock sequence associated with either evolutionary or environmental change.

UNIT GL5: GEOLOGICAL THEMES

The Geological Themes build on the GL1 Foundation Geology, GL3 Geology and the Human Environment and GL4 Extension Geology units. They demonstrate how interconnections between different areas of geology are important to the study of major geological themes.

A Level candidates must study TWO themes

Theme 1: QUATERNARY GEOLOGY

This half-unit aims to develop:

- knowledge with understanding of the link between geological process and product, and an appreciation of the importance of this link in interpreting the geological record;
- an appreciation of the fragmentary geological record of Quaternary environmental and climatic change in the British area;
- fieldwork skills of investigating and interpreting a modern sedimentary environment.

Key Idea 1: The study of modern environments enables us to interpret the sedimentary rock record

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) In modern environments the link between process and product can be studied: this enables the reconstruction of earlier environments recorded in sedimentary rock sequences.	Field investigation of a modern sedimentary environment to identify characteristic bed geometries, lithologies, sedimentary structures, organic forms and field relations, linking product to process. Graphical representation of data to include: triangular graphs, logarithmic graphs, rose diagrams. Use of the Hjulstrom graph.	A coastal investigation of lithologies (sands, silts, muds), geometries (channel fills, drapes), bedforms (symmetrical and asymmetrical ripple marks), organic forms (shells, burrows, trails).
(b) Study of modern marine environments (lagoons; reefs; submarine slopes; deep sea) enables us to determine the biological, physical and chemical processes that lead to the formation of sediments.	(i) Identification of different limestones based on grain size, grain type, composition and texture, and interpretation of depositional environments. (ii) Investigation of causes of turbidity currents and simple explanation of resulting sediments in terms of physical processes involved. (iii) Identification and interpretation of sedimentary structures common in ancient turbidites.	(i) Investigation of composition and texture of British limestones (eg, Carboniferous limestones, Jurassic limestones, Cretaceous chalk) to interpret palaeoenvironments. (ii) Release of sediment suspensions into water filled tanks to simulate turbidity currents. Submarine cable failures related to turbidity currents (eg, 1929 Grand Banks). (iii) Investigation of the British stratigraphic record to identify turbidite sequences.

Key Idea 2: The wide range of Quaternary deposits and landforms in Britain provides a fragmentary record of former glacial and interglacial stages in Britain

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) The wide range of glacial, periglacial, fluvioglacial and interglacial deposits and landforms in Britain provides an incomplete record of climatic fluctuations and varying sedimentary environments. Information may be deduced on ice sheet dimensions and ice movement patterns.	Investigation of Quaternary sediments and landforms based on interpretation of: section logs of Quaternary sequences; "drift" geological maps; palaeoenvironmental maps. Development of a stratigraphic record.	Field investigation and interpretation of glacial sediments and landforms in an upland region, or Quaternary sequences exposed in a coastal section (e.g., raised beach deposits, till, "head"). Visits to sites (eg, show caves). Provenance and fabric study of clast types derived from till. Estimation of the duration and frequency of glacial and interglacial cycles; historical review of earlier ideas based on Alpine moraines. Raised beach patterns in, eg, Isle of Man, Scandinavia.
(b) (i) There is geological evidence for glacial and interglacial stages, and for shorter-term climatic cycles superimposed on the dominant pattern of glacial and interglacial stages.	(i) Analysis of evidence for Quaternary sea level changes (eg, raised beaches, drowned valleys); interpretation of geological maps.	
(ii) There is a link between continental ice sheets and sea level: low sea levels during glacials, high sea levels during interglacials. Isostatic response to ice loading and unloading.	(ii) Simple calculations of amount of rebound caused by ice unloading. Analysis of evidence for relative changes in sea level caused by ice loading.	
(c) (i) Fossils provide evidence for climatic fluctuations in Britain during the Quaternary period. Radiocarbon (^{14}C) dating of organic material.	(i) Analysis of pollen diagrams. Analysis of the vertebrate record.	
(ii) Ice core evidence for atmospheric change.		

Key Idea 3: Quaternary landforms and drainage are partly controlled by geological structure and lithology

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Geological structures and bodies result in a variety of relief forms.	Interpretation of the relationship between geology and topography using maps, photographs and field observations: landforms associated with dipping strata; folds; faults; joints; igneous bodies	Modelling bedding, fold and fault structures using Plasticine or wooden blocks. Geology and scenery in Britain: Wenlock Edge, Pennines, Weald, Great Glen Fault, Arthur's Seat. Rift valleys. Deccan Plateau. Lithological and structural controls of coastal erosion.
(b) Geological structure and lithology control river drainage patterns - radial, trellised, dry valleys, subterranean river courses, groundwater flow, springs.	Interpretation of the relationship between geology and drainage using maps, photographs and field observations.	

Issues that might be further investigated and used for GL6 Geological Investigations:

Field investigation of coastal evidence for Quaternary sea level change.
Field investigation of a modern sedimentary environment.
Field investigation of sediments and landforms in a glaciated region.
Palaeoenvironmental analysis of a local sedimentary rock sequence (of any age) based on a modern sedimentary example.
Investigative study of surface relief feature(s) formed by active tectonism.

Theme 2: GEOLOGY OF NATURAL RESOURCES

This half-unit aims to develop:

- knowledge with understanding of the geological processes that lead to the formation and accumulation of natural resources;
- knowledge with understanding of the methods of exploration for geological resources;
- appreciation of the need for control of the extraction of geological raw materials to minimise environmental problems;
- appreciation of the wide range of uses of geological raw materials and their importance to society and industry.
- skills in interpreting geological data to assess resource potential.

Key Idea 1: Geological processes lead to the concentration and accumulation of natural resources in deposits that can be exploited; economic minerals can be concentrated by igneous and sedimentary processes

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Processes of formation of metalliferous ores. (i) Igneous associations - magmatic segregation, pegmatites, hydrothermal activity. (ii) Sedimentary associations - placer deposits; residual deposits; precipitated deposits.	Geological map interpretation (ore body geometry, field relations); section drawing through ore bodies.	Experimental formation of cumulate deposits due to crystal settling (as analogues of, e.g., iron or chromite ores formed by magmatic segregation); study of video of black smokers at modern oceanic spreading centres; experimental formation of placer deposits (as analogues of, eg gold or cassiterite ores); simple experiments to precipitate minerals (as analogues of eg, halite or gypsum deposits); mine visits.
(b) Processes of formation of non-metallic minerals of economic importance: barite (baryte), china clay, fluorite. Formation of igneous, sedimentary and metamorphic rocks of economic importance in bulk ("bulk minerals" exemplified by sand, gravel, limestone), or containing industrial minerals.	Geological map interpretation; section drawing through industrial mineral deposits	Bulk rocks for aggregate or ballast; sand and gravel for the construction industry; clays for brick making; limestones and clays for cement; gypsum for plaster; kaolin, talc, ground slate as examples of fillers; quarry/pit visits.
(c) Origin of hydrocarbons and coals: hydrocarbons and coals result from the thermal alteration of organic material due to burial. (i) Hydrocarbons: source rocks; sediment burial and the temperature and pressure conditions of oil and natural gas formation. (ii) Coal forming environments; peat, lignite, bituminous coal, anthracite; coal rank.	Identification of coal types. Simple assessment of reasons (e.g. tonnage of coal in a given area). Simple analysis of maturity: depth (temperature) graphs showing oil and natural gas windows.	Examples of hydrocarbon source rocks in British stratigraphy; peat forming environments in the UK; study of a coalfield to consider origin of coal and distribution of coal types.

Key Idea 2: Permeable rocks offer pathways for oil and gas migration; highly porous rocks can act as natural reservoirs for underground supplies of oil and gas

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Porosity and permeability affect oil and natural gas distribution and migration: types of porosity in rock; factors that affect porosity and permeability.	Analysis of rock textures in terms of porosity and permeability (grain size, shape, packing, sorting; cementation); primary and secondary porosity.	Experiments on porosity and permeability.
(b) (i) Oil and gas migration are controlled by geological factors: migration paths - relative buoyancy of oil and natural gas; structural and stratigraphic traps for hydrocarbons; reservoir rocks and cap rocks. (ii) Use of depleted oil and gas reservoirs as possible CO_2 repositories (sequestration).	Analysis of geological sections through oil and natural gas bearing structures.	Simple test-tube distillation of oil from oil shale; experiments on oil migration and trapping using oil/water mixes in layered sequences; use of geological sections from selected North Sea oil or natural gas fields.

Key Idea 3: A wide range of prospecting techniques can be employed to explore for mineral resources

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
Techniques used to prospect for mineral resources: geological mapping; drilling and downhole logging; geophysical surveying (gravity, seismic, magnetic, electrical surveys); geochemical prospecting using river water, river sediment, soil and vegetation sampling; satellite remote sensing. Each method has particular applications and limitations.	Geological map interpretation; simple analysis of geophysical, geochemical and well log data related to mineral exploration. Construction of geological sections from drilling data, including dating and correlation. Selection of appropriate geophysical methods for different mineral searches, depending upon the geometry and physical properties of the target body. Interpretation of seismic reflection sections to identify potential oil and natural gas-bearing structures.	Use of geological maps of mineralised areas; geophysical datasets (e.g. seismic, gravity, electrical or magnetic) in mineral exploration; Landsat imagery to show geological features in mineralised zones; geochemical sampling and simple analysis of local soils.

Key Idea 4: The extraction of geological raw materials must be carried out in a controlled manner to minimise environmental damage

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
Extraction of geological raw materials involves interference with the surface and/or subsurface environment, by quarrying or mining. These activities are controlled by planning and legislation to protect the environment and limit the adverse effects from pollution on local communities.	Analysis of the methods of extraction of geological raw materials to identify potential environmental problems and the ways by which these may be minimised.	Investigation of deep mining, opencast workings, brine pumping, quarrying, dredging.

Issues that might be further developed in Unit GL6 Geological Investigations:

Investigation of: properties of local building stones; geological materials in everyday items.
Geology of local water supplies.
Physical and/or chemical properties of geological raw materials.
Properties of coal and their uses.
Properties of oils and their uses.

Theme 3: GEOLOGICAL EVOLUTION OF BRITAIN

This half-unit aims to develop:

- awareness with understanding of the broad patterns of rock outcrop, and of the wide range of igneous, sedimentary, metamorphic and tectonic processes that have created the geology of Britain and adjoining continental shelf regions;
- knowledge with understanding of the geological evolution of Britain and the evidence that the area of Britain has moved northward, in a global context, through Phanerozoic time;
- an appreciation of the techniques of collecting geological field data and presenting and interpreting them in the form of maps and sections;
- skills in interpreting geological maps and field observations in plate tectonic terms.

Key Idea 1: The surface distribution of rocks in Britain has been determined largely by tectonic activity related to former lithospheric plate movements

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Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Rocks from all the major subdivisions of geological time occur in Britain and surrounding shelf areas: Precambrian, Early and Late Palaeozoic, Mesozoic, Cenozoic (Tertiary, Quaternary).	Study of geological maps at various scales including maps linking onshore and offshore areas. Use of maps and related data to investigate major geological processes operating in different parts of the British area from the Precambrian through to the Quaternary.	Investigative field study of an area to identify major rock-forming processes during selected geological periods and use of regional geological maps in order to place local geology in a broader context. Use of aerial photographs and satellite images to obtain an awareness of the wide variety of surface rock types and their associated outcrop patterns.
(b) A number of orogenic events have affected the British area: location and large-scale geology (ages, main structures and dominant trends, plutonic and metamorphic rocks) of the Caledonian and Variscan orogenic belts; Alpine orogenic influences in Britain.	Interpretation of geological maps to identify outcrop patterns associated with large-scale geological features of orogenic belts; fold shapes and descriptors, plunging folds; fault descriptors; regional structural trends as displayed by major folds and faults.	Use of the BGS Tectonic map and 1:625 000 ("Ten-Mile") Geological Maps of Britain. Use of aerial photographs and satellite images.
(c) Study of the geology of these orogenic belts enables a reconstruction of the plate tectonic regimes in which they developed.	(c) & (d) Collation and evaluation of geological evidence to interpret the Caledonian and Variscan orogenic belts and Tertiary Igneous Province in plate tectonic terms.	Investigative field study of one tectonic province within an orogenic belt, interpreting rocks and structures, as far as is practicable, in plate tectonic terms.
(d) The Tertiary Igneous Province of NW Britain provides evidence of the early history of the opening of the North Atlantic Ocean, with associated basaltic volcanicity.	Interpretation of the geological characteristics of the Tertiary Igneous Province in plate tectonic terms.	

Key Idea 2: Changes in the latitude of the British area through geological time are interpreted from evidence of former climates and from inferred palaeomagnetic pole positions

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) (i) Sedimentary rocks and their contained fossils may be used to interpret environments of deposition: fluvial, deltaic, shallow and deep marine.	Investigation and interpretation of diagnostic characteristics of sedimentary rocks and fossils in terms of depositional environments.	
(ii) Rocks in Britain show evidence of major climatic change through Phanerozoic time, exemplified by: Permo-Triassic - semi-arid and desert terrestrial and hypersaline marine deposits. Carboniferous, Jurassic and Cretaceous - tropical, shallow marine and terrestrial deposits.	Investigation and interpretation of climatic change as evidence for change of latitude, assuming that the major climatic zones of the Earth have been present throughout much of Phanerozoic time.	
(b) The palaeomagnetic field direction in some British rocks provides evidence of latitude at the time of magnetisation, assuming that geographical and magnetic poles have always lain close together.	The use of palaeomagnetic data to calculate palaeolatitudes for the British area, and interpretation of apparent polar wandering curves to determine palaeolatitude changes through time.	

Key Idea 3: Plate tectonic movements have resulted in the northward drift of the British area through Phanerozoic time

NB: This key idea is intended to provide "snapshots" of the geological past to develop an appreciation of the global plate tectonic controls underlying regional geology and to increase understanding of changing plate environments within and beyond the British area. **Detailed stratigraphical development is not required.**

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Geological information from Britain may be related to global events to develop a model of change due to plate tectonics:	Study of palaeogeographical maps to relate the location, climatic and physiographic conditions of the British area at selected geological times.	A study of one tectonic province within Britain relating rocks and structures to palaeogeography and plate setting.
(i) *Early Palaeozoic*. Northern and southern parts of Britain in different continents separated by the Iapetus Ocean. Deep and shallow marine environments.	Interpretation of maps, rocks, fossils, sedimentary structures and palaeomagnetism to evaluate the evidence for latitude and climate change, and evidence of plate movements, with particular reference to:	Examples from key ideas 1 - 2 in the Geological Evolution of Britain unit could be extended here.
(ii) *Mid Palaeozoic*. Caledonian Orogeny and fusion of Euramerica. Region of Britain immediately south of the equator.	(i) deep: black graptolitic shales and turbidites; shallow: sandstones, shales and limestones with shallow water fossil assemblages including corals, brachiopods, trilobites.	
(iii) *Late Palaeozoic*. Britain drifted north across the equator with possible destruction of a tract of oceanic lithosphere during the Variscan Orogeny.	(ii) continental red beds: sandstones; breccias; conglomerates; mudstones.	
(iv) *Early Mesozoic*. Separation of Laurasia and Gondwana by the Tethys ocean in southern Europe. Region of Britain lay about 20°N of the equator. Rifting and subsidence in the North Sea area related to the opening of the Atlantic Ocean.	(iii) equatorial rain forest conditions: coal measures with sandstones, shales, bivalves and plant remains. Coal seams and seat-earths with rootlets.	
(v) *Late Mesozoic*. During the Cretaceous, continued opening of the Atlantic and continued subsidence of the North Sea area. Region of Britain now about 35°N.	(iv) red beds and evaporites. Shallow marine shelf deposits.	
	(v) open marine chalk deposits recording a period of high global temperatures and sea levels.	
(vi) Ce*nozoic*. Formation of the Alps with related tectonic movements in the British area. Extensive volcanism in NW Britain. Ongoing subsidence in North Sea area.	(vi) Tertiary Igneous Province associated with opening of North Atlantic.	

Issues that might be further developed in Unit GL6 Geological Investigations:

The unit offers an ideal context for any investigative work into the geology of a chosen area, allowing synthesis of individual interpretations within a broader stratigraphical context. Assembly and interpretation of field data to construct a geological map of relevance to an enquiry.

Theme 4: GEOLOGY OF THE LITHOSPHERE

This half-unit aims to develop:

- an understanding that the lithosphere consists of the crust and uppermost part of the mantle and is a layer of distinctive mechanical properties;
- knowledge with understanding of the geological processes underlying the formation and evolution of the lithosphere;
- knowledge with understanding of the methods of investigating the internal structure and constitution of crustal and mantle lithosphere;
- skills interpreting geological and geophysical data to investigate lithospheric structure and processes in the context of plate tectonics.

Key Idea 1: The loss of heat through the Earth's surface leads to cooling and the development of an outer shell of high strength known as the lithosphere underlain by a layer of lower strength known as the asthenosphere

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Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) The Earth loses heat through its surface, leading to the formation of a cold, rigid outer layer known as the lithosphere: surface heat flow and temperature variation with depth; rock strength related to temperature; localised melting in the asthenosphere generating basaltic magmas.	Graphical comparison of continental and oceanic geotherms with the mantle solidus curve to explain lithosphere/asthenosphere distinction.	Laboratory investigation of strength of materials in relation to melting temperature.
(b) The base of the lithosphere is defined as the 1300ºC isotherm; lithospheric thickness differs between continents and oceans.		Comparison of thermal structure and lithospheric thickness in continental shields and ocean basins.
(c) Global seismology provides evidence for the distinction between lithosphere and asthenosphere: seismic low velocity zone in upper mantle.	(i) Ray path modelling to show refraction of earthquake body waves through low velocity zone. (ii) Interpretation of P- and S-wave velocity-depth curves and identification of low velocity zone.	
(d) The crust is a surface layer of distinctive composition at the top of the lithosphere: seismological estimates of crustal thickness; Mohorovičić discontinuity (Moho).	Simple interpretation of seismic refraction data to define crustal layering and reflection data to investigate the internal structure of the crust.	Use of deep crustal seismic reflection sections, e.g., those published by COCORP (US Consortium for Continental Reflection Profiling) and BIRPS (British Institutions Reflection Profiling Syndicate), to investigate continental crustal structures.

Key Idea 2: Oceanic lithosphere is formed at divergent (constructive) plate boundaries and destroyed at convergent (destructive) plate boundaries

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) The ocean crust has a layered structure: seismic layers 1, 2 and 3.	(a) & (b) Geological interpretation of layers 1, 2 and 3 (sediments, pillow lavas, sheeted dykes and gabbro) using evidence from ophiolites and ocean drilling.	
(b) Ophiolites and ocean drilling provide evidence for the origin and composition of the oceanic crust and upper mantle.	Investigation of an ophiolite complex.	Study of a classic ophiolite complex (eg, Oman, Troodos) or a British example (eg, Ballantrae, Lizard).
(c) Rates and directions of seafloor spreading may be calculated from the dating of oceanic crust and from the patterns of ocean magnetic anomalies caused by field reversals: use of radiometric dating and ocean drilling to date magnetic anomalies.	Interpretation of ocean magnetic anomaly profiles and maps and ocean floor age distribution maps; calculation of rates of seafloor spreading from magnetic anomaly and mantle plume (hotspot) data – plumes as frames of reference for absolute plate movements.	Investigation of the plate tectonic evolution of a major ocean basin.
(d) Oceanic lithosphere cools by conduction as it moves away from a spreading centre, leading to a thickening of oceanic lithosphere with age.	(i) Interpretation of heat flow variation across an ocean basin.	
(e) Oceanic lithosphere is reabsorbed into the mantle by sinking in subduction zones: subduction zones within oceans and at active continental margins; island arc and cordilleran magmatism.		
(f) Ocean basin evolution can be traced from continental rifts through narrow seas to mature ocean basins: the J. Tuzo Wilson cycle - ocean growth and destruction as a cyclic event; age and location of oldest ocean floor.		Present day Atlantic Ocean on the approximate site of the former Iapetus Ocean that was destroyed during the Caledonian orogeny.

Key Idea 3 A wide range of lithospheric processes contributes to the formation and deformation of continental crust

Knowledge and understanding	*Techniques and skills*	*Possible learning experiences*
(a) Being of relatively low density, continental lithosphere resists subduction and tends to avoid destruction during plate tectonic cycles, hence the Earth's oldest crustal rocks are found in continental areas.	Investigation of the range of distribution of ages of rocks in continental areas using geological maps.	Analysis of published geochronological data from continental areas: N. America.
(b) Orogenic belts are sites of major lithospheric thickening: continent-continent collision; continent-island arc collision; cordilleran mountain belts; incorporation of oceanic lithosphere into orogenic belts ; ophiolites and accretionary prisms; partial melting and granite magmatism;-delamination; isostatic uplift and gravitational collapse.	Identification of large scale features of continental geology and interpretation of their origin and tectonic setting. Investigation of isostasy by use of published lithospheric sections and densities to compare the relative weights and heights of columns of continental and oceanic lithosphere.	Use of sections to explore the internal construction of different types of orogenic belt.
(c) Forces acting on the continental crust (plate boundary forces and gravitational spreading) give rise to tectonic stresses that cause brittle and ductile deformation on all scales in crustal rocks. Regional structures: fold and thrust belts.	Field interpretation of folds and faults in terms of applied stresses, and their relationship to the regional structural setting.	

Issues that might be further developed in Unit GL6 Geological Investigations:

Field investigation of igneous and/or metamorphic rocks whose origin may be related to the lithospheric processes studied in this unit (eg, granites, arc-related volcanic rocks, ophiolites).
Field investigations of local structures within an orogenic belt.

UNIT GL6: GEOLOGICAL INVESTIGATIONS

Internally Assessed Geological Investigations

GL6 is assessed by Internal Assessment – see **Section 8** for details.

5 SCHEME OF ASSESSMENT

AS and A level qualifications are available to candidates following this specification.

AS

The AS is the first half of an A level course. It will contribute 50% of the total A level marks. Candidates must complete the following **three units** in order to gain an AS qualification.

		Weighting Within AS	Weighting Within Advanced
GL1	Foundation Geology	35 %	17.5 %
GL2	Investigative Geology	30 %	15 %
GL3	Geology and the Human Environment	35 %	17.5 %

GL1: Written Paper (1hr)

Structured data-response questions. All questions compulsory.

GL2: Internal assessment

either **GL2(a)** A practical exercise based on a simplified geological map, with specimens, photographs and other data. Questions enable the application of investigative skills (both field and laboratory), to determine the geological background and solve geological problems of a hypothetical area.
Administered and marked by the Centre.

or **GL2(b)** A report of a field investigation to determine the geological background and solve geological problems of an area visited by the Centre

GL3: Written Paper (1hr 15min)

Two compulsory structured data-response questions and a choice of one essay from three.

Advanced

The A level specification consists of two parts: Part 1 (AS) and Part 2 (A2).

Part 1 (AS) may be taken separately and added to A2 at a further examination sitting to achieve an A level qualification, or alternatively, both the AS and A2 may be taken at the same sitting.

Candidates must complete the AS units outlined above plus a further three units to complete A level Geology. The A2 units will contribute 50% of the total A level marks.

		Weighting within A2	**Weighting within Advanced**
GL4*	Interpreting the Geological Record	35 %	17.5 %
GL5*	Geological Themes	35 %	17.5 %
GL6*	Geological Investigations	30 %	15%

*Includes synoptic assessment

GL4: Written Paper (2hr)

Integrated structured questions, interpreting a variety of data, including geological maps.

GL5: Written Paper (2hr)

A choice of two papers from the four themes. Each paper has a compulsory structured data-response question followed by a choice of one essay from three.

GL6: Internal Assessment

Two geological investigations with a minimum of 50% field evidence and a maximum of 50% laboratory work, the latter being optional.

Synoptic Assessment

Synoptic assessment, testing candidates' understanding of the connections between the different elements of the subject and their holistic understanding of the subject, is a requirement of all A level specifications.

Candidates make and use connections within and between different areas of geology at AS and A2, by:

- applying knowledge and understanding of more than one area to a particular situation or context;
- bringing together scientific knowledge and understanding from different areas of the subject and applying them;
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data.

The topic of Climate Change in GL4 and the themes in GL5 bring together different aspects of geology from the AS Foundation, and Geology and the Human Environment units. Thus the knowledge and understanding of the geological strands of rocks, structures, processes, fossils and their impact on society are further developed and linked in the investigation of chosen geological themes. Examination questions in GL4 and GL5 test a candidate's understanding of the connections between the different strands through recall and application of the subject.

Geological Investigations encourage the identification and use of appropriate knowledge, understanding and skills introduced in other parts of the course. Throughout the specification a section at the end of each unit links its content to possible development within GL6. The planning and conclusions sections of GL6 must refer to geology acquired earlier in the course. Students must demonstrate a high level of independent performance in a new environment.

Quality of Written Communication

Candidates will be required to demonstrate their competence in written communication in all assessment units where they are required to produce extended written material: GL3; GL5; GL6. Mark schemes for these units include the following specific criteria for the assessment of written communication.

- legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning;
- selection of a form and style of writing appropriate to purpose and to complexity of subject matter;
- organisation of information clearly and coherently; use of specialist vocabulary where appropriate.

Availability of Units

Availability of Assessment Units				
Unit	**January 2009**	**June 2009**	**January 2010 & each subsequent year**	**June 2010 & each subsequent year**
GL1	✓	✓	✓	✓
GL2		✓		✓
GL3	✓	✓	✓	✓
GL4				✓
GL5				✓
GL6				✓

Awarding, Reporting and Re-sitting

The overall grades for the GCE AS qualification will be recorded as a grade on a scale from A to E. The overall grades for the GCE A level qualification will be recorded on a grade scale from A* to E. Results not attaining the minimum standard for the award of a grade will be reported as U (Unclassified). Individual unit results and the overall subject award will be expressed as a uniform mark on a scale common to all GCE qualifications (see table below). The grade equivalence will be reported as a lower case letter ((a) to (e)) on results slips, but not on certificates:

	Max. UM	A	B	C	D	E
Units 1, 3, 4 and 5 (weighting 17.5 %)	105	84	73.5	63	52.5	42
Units 2 and 6 (weighting 15 %)	90	72	63	54	45	36
AS Qualification	300	240	210	180	150	120
A Qualification	600	480	420	360	300	240

At A level, Grade A* will be awarded to candidates who have achieved a Grade A in the overall A level qualification and 90% of the total uniform marks for the A2 units.

Candidates may re-sit units prior to certification for the qualification, with the best of the results achieved contributing to the qualification. Individual unit results, prior to certification of the qualification have a shelf-life limited only by the shelf-life of the specification.

6 KEY SKILLS

Key Skills are integral to the study of AS/A level Geology and may be assessed through the course content and the related scheme of assessment as defined in the specification. The following key skills can be developed through this specification at level 3:

- Communication
- Application of Number
- Problem Solving
- Information and Communication Technology
- Working with Others
- Improving Own Learning and Performance

Mapping of opportunities for the development of these skills against Key Skills evidence requirement is provided in 'Exemplification of Key Skills for Geology, available on the WJEC website.

7 PERFORMANCE DESCRIPTIONS

Introduction

Performance descriptions have been created for all GCE subjects. They describe the learning outcomes and levels of attainment likely to be demonstrated by a representative candidate performing at the A/B and E/U boundaries for AS and A2.

In practice most candidates will show uneven profiles across the attainments listed, with strengths in some areas compensating in the award process for weaknesses or omissions elsewhere. Performance descriptions illustrate expectations at the A/B and E/U boundaries of the AS and A2 as a whole; they have not been written at unit level.

Grade A/B and E/U boundaries should be set using professional judgement. The judgement should reflect the quality of candidates' work, informed by the available technical and statistical evidence. Performance descriptions are designed to assist examiners in exercising their professional judgement. They should be interpreted and applied in the context of individual specifications and their associated units. However, performance descriptions are not designed to define the content of specifications and units.

The requirement for all AS and A level specifications to assess candidates' quality of written communication will be met through one or more of the assessment objectives.

The performance descriptions have been produced by the regulatory authorities in collaboration with the awarding bodies.

AS performance descriptions for geology

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Assessment objectives	**Knowledge and understanding of science and of How science works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How science works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes • apply scientific knowledge and processes to unfamiliar situations including those related to issues • assess the validity, reliability and credibility of scientific information.	**How science works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge of most principles, concepts and facts from the AS specification b) show understanding of most principles, concepts and facts from the AS specification c) select relevant information from the AS specification d) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument b) describe significant trends and patterns shown by data presented in tabular or graphical form and interpret phenomena with few errors and present arguments and evaluations clearly c) explain and interpret phenomena with few errors and present arguments and evaluations clearly d) carry out structured calculations with few errors.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques c) make observations and measurements with appropriate precision and record these methodically d) interpret, explain, evaluate and communicate the results of their own and others experimental and investigative activities, in appropriate contexts.
E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge of some principles and facts from the AS specification b) show understanding of some principles and facts from the AS specification c) select some relevant information from the AS specification d) present information using basic terminology from the AS specification.	Candidates characteristically: a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument b) describe some trends or patterns shown by data presented in tabular or graphical form c) provide basic explanations and interpretations of some phenomena, presenting very limited evaluations d) carry out some steps within calculations.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques c) make observations and measurements, and record them d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

A2 performance descriptions for geology

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Assessment objectives	**Knowledge and understanding of science and of How science works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How science works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes • apply scientific knowledge and processes to unfamiliar situations including those related to issues • assess the validity, reliability and credibility of scientific information.	**How science works** Candidates should be able to: • demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods • make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary performance descriptions	Candidates characteristically: a) demonstrate detailed knowledge of most principles, concepts and facts from the A2 specification b) show understanding of most principles, concepts and facts from the A2 specification c) select relevant information from the A2 specification d) organise and present information clearly in appropriate forms using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving several steps in the argument b) describe significant trends and patterns shown by complex data presented in tabular or graphical form, interpret phenomena with few errors, and present arguments and evaluations clearly and logically c) explain and interpret phenomena effectively, presenting arguments and evaluations d) carry out extended calculations, with little or no guidance e) select a wide range of facts, principles and concepts from both AS and A2 specifications f) link together appropriate facts principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques b) demonstrate safe and skilful practical techniques c) make observations and measurements with appropriate precision and record these methodically d) interpret, explain, evaluate and communicate the results of their own and others experimental and investigative activities, in appropriate contexts.

E/U boundary performance descriptions	Candidates characteristically: a) demonstrate knowledge of some principles and facts from the A2 specification b) show understanding of some principles and facts from the A2 specification c) select some relevant information from the A2 specification d) present information using basic terminology from the A2 specification.	Candidates characteristically: a) apply given principles or concepts in familiar and new contexts involving a few steps in the argument b) describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form c) provide basic explanations and interpretations of some phenomena, presenting very limited arguments and evaluations d) carry out routine calculations, where guidance is given e) select some facts, principles and concepts from both AS and A2 specifications f) put together some facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities b) demonstrate safe practical techniques c) make observations and measurements and record them d) interpret, explain and communicate some aspects of the results of their own and others experimental and investigative activities, in appropriate contexts.

8 INTERNAL ASSESSMENT GUIDELINES

The assessment of GL2 is through Internal Assessment

EITHER **GL2(a) A controlled practical exercise based on a simplified geological map, with specimens, photographs and other data, to determine the geological succession and structure and solve geological problems of a hypothetical area.**

Some questions will draw on candidates' ability to apply:
acquired field skills or investigation into case studies, to the interpretation of:

- Igneous rocks and bodies
- Sedimentary rocks and structures
- Metamorphic rocks
- Dip and strike of beds
- Folds, faults
- Unconformities
- Mineral veins and superficial deposits.

OR **GL2(b) A field-based investigation to determine the geological succession and structure and using other problem-solving exercises devised for an area visited by the Centre**

The AS teaching programme should include investigations designed to develop geological investigative skills in the field **within the context of GL1**. It is recommended that all AS candidates should have devoted a minimum of 3 days to geological work in the field. A proportion of this time should be devoted to work associated with the production of a report of one field-based investigation. The field-based investigation requires:

Planning The type of investigation attempted should be more complex than GCSE.
It is expected that the teacher will introduce, through discussion, a suitable general topic for investigation, based on a chosen area. The area may be a single locality, eg, a quarry, or a larger area, though areas larger than 1 sq. km would normally be inappropriate. The teacher may wish to provide some of the original material, eg, a simple base map, photos, specimens, etc. from which candidates develop their own investigation. Any material provided by the teacher, or researched from other sources, e.g. the internet, must be acknowledged in the candidates' submission. Using the material given, students should plan, and justify, safe and effective procedures to be followed when they go into the field. They should recognise how much evidence needs to be collected for their investigation.

Implementing Data collection is to be outside the classroom.
Candidates may need to work in groups to collect data in the field where safety considerations may preclude individual work. In such situations, the contribution of the individual to the planning and execution of group activities must be made explicit in individual submissions. Group activity must be designed to:

- be appropriate to each candidate in terms of level of difficulty;
- allow candidates of differing ability to differentiate;
- provide opportunity for the development of individual lines of enquiry;
- allow ready identification of assessment criteria by candidate, teacher and moderator.

Analysing evidence and drawing conclusions.
This activity may be field- or classroom-based.

Evaluation.
This involves comment on the level of success, both positive and negative, of the investigation in relation to the original planning.

The report of the field-based investigation should: justify the planning procedures chosen; include the recording of the **original data** collection and explain any steps taken to minimise error in collection; use cartographical and/or graphical techniques to aid interpretation; use numerical analysis if appropriate; draw conclusions; evaluate the level of success of the investigation. The report must be presented in an A4 format (large maps in tubes, specimens, etc, will not be accepted), with a completed cover sheet obtainable from WJEC.

3. **Assessment criteria**

Both internal assessments are made against the same assessment objective weightings

Assessment Objectives (AO)	AO1 Knowledge and understanding	AO2 Application of knowledge and understanding	AO3 How science works	Total marks
	4	4	22	30
Criteria				
Planning	4	2	2	8
Implementing			8	8
Analysing/ Concluding			8	8
Evaluating		2	4	6

The mark awarded for each component takes into account the **quality of written communication [QWC]** used by the candidate. This includes:

- legibility, spelling, punctuation and grammar;
- the selection and use of a form and style of writing appropriate to the purpose of a geological report;
- the clear and coherent organisation of information, using appropriate specialist vocabulary.

The QWC contributes to the individual mark for each of the four criteria.

GL2(a)

The specimen GL2(a) controlled practical exercise and its mark scheme exemplify the nature of this assessment.

GL2(b)
The following assessment criteria and mark ranges must be used for the assessment.

The assessment of QWC is inherent within each of the criteria.
In particular, the QWC marks within:

planning	apply to the suitability and clarity of writing used on the planning sheet provided by WJEC;
implementation	relate to the recording methods used whilst completing obsevations and measurements in the field and laboratory, these could include numbers, maps, diagrams, annotations;
analysis	include cartographical, graphical, numerical analysis in addition to quality of written explanations and conclusions;
evaluation	incorporate evidence of clear, logical and critical thought.

(i) ***PLANNING*** *(8 marks)*

Following discussion with the teacher the student should:

- formulate a plan to carry out an investigation by:
  identifying and defining the nature of a question or problem recognising, recalling and showing understanding of geology (AO1a);
  applying geological knowledge and processes to unfamiliar situations (AO2b);
  retrieving and evaluating information from multiple sources, including computer databases where appropriate.

- choose effective and safe procedures to be followed including:
  identification of factors to be investigated;
  explanation of the methodology (AO3c) i.e. selection of suitable qualitative and quantitative methods (AO3a): equipment, methods of data collection; sampling, recording, cartographic and graphic methods of refinement.

(ii) ***IMPLEMENTING*** *(8 marks)*

The student should:

- demonstrate ethical, safe and skilful practical geological techniques and processes (AO3a).

- obtain reliable and valid information relevant to the investigation, to include:
  observation,
  identification,
  description,
  measurement,
  with an appropriate degree of precision and accuracy (AO3b)

- record sufficient, relevant information in a suitable, clear, precise and accurate way whilst conducting the investigation, using ICT where appropriate (AO3b)

- carry out the work in an appropriate context.

It is expected that all coursework will be undertaken with maximum regard for safety.

NB: All the evidence for the assessment of this component must be based on original field records. Marks cannot be awarded without this evidence. Later 'write-ups' do NOT provide evidence of 'Implementing'

(iii) ***ANALYSING EVIDENCE AND DRAWING CONCLUSIONS*** *(8 marks)*

The student should:

- communicate the recorded data in an appropriate and effective way using cartographic, graphical, or numerical techniques (AO3b)

- analyse, interpret, explain and synthesise the resulting geological data by:
  manipulating data;
  recognising patterns and trends;
  identifying sources of error and recognising the limitations of the experimental measurements (AO3b)

- draw valid conclusions by applying their knowledge and understanding of geology (AO2b)

(iv) ***EVALUATING EVIDENCE AND PROCEDURES*** *(6 marks)*

The student should:

- evaluate the methodology and results of their own investigative (and experimental) activities recognising limitations (AO3c)
- assess the reliability of their data and the conclusions drawn from it.

The Assessment Framework Criteria on the next page must be used to arrive at the appropriate marks. The mark descriptions follow the expectations above and are also divided into the same series of threads.

Activities chosen for assessment should, wherever possible, provide opportunities for all the statements in a mark description to be addressed.

Descriptions are provided for 2, 4, 6 and 8 marks for Planning, Implementation, Analysis and Conclusion, and 2, 4 and 6 marks for Evaluation. The performance needed to gain six marks for E is commensurate with that for 8 marks in the other criteria.

Whenever assessments are made, the mark descriptions should be used to judge which mark **best fits** the candidate's performance. The statements should not be taken as discrete and literal hurdles, all of which must be fulfilled for a mark to be awarded.

The mark descriptions within the criterion are designed to be hierarchical. This means that, in general, a description at a particular mark subsumes those at lower marks. It is assumed that activities which access higher marks will involve a more sophisticated approach and/or a more complex treatment.

Adjacent descriptions should be considered when making judgements. The descriptions are in bands of two marks. The lower mark should be used if the performance is better than the adjacent lower band description but the work does not fully meet the description in the band. Zero marks should **only** be awarded in the unlikely event of a candidate failing to demonstrate any achievement in that skill.
The **professional judgement** of the teacher in making these judgements is important.

Assessment Criteria for GL2(b)

The candidate has:

	1-2 marks	3-4 marks	5-6 marks	7-8 marks
P	* shown limited ability in **planning** an investigation * required assistance to make modifications to originally suggested **procedures**	* shown ability to **plan** investigation but the design may lack sense of purpose * adequately organised some **procedures** but needed help in others	* carefully **planned** the investigation with a clear sense of purpose * devised, and fully detailed, suitable **procedures**	* fully justified an investigation that is related to geological knowledge and understanding, is meticulously **planned** and related to any predictions * individualised the **procedures** to the specific investigation
I	* made some appropriate **data collection** * some **record** of the information which may be haphazard and inappropriate	* **collected** most of the required data showing competent use of equipment * methodically **recorded** most of the data required * carried out the work in the appropriate context	* **collected** all relevant data required to obtain appropriate information with precision and skill * considered sources of **error** * **fully recorded** accurate data	* **collected data** to the highest level of accuracy that can be expected * taken appropriate steps to minimise **error** * succinctly and clearly **recorded** all relevant data
A	* added little to the report of the investigation through the presentation of **graphical and/or numerical** analysis * some difficulty in interpreting the data, the work is mainly **descriptive** * made superficial **conclusions**	* used some **graphical and numerical** methods accurately which have added to the communication of the investigation * **interpreted and analysed** the data * made relevant **conclusions,** though not all aspects are considered	* accurately used appropriate **graph and/or numerical** methods which fully appreciate the data and highlight any anomalies * **interpreted, analysed, explained and synthesised** the data competently recognising sources of error and limitations * made thoughtful and appropriate **conclusions** related closely to the data and to knowledge and understanding of geology	* **presented data** so that it contributes to the clear identification of complex relationships * excellent **interpretations, analysis, explanation and synthesis** * made full and valid **conclusions** which assess the reliability of the conclusions in relation to knowledge and understanding of geology
E	* limited awareness of the investigation's **potentialities** or techniques * identified the level of **reliability** of collected data and the resultant conclusions	* Shown awareness of the **suitability and reliability of the methodology,** identifying improvements * evaluated the level of **reliability** of the evidence recognising any anomalous results	* critically evaluated the **level of success** of all parts of the investigation including **methodology**. The improvements suggested also provide evidence of critical thought. * assessed the **reliability of the evidence** and related it to any predictions made.	

Administration of the Internal Assessment GL2

GL2(a) The Controlled Practical exercise is to be undertaken on one specified day in Week O (mid-May).

- materials (specimens, map, photographs, exercise) to be supplied by Board
- to be marked by the Centre to the Board mark scheme
- marks to be submitted to the Board by a specific date
- on the same date a sample of completed, marked practical exercises are to be submitted for moderation

GL2(b) Internal assessment is submitted for moderation in early May.
The work is internally assessed by teachers and externally moderated by the Board. Teachers must indicate the elements of the submission that have formed the basis of the assessment.

Moderation procedures for GL2(a) and (b) and recording forms for GL2(b)

EXAMPLES OF FORMS ARE FOUND IN THE APPENDIX

1. **Teacher assessment form for GL2(a)**
   For the whole entry, the total mark must be entered in the correct column on the **AS GL2a 1** form. Centres will be notified of the exact date of submission of **AS GL2a 1** each year.

   Teacher assessment form for GL2(b)
   Each candidate's ability must be assessed in accordance with the marking criteria given above. For the whole entry, the marks awarded under each criterion, together with each candidate's total mark must be entered in the correct column on the form **AS GL2b 1**. Whole numbers must be used. Where two or more teachers are involved in the assessment, marks should be cross-moderated before completing this form to ensure a uniform standard within the Centre. It will be in early May preceding the examination.

2. **Choosing the sample for submission [GL2(a) and GL2(b)]**
   The teacher assessments will be moderated by the WJEC, according to the Board's guidelines and using the same criteria. The sample required for moderation will be chosen by the Centre using the formula found in the WJEC Internal Assessment Manual. This is:

Total number of candidates	Work to be submitted (Numbers relate to rank order)
1 – 10	All
11 – 19	1st and every second (1, 3, 5, 7, etc)
20 – 29	1st and every third (1, 4, 7, 10, etc)
30 – 59	1st and every fourth (1, 5, 9, 13, etc)

3. **Coversheet AS GL2a 2 for GL2(a)**
   The work of individual candidates, including those submitted for moderation, must have a coversheet **AS GL2a 2** attached. The form must be signed for authentication purposes.

   Coversheet AS GL2b 3 for GL2(b)
   The work of individual candidates submitted for moderation must have a coversheet **AS GL2b 3** attached. This must show clearly where the evidence for the marks awarded is located within the submission. The form must be signed for authentication purposes and any assistance, given within the specification remit, indicated.

4. **Submitting the sample for moderation**
   For GL2(a) the sample Controlled Practical exercises, chosen according to paragraph 2 above, should be sent to the moderator along with the **AS GL2a 1** forms.
   For GL2(b) completed **AS GL2b 1 forms** should be sent to the **moderator.**
   A record of all marks must be retained by the Centre. A separate parcel containing the sample of submissions with attached coversheets **AS GL2b 3**, planning sheets **AS GL2b 2**
   and field (and laboratory) notebooks, should be sent to the **moderator** at the same time.

5. WJEC reserves the right to ask for further samples or for the work of the Centre's whole entry. The moderation procedure may lead to some adjustment of the internally assessed marks for each candidate though not normally a change in rank order. The moderator will return the work directly to the Centre as soon as possible after completing the moderation.

6. With the publication of results, each Centre will be informed of the moderated marks awarded and receive a report. Centres are asked to keep the work under locked conditions until the time for any appeal has elapsed.

Supervision and Authentication

1. Centres will be expected to provide sufficient supervision to ensure that submissions arising from field and laboratory experiments and investigations are the work of the candidates concerned. As much work as possible must be conducted under the direct supervision of the teacher.

2. The teacher responsible for the supervision of the candidate's work will be required to certify, by completing the Coversheet **AS GL2b 3**, that the marks submitted were awarded in accordance with the specification and Instructions and Guidance for Teachers and that the work submitted is that of the candidate concerned. The type and degree of assistance given, especially under Criterion 1, is also to be completed on the Tracking Sheet **AS GL2b 2**.

3. It is acceptable for parts of the assessed work to use other geological sources where these are relevant and appropriate to the investigation but all such cases must be clearly identified in the text and fully acknowledged in the supporting evidence. Candidates will be required to certify that they have acknowledged all sources used and, apart from the assistance of teachers, all help given by others.

4. If a candidate suffers from a disability which may have affected his/her work or has been absent due to illness for a prolonged period, a request for special consideration should be submitted to the Board at the appropriate time, together with substantiating medical evidence.

The assessment of GL6 is through Internal Assessment

Assessment of Geological Investigations GL6

1. A central aim of the AS and A level specification is the development of geological investigative and experimental skills in the field and the laboratory. The teaching programme should include investigations designed to develop these skills. Assessments should arise naturally from these investigations. The assessment of a candidate's performance should be made during the normal teaching and learning programme and should be an integral part of the scheme of work associated with the various units of the specification.

2. Assessment must be made against the following four criteria:
   - *Planning*
   - *Implementing*
   - *Analysing evidence and drawing conclusions*
   - *Evaluating evidence and procedures*

   Each criterion is to be assessed twice (giving 8 component marks). At least 50% (4 component marks) of the assessment is to be from evidence derived from fieldwork to include at least one 'Implementing' mark. 50% of the assessment may be derived from experimental geology carried out in the laboratory. "Fieldwork" is defined as work outside the classroom; "laboratory" as any classroom with sufficient safety for practical work to be undertaken.
   The eight marks may be gained from two pieces of work, each of which addresses all four criteria, **or** from a larger number of pieces of work which, in total, provide evidence for the eight submitted marks.

3. The candidate, in choosing topics to investigate, is expected to apply the appropriate skills and ideas that have been acquired in the geology course. Suitable topics for investigation can be introduced by teachers. **Progression from GL2 is achieved by drawing from a synopsis of the whole A level content.**

   Data collection may involve a single geological skill, eg, geological mapping, or may involve a range of geological skills that could include any of the following examples: field mapping; section logging; structural measurements; laboratory testing of rock properties; investigation of rock, mineral or fossil suites; analysis of thin sections or photomicrographs; geological computing; laboratory modelling of geological processes.

   The submission may be a candidate's individual investigation or may represent the candidate's contribution to an investigation carried out in a group. Candidates may need to work in groups to collect data, eg, in the field where safety considerations may preclude individual work. In such cases, the contribution of the individual candidate to the planning and execution of group activities must be made explicit in the submission. Any data used by a candidate but collected by others must be acknowledged as secondary data.

   Group activity must be designed to:
   - be appropriate to each candidate in terms of level of difficulty;
   - allow candidates of differing ability to differentiate;
   - provide opportunity for the development of individual lines of enquiry;
   - allow ready identification of assessment criteria by candidate, teacher and moderator.

The work produced for this unit could form a major part of the portfolio of evidence for a *Key Skills qualification*. It has been found that candidates gain more marks if the report is written for a geologically educated audience that is unknown to the writer. This encourages justification and explanation of method. Candidates may use computers for processing data and word processing throughout the investigation. Application of number would be addressed with the collection, refinement and analysis of a large data set. *The Key Skills of Problem Solving, Working with Others and Improving Own Learning and Performance are also developed within this unit.*

4. No strict time limit is specified because of the practical problems associated with field-based investigations. However, an approximate guide is a total of 10 hrs for planning and implementing and 10 hrs for analysing, drawing conclusions and evaluating. Guidance on issues associated with submissions is provided by contacting the Geology Officer at the WJEC. Further guidance with investigations is covered by the annual INSET provision which provides an opportunity for dialogue with the Chief Examiner and Chief Moderator. Succinct and focused submissions are the aim; long descriptions of field excursions will gain few marks.

5. The total submission must be presented in an A4 format with a completed cover sheet obtainable from the WJEC. The Board will meet any requests for further guidance on design or assessment of unit GL6.

6. The work is internally assessed by teachers and moderated by WJEC. Teachers must indicate the elements of the submission that have formed the basis of the assessment.

7. The weightings of the skills areas to be assessed are:

(i)	Planning	8 marks
(ii)	Implementing	8 marks
(iii)	Analysing evidence & drawing conclusions	8 marks
(iv)	Evaluating evidence and procedures	6 marks
		30 marks x 2 total 60 marks

The synoptic element of this Unit is the candidate's use of **appropriate** geological knowledge, understanding and skills accumulated throughout the A level course. Also a high level of independent performance in new and unfamiliar contexts should be demonstrated.

The assessment of QWC is inherent within each of the criteria.
In particular, the QWC marks within:

planning	apply to the suitability and clarity of writing used on the planning sheet provided by WJEC;
implementation	relate to the recording methods used whilst completing obsevations and measurements in the field and laboratory, these could include numbers, maps, diagrams, annotations;
analysis	include cartographical, graphical, numerical analysis in addition to quality of written explanations and conclusions;
evaluation	incorporate evidence of clear, logical and critical thought.

8. The following assessment criteria and mark ranges must be used for the assessment.

(i) ***PLANNING*** *(8 + 8 marks)*

Following discussion with the teacher the student should:

- formulate a plan to carry out an investigation by:
  identifying and defining the nature of a question or problem recognising, recalling and showing understanding of geology (synoptic element, AO1a);
  applying geological knowledge and processes to unfamiliar situations (AO2b);
  retrieving and evaluating information from multiple sources, including computer databases where appropriate.
- chose effective and safe procedures to be followed including:
  identification of factors to be investigated (synoptic element);
  explanation of the methodology (AO3c) i.e. selection of suitable qualitative and quantitative methods(AO3a): equipment, methods of data collection; sampling, recording, cartographic and graphic methods of refinement (synoptic element).

The Planning Sheet, Form A2 GL6 F2 must be used for this skill area. An example is found in the Appendix. The degree of assistance given in the design stage must be indicated on the tracking form.

(ii) ***IMPLEMENTING*** *(8 + 8 marks)*

The student should:

- demonstrate ethical, safe and skilful practical geological techniques and processes (AO3a).
- obtain reliable and valid information relevant to the investigation, to include:
  observation,
  identification,
  description,
  measurement,
  with an appropriate degree of precision and accuracy (AO3b)
- record sufficient, relevant information in a suitable, clear, precise and accurate way whilst conducting the investigation, using ICT where appropriate (AO3b)
- carry out the work in an appropriate context.

It is expected that all coursework will be undertaken with maximum regard for safety.

NB: All the evidence for the assessment of this component must be based on original field and (if chosen) laboratory records. Marks cannot be awarded without this evidence. Later 'write-ups' do NOT provide evidence of 'Implementing'

(iii) ***ANALYSING EVIDENCE AND DRAWING CONCLUSIONS*** *(8 + 8 marks)*

The student should:

- communicate the recorded data in an appropriate (synoptic element) and effective way using cartographic, graphical, or numerical techniques (AO3b)
- analyse, interpret, explain and synthesise the resulting geological data by:
  manipulating data;
  recognising patterns and trends;
  identifying sources of error and recognising the limitations of the experimental measurements (AO3b)
- draw valid conclusions by applying their knowledge and understanding of geology (synoptic element).(AO2b)

(iv) ***EVALUATING EVIDENCE AND PROCEDURES*** *(6 + 6 marks)*

The student should:

- evaluate the methodology and results of their own investigative (and experimental) activities recognising limitations (AO3c)
- assess the reliability of their data and the conclusions drawn from it.

The Assessment Framework Criteria on the next page must be used to arrive at the appropriate marks. The mark descriptions follow the expectations above and are also divided into the same series of threads.

Activities chosen for assessment should, wherever possible, provide opportunities for all the statements in a mark description to be addressed.

Descriptions are provided for 2, 4, 6 and 8 marks for Planning, Implementation, Analysis and Conclusion, and 2, 4 and 6 marks for Evaluation. The performance needed to gain six marks for E is commensurate with that for 8 marks in the other criteria.

Whenever assessments are made, the mark descriptions should be used to judge which mark **best fits** the candidate's performance. The statements should not be taken as discrete and literal hurdles, all of which must be fulfilled for a mark to be awarded.

The mark descriptions within the criterion are designed to be hierarchical. This means that, in general, a description at a particular mark subsumes those at lower marks. It is assumed that activities which access higher marks will involve a more sophisticated approach and/or a more complex treatment.

Adjacent descriptions should be considered when making judgements. The descriptions are in bands of two marks. The lower mark should be used if the performance is better than the adjacent lower band description but the work does not fully meet the description in the band. Zero marks should **only** be awarded in the unlikely event of a candidate failing to demonstrate any achievement in that skill.

The **professional judgement** of the teacher in making these judgements is important.

Assessment Criteria for GL6

	The candidate has:			
	1-2 marks	**3-4 marks**	**5-6 marks**	**7-8 marks**
P	* shown limited ability in **planning** an investigation * required assistance to make modifications to originally suggested **procedures**	* shown ability to **plan** investigation but the design may lack sense of purpose * adequately organised some **procedures** but needed help in others	* carefully **planned** the investigation with a clear sense of purpose * devised, and fully detailed, suitable **procedures**	* fully justified an investigation that is related to geological knowledge and understanding, is meticulously **planned** and related to any predictions * individualised the **procedures** to the specific investigation
I	* made some appropriate **data collection** * some **record** of the information which may be haphazard and inappropriate	* **collected** most of the required data showing competent use of equipment * methodically **recorded** most of the data required * carried out the work in the appropriate context	* **collected** all relevant data required to obtain appropriate information with precision and skill * considered sources of **error** * **fully recorded** accurate data	* **collected data** to the highest level of accuracy that can be expected * taken appropriate steps to minimise **error** * succinctly and clearly **recorded** all relevant data
A	* added little to the report of the investigation through the presentation of **graphical and/or numerical** analysis * some difficulty in interpreting the data, the work is mainly **descriptive** * made superficial **conclusions**	* used some **graphical and numerical** methods accurately which have added to the communication of the investigation * **interpreted and analysed** the data * made relevant **conclusions,** though not all aspects are considered	* accurately used appropriate **graph and/or numerical** methods which fully appreciate the data and highlight any anomalies * **interpreted, analysed, explained and synthesised** the data competently recognising sources of error and limitations * made thoughtful and appropriate **conclusions** related closely to the data and to knowledge and understanding of geology	* **presented data** so that it contributes to the clear identification of complex relationships * excellent **interpretations, analysis, explanation and synthesis** * made full and valid **conclusions** which assess the reliability of the conclusions in relation to knowledge and understanding of geology
E	* limited awareness of the investigation's **potentialities** or techniques * identified the level of **reliability** of collected data and the resultant conclusions	* Shown awareness of the **suitability and reliability of the methodology,** identifying improvements * evaluated the level of **reliability** of the evidence recognising any anomalous results	* critically evaluated the **level of success** of all parts of the investigation including **methodology**. The improvements suggested also provide evidence of critical thought. * assessed the **reliability of the evidence** and related it to any predictions made.	

Recording of Geological Investigations marks and Moderation Procedures

EXAMPLES OF FORMS ARE FOUND IN THE APPENDIX

1. **Teacher assessment form A2 GL6 F1**
Each candidate's ability must be assessed in accordance with the marking criteria given above. For the whole entry, the marks awarded under each criterion, together with each candidate's total mark must be entered in the correct column on the form **A2 GL6 F1.** Whole numbers must be used. Where two or more teachers are involved in the assessment, marks should be cross-moderated before completing this form to ensure a uniform standard within the Centre. Centres will be notified of the exact date of submission of **A2 GL6 F1** each year. It will be in early May preceding the examination.

2. **Choosing the sample for submission**
The teacher assessments will be externally moderated by the WJEC, according to the Board's guidelines and using the same criteria. The sample required for moderation will be chosen by the Centre using the formula found in the WJEC Internal assessment Manual. This is:

Total number of candidates	Work to be submitted (Numbers relate to rank order)
1 – 10	All
11 – 19	1st and every second (1, 3, 5, 7etc)
20 – 29	1st and every third (1, 4, 7, 10etc)
30 – 59	1st and every fourth (1, 5, 9, 13etc)

Only those candidates whose work is submitted for moderation should be listed on the **A2 GL6 F1 form.**

3. **Coversheet A2 GL6 F3**
The work of individual candidates submitted for moderation must have a coversheet **A2 GL6 F3** attached. This must show clearly where the evidence for the marks awarded is located within the submission. The form must be signed for authentication purposes and any assistance, given within the specification remit, indicated.

4. **Submitting the sample for moderation**
Completed **A2 GL6 F1 forms** should be sent to the **moderator.** A record of all marks must be retained by the Centre. A separate parcel containing the sample of submissions with attached coversheets **A2 GL6 F3**, planning sheets **A2 GL6 F2** and field (and laboratory) notebooks, should be sent to the **moderator** at the same time.

5. WJEC reserves the right to ask for further samples or for the work of the Centre's whole entry. The moderation procedure may lead to some adjustment of the internally assessed marks for each candidate though not normally a change in rank order. The moderator will return the work directly to the Centre as soon as possible after completing the moderation.

6. With the publication of results, each Centre will be informed of the moderated marks awarded and receive a report. Centres are asked to keep the work under locked conditions until the time for any appeal has elapsed.

Supervision and Authentication

1. Centres will be expected to provide sufficient supervision to ensure that submissions arising from field and laboratory experiments and investigations are the work of the candidates concerned. As much work as possible must be conducted under the direct supervision of the teacher.

2. The teacher responsible for the supervision of the candidate's work will be required to certify, by completing the Coversheet **A2 GL6 F3**, that the marks submitted were awarded in accordance with the specification and Instructions and Guidance for Teachers and that the work submitted is that of the candidate concerned. The type and degree of assistance given, especially under Criterion 1, is also to be completed on the Tracking Sheet **A2 GL6 F2**.

3. It is acceptable for parts of the assessed work to use other geological sources where these are relevant and appropriate to the investigation but all such cases must be clearly identified in the text and fully acknowledged in the supporting evidence. Candidates will be required to certify that they have acknowledged all sources used and, apart from the assistance of teachers, all help given by others.

4. If a candidate suffers from a disability which may have affected his/her work or has been absent due to illness for a prolonged period a request for special consideration should be submitted to the Board at the appropriate time together with medical evidence.

Private Candidates

Work submitted by private candidates will be assessed by moderators appointed by the Boards. Private candidates will be responsible for ensuring that their work is of an appropriate level. All private candidates will be required to submit their work to the WJEC by 1 May in the year of the examination. The work must be presented in accordance with the guidelines given above. After the work has been assessed, each candidate may be required to attend, at his/her own expense, for an interview by a moderator appointed by the Boards in order to establish the authenticity of the work. All interviews will be completed by 30 June. The coursework submissions will be returned after the publication of results.

The WJEC provides teachers with the opportunity to have dialogue with the Chief Examiner and Chief Moderator at the annual INSET provision. If teachers have a query for the examination personnel at other times, they should contact the Geology Officer, WJEC.

Appendix

WJEC CBAC

AS GEOLOGY

AS GL2a 1

MODERATION MARKSHEET FOR UNIT **GL2a**

Scaling	

Please list **all** candidates entered for this unit and indicate with a ✱ those chosen for the moderation sample

Centre Name: .... Centre Number: ....

Candidate's Number	Candidate's Name IN RANK ORDER	Teacher's total mark	Moderator's mark
		60	60

Date: ....

Signed: ....
(Subject Teacher)

Counter-Signed: ....
(Headteacher/Examinations Officer

AS GEOLOGY UNIT GL2a
GEOLOGICAL INVESTIGATION

AS GL2a 2

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.

If you copy from someone else, allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

Declaration by candidate

I have read and understood the **Notice to Candidate** (above). I have produced the attached work without assistance other than that which my teacher has explained is acceptable within the specification.

Candidate's signature: ………………………………………………………………………… **Date:** …………………………

Declaration by teacher

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate.

Teacher's signature: …………………………………………………………………… **Date**: ………………………………

WJEC CBAC

AS GEOLOGY

AS GL2b 1

MODERATION MARKSHEET FOR UNIT **GL2b**

Scaling	

Please list **all** candidates entered for this unit and indicate with a ❋ those chosen for the moderation sample

Centre Name: .... Centre Number: ....

Candidate's Number	Candidate's Name IN RANK ORDER	Planning	Imple-menting	Analysis and conclusion	Evaluation	Teacher's total mark	Teacher's total mark x2	Moderator's mark
		8	8	8	6	30	60	60

Context of any Group Work:

Any Special Circumstances affecting an individual candidate:

Date: ....

Signed: ....
(Subject Teacher)

Counter-Signed: ....
(Headteacher/Examinations Officer

AS GL2b 2

WJEC AS GEOLOGY PLANNING (Tracking) SHEET GL2b	
Centre Name ………………………………………………………………… Centre No……………………... Candidate Name ……………………………………………………………… Candidate No ……………………	
1. **INVESTIGATION TITLE** (This should take the form of a question, problem, idea or hypothesis that can be scientifically investigated in the field)	
2. **ENQUIRY FOCUS** (Key factors to be investigated in order of implementation)	**3. PREDICTED OUTCOMES**
4. **PRIMARY DATA** to be collected. (Procedures/Methods of enquiry/Sampling)	
5. **Methods of ANALYSIS/DATA PRESENTATION** to be used.	
6. **Anticipated ERRORS/LIMITATIONS** and steps to be taken to minimise.	
7. **Degree of assistance given.**	**Approved by (Supervising teacher)** **Date …./…./….**

P.T.O.

**EFFECTIVE PLANNING AID for
GEOLOGY COURSEWORK INVESTIGATIONS (GL2b)**

The following are a number of questions to help students at the planning stage of their AS investigations.
Not all will be relevant for every investigation. Some questions are designed to help provide evidence for Key Skills.

ENQUIRY FOCUS/PREDICTED OUTCOMES

- What question/hypothesis/ problem/idea will you be investigating?
- Why have you chosen this? What is the geological background/context of your investigation?
- What factors do you intend to investigate? Why have you chosen these?
- What do you predict will be the final outcomes of your results? What are your reasons?
- What secondary sources can you use to obtain further information? (Books, databases, INTERNET)

DATA COLLECTION PROCEDURES

- What primary data do you need to collect?
- How will you effectively and efficiently collect this data?
- What sampling techniques will you need to employ? Why these?
- What specific reasons do you have for doing it this way rather than another?
- How will you ensure/maintain accurate measurements?
- What controls will you use to ensure a fair test?
- What equipment will you require? Why will you use this particular equipment?
- How will you record your data? Why is this the best method?
- Have you undertaken a *pilot study* to test out procedures and equipment? What changes, if any, will you make to you original plan.
- What safety issues have you considered resulting from the implementation of your plan? How will you minimise any risk?
- What help will you need from others in achieving you goal? How will you achieve this?

ERRORS/LIMITATIONS

- What unavoidable limitations/sources of error do you anticipate?
- Is it possible to minimise these errors? What steps will you take?

DATA HANDLING/ANALYSIS/PRESENTATION

- How will you communicate your findings?
- What graphic, cartographic, photographic methods would best suit the form of data you intend to collect?
- What statistical analysis, if any, will you use to help simplify complex relationships?
- What statistical errors might this bring to your results?
- What use will you make of available IT facilities? Which ones? Why?
- Is your plan written in the *future* tense (e.g. I *will* measure….)?

PLANNING

Following discussion with the teacher the student should:

- formulate a plan to carry out an investigation by:
  identifying and defining the nature of a question or problem using available information and knowledge of geology;
  retrieving and evaluating information from multiple sources, including computer databases where appropriate.
- Chose effective and safe procedures to be followed including:
  identification of factors to be investigated;
  methods of enquiry i.e. selection of suitable: equipment, methods of data collection, sampling, recording, cartographic and graphic methods of refinement.

WJEC CBAC

AS GEOLOGY UNIT GL2b
GEOLOGICAL INVESTIGATION

AS GL2b 3

	Full Name	Number
Centre		
Candidate		

Title of Field-based Investigation

____

____

Details of assessment criteria may be found in the Geology Specification.

Please complete **all** the boxes.

	Mark	**Location of evidence for these marks**
Planning max 8		
Implementation max 8		
Analysis and Conclusions max 8		
Evaluation max 6		
TOTAL MARK (P+I+A+E) max 30		
TOTAL x 2 max 60		

Context of investigation; participation in group work

____

____

____

Please complete statements overleaf.

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.

If you copy from someone else, allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

Declaration by candidate

I have read and understood the **Notice to Candidate** (above). I have produced the attached work without assistance other than that which my teacher has explained is acceptable within the specification.

Candidate's signature: …………………………………………………………… **Date:** …………………………

Declaration by teacher

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate.

Teacher's signature: ………………………………………………………………… **Date**: ………………………………

WJEC CBAC

GEOLOGY

A2 GL6 F1

MODERATION MARKSHEET FOR UNIT **GL6**

Scaling	

Please list **all** candidates entered for this unit and indicate with a ❋ those chosen for the moderation sample

Centre Name: ______________________ Centre Number: ____________ Total number of candidates entered: __________

Candidate's Number	Candidate's Name DESCENDING RANK ORDER	Plan 8 F or L	Impl 8 F or L	Analys 8 F or L	Eval 6 F or L	Total 30	Plan 8 F or L	Impl 8 F or L	Analys 8 F or L	Eval 6 F or L	Total 30	TOTAL 60	For WJEC Use only

Context of any Group Work:

Any Special Circumstances affecting an individual candidate:

Date: ____________________

Subject Teacher
Signed: ____________________
Print Name: ____________________

Head-Teacher/Examinations Officer
Counter-Signed: ____________________
Print Name: ____________________

<table>
<tr><th colspan="2">WJEC A2 GEOLOGY PLANNING (Tracking) SHEET A2 GL6 F2</th></tr>
<tr><td colspan="2">Centre
Name ……………………………………………………… Centre No………………………

Candidate
Name …………………………………………………... Candidate No ………………………</td></tr>
<tr><td colspan="2">1. INVESTIGATION TITLE (This should take the form of a question, problem, idea or hypothesis that can be scientifically investigated in the field and/or laboratory)</td></tr>
<tr><td>2. ENQUIRY FOCUS (Key factors to be investigated in order of implementation)</td><td>3. PREDICTED OUTCOMES</td></tr>
<tr><td colspan="2">4. PRIMARY DATA to be collected. (Procedures/Methods of enquiry/Sampling)</td></tr>
<tr><td colspan="2">5. Methods of ANALYSIS/DATA PRESENTATION to be used.</td></tr>
<tr><td colspan="2">6. Anticipated ERRORS/LIMITATIONS and steps to be taken to minimise.</td></tr>
<tr><td>7. Degree of assistance given.</td><td>Approved by (Supervising teacher)

Date …./…./….</td></tr>
</table>

EFFECTIVE PLANNING AID for
GEOLOGY COURSEWORK INVESTIGATIONS (GL6)

The following are a number of questions to help students at the planning stage of their A2 investigations.
Not all will be relevant for every investigation. Some questions are designed to help provide evidence for Key Skills.

ENQUIRY FOCUS/PREDICTED OUTCOMES
- What question/hypothesis/ problem/idea will you be investigating?
- Why have you chosen this? What is the geological background/context of your investigation?
- What factors do you intend to investigate? Why have you chosen these?
- What do you predict will be the final outcomes of your results? What are your reasons?
- What secondary sources can you use to obtain further information? (Books, databases, INTERNET)

DATA COLLECTION PROCEDURES
- What primary data do you need to collect?
- How will you effectively and efficiently collect this data?
- What sampling techniques will you need to employ? Why these?
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- How will you ensure/maintain accurate measurements?
- What controls will you use to ensure a fair test?
- What equipment will you require? Why will you use this particular equipment?
- How will you record your data? Why is this the best method?
- Have you undertaken a *pilot study* to test out procedures and equipment? What changes, if any, will you make to you original plan.
- What safety issues have you considered resulting from the implementation of your plan? How will you minimise any risk?
- What help will you need from others in achieving you goal? How will you achieve this?

ERRORS/LIMITATIONS
- What unavoidable limitations/sources of error do you anticipate?
- Is it possible to minimise these errors? What steps will you take?

DATA HANDLING/ANALYSIS/PRESENTATION
- How will you communicate your findings?
- What graphic, cartographic, photographic methods would best suit the form of data you intend to collect?
- What statistical analysis, if any, will you use to help simplify complex relationships?
- What statistical errors might this bring to your results?
- What use will you make of available IT facilities? Which ones? Why?
- Is your plan written in the *future* tense (e.g. I *will* measure….)?

***PLANNING** (8 + 8 marks)*

Following discussion with the teacher the student should:
- formulate a plan to carry out an investigation by:
  identifying and defining the nature of a question or problem using available information and knowledge of geology;
  retrieving and evaluating information from multiple sources, including computer databases where appropriate.

- Chose effective and safe procedures to be followed including:
  identification of factors to be investigated;
  methods of enquiry i.e. selection of suitable: equipment, methods of data collection, sampling, recording, cartographic and graphic methods of refinement.

WJEC CBAC

A2 GEOLOGY UNIT GL6
GEOLOGICAL INVESTIGATION

A2 GL6 F3

	Full Name	Number
Centre		
Candidate		

Investigation Titles

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Details of assessment criteria may be found in the Geology Specification.

Please complete **all** the boxes.

	Mark	F/L	Location of evidence for these marks	Mark	F/L	Location of evidence for these marks
Planning max 8						
Implementation max 8						
Analysis max 8						
Evaluation max 6						

TOTAL MARK	Max 60

Context of investigations; participation in group work:

____

____

____

Please complete statements overleaf.

NOTICE TO CANDIDATE
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Declaration by candidate

I have read and understood the **Notice to Candidate** (above). I have produced the attached work without assistance other than that which my teacher has explained is acceptable within the specification.

Candidate's signature: …………………………………………………………………… **Date:** …………………………

Declaration by teacher

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate.

Teacher's signature: ………………………………………………………………… **Date**: ………………………………

Mathematical content for Geology.

1. In order to be able to develop their skills, knowledge and understanding in science, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated below.

2. <u>Arithmetic and numerical computation</u>

   (a) recognise and use expressions in decimal and standard form
   (b) use ratios, fractions and percentages
   (c) make estimates of the results of calculations (without using a calculator)

3. <u>Handling data</u>

   (a) use an appropriate number of significant figures
   (b) find arithmetic means
   (c) construct and interpret frequency tables and diagrams, bar charts and histograms
   (d) understand simple probability
   (e) understand the principles of sampling as applied to scientific data
   (f) understand the terms mean, median and mode
   (g) use a scatter diagram to identify a correlation between two variables
   (h) use a simple statistical test
   (i) make order of magnitude calculations.

4. <u>Algebra</u>

   (a) understand and use the symbols: $=$, $<$, $\ll$, $\gg$, $>$, $\propto$, $\sim$
   (c) substitute numerical values into algebraic equations using appropriate units for physical quantities

5. <u>Graphs</u>

   (a) translate information between graphical, numerical and algebraic forms
   (b) plot two variables from experimental or other data
   (c) understand that $y = mx + c$ represents a linear relationship
   (d) determine the slope and intercept of a linear graph
   (e) calculate rate of change from a graph showing a linear relationship

6. <u>Geometry and trigonometry</u>

   (b) visualise and represent 2-D and 3-D forms including two-dimensional representations of 3-D objects
   (d) calculate areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders and spheres