

# SUMMARY OF AMENDMENTS

Version	Description	Page number
2	'Making entries' section has been amended to clarify resit rules.	27



# WJEC Eduqas GCE AS in GEOLOGY

For teaching from 2017  
For award from 2018

	<b>Page</b>
<b>Summary of assessment</b>	<b>2</b>
<b>1. Introduction</b>	<b>3</b>
1.1 Aims and objectives	3
1.2 Prior learning and progression	4
1.3 Equality and fair access	4
<b>2. Subject content</b>	<b>5</b>
<b>3. Assessment</b>	<b>26</b>
3.1 Assessment objectives and weightings	26
<b>4. Technical information</b>	<b>27</b>
4.1 Making entries	27
4.2 Grading, awarding and reporting	27
<b>Appendices</b>	
A: Working scientifically	28
B: Practical technique requirements and exemplification	30
C: Use of mathematical skills	37
D: Scientific skills	40
E: SI units in geology	41

# GCE AS GEOLOGY

## SUMMARY OF ASSESSMENT

### **Component 1: Geological Enquiries** **Written examination: 1 hour 30 minutes** **40% of qualification**

An investigation of the geology of an area shown on an accompanying simplified geological map.

The component involves:

- the interpretation of hand specimens and photographs of minerals, rocks and fossils
- the interpretation of a geological map
- the construction of a geological cross-section
- the completion of data and stimulus response questions using short, structured and extended answers.

A mineral data sheet accompanies this assessment.

### **Component 2: Foundation Geology** **Written examination: 1 hour 30 minutes** **60% of qualification**

An assessment which covers all the AS Geology content.

This component involves:

- questions which require learners to respond to aspects of geology shown in photographs, maps, diagrams and graphs
- the completion of data and stimulus response questions using multiple-choice, short, structured and extended answers.

A mineral data sheet may accompany this assessment on occasions.

This linear qualification will be available for assessment in May/June each year. It will be awarded for the first time in summer 2018.

**Ofqual Qualification Number (listed on [The Register](#)): 603/0860/6**

**Qualifications Wales Designation Number (listed on [QiW](#)): C00/1174/6**

# GCE AS GEOLOGY

## 1 INTRODUCTION

### 1.1 Aims and objectives

The WJEC Eduqas AS in Geology provides the foundations for the study of the Earth, its structures, evolution and dynamics. It develops four main concepts:

- elements, minerals and rocks
- surface and internal processes of the rock cycle
- time and change
- Earth structure and global tectonics.

Learners following this specification are introduced to Key Ideas which provide a framework for study.

This specification encourages learners to:

- develop essential knowledge and understanding of different areas of geology and how they relate to each other, to include civil engineering, engineering geology, hydrogeology, mining geology and petroleum geology
- develop through critical practice the skills, knowledge and understanding of scientific methods as applied in geology
- develop competence and confidence in selecting, using and evaluating a range of quantitative and qualitative skills and approaches, (including observing, collecting and analysing geo-located field data, and investigative, mathematical and problem solving skills) and applying them as an integral part of their geological studies
- understand how society makes decisions about geological issues and how geology contributes to the success of the economy and society.

The WJEC Eduqas AS in Geology places problem solving at the heart of learning. Learners are encouraged to respond to geological information in both familiar and novel situations in the laboratory and in the field. Learners should be able to apply their knowledge and understanding of the contents of this specification by exploring contexts and situations that are not explicitly indicated in the specification, reflecting the skills demanded by those engaged in the study of geology, and other disciplines, beyond AS.

The specification lends itself to a variety of teaching and learning styles and offers learners of all abilities an enjoyable and positive learning experience. Practical work within the specification is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of geology.

## 1.2 Prior learning and progression

There are no prior learning requirements. Any requirements set for entry to a course following this specification are at the discretion of centres. It is reasonable to assume that many learners will have achieved qualifications equivalent to Level 2 at KS4. Skills in Numeracy/Mathematics, Literacy/English and Information Communication Technology will provide a good basis for progression to this qualification.

Some learners will have already gained knowledge, understanding, and skills through their study of geology at GCSE.

This specification provides a suitable foundation for the study of geology at A level. It also provides a good basis for many vocations, not just geological, which require initiative in thought and problem solving. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

This specification is not age specific and, as such, provides opportunities for candidates to extend their life-long learning.

## 1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications*.

This document is available on the JCQ website ([www.jcq.org.uk](http://www.jcq.org.uk)). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

## 2 SUBJECT CONTENT

### Integrated Study

The WJEC Eduqas AS in Geology promotes the integrated study of geology. It enables learners to develop a broad range of skills and techniques in the areas of analysis and interpretation of data, problem-solving and drawing conclusions. In addition it enables learners to acquire data collection and interpretation skills in the field.

This specification provides knowledge of the main aspects of geology as a science through three overarching concepts which link all topics studied:

- a scientific understanding of the Earth, its evolution and its sustainable development
- the central paradigms in geology: uniformitarianism (“the present is the key to the past”); the extent of geological time; and plate tectonics
- the cycling of matter and the flows of energy into, between and within the solid Earth, the Earth's surface, the hydrosphere, the atmosphere and the biosphere.

### Fieldwork

Fieldwork has long been an attractive aspect of the study of geology and has been incorporated at the heart of this specification. Learners are required to undertake a minimum of **two** days of work in the field in order to develop field observation and practical skills.

Each centre must provide a **fieldwork statement** to WJEC that details the fieldwork carried out by learners from the centre in each assessment cycle. Centres will be able to make their fieldwork statement by completing the form that will be available to download from the AS/A level Geology subject page of the Eduqas website. The fieldwork statement must be submitted to WJEC by 15 May of the year of the award.

Centres will be able to use the form to:

- confirm that each learner has been provided with opportunities to undertake geological fieldwork on **at least two occasions** and in respect of each of those opportunities:
  - the date on which it was provided
  - the number of learners who participated
  - the location at which it was provided
  - a brief description of the fieldwork undertaken
- confirm that each learner has been provided with the opportunity to undertake the compulsory fieldwork skills and techniques indicated in Appendix A, part 2.

It is recommended that centres adopt an investigative approach to fieldwork involving learners answering a geological question during at least one of their field days.

Examples of suitable geological questions include:

- What does the evidence from these localities reveal about the relative time sequence of geological events in this area?

- What does the sedimentological and palaeontological evidence indicate about the changes in the environments of deposition of the sedimentary rocks at this locality?

These examples are by no means the only geological questions that could be asked and centres should feel able to devise other examples of geological questions relevant to the field locations which are used.

**Safety is paramount in the field and it is essential that all centres adhere to 'The Geological Code of Conduct' and the regulations of their centre concerning off-site activities.**

This specification requires learners to:

- undertake fieldwork in different contexts: virtual fieldwork, local fieldwork outside the classroom and fieldwork on unfamiliar outcrop geology
- experience and develop competency in the skills and techniques contained in Appendix A
- apply knowledge and concepts to identify and understand field observations.

### **Practical work**

Practical work is an intrinsic part of this specification. The practical skills developed are also fundamentally important to learners going on to further study in geology and related subjects, and are transferable to many careers.

The column featuring geological techniques and skills of the subject content includes activities that must be undertaken by learners in order to ensure that they are suitably prepared for the written examinations. Items labelled 'P' in the geological techniques and skills column represent opportunities for the development of required practical techniques (see Appendix B).

Learners who follow this specification will develop a wide range of mathematical skills as outlined in Appendix C. Calculators may be used in both components. Candidates are responsible for making sure that their calculators meet the relevant regulations for use in written examinations: information is found in the JCQ publications *Instructions for conducting examinations* and *Information for candidates for written examinations*.

## Scientific skills

All content in the specification should be introduced in such a way that it develops learners' ability to apply the following scientific skills:

- use theories, models and ideas to develop geological explanations
- use knowledge and understanding to pose scientific questions, define geological problems, present scientific arguments and geological ideas
- use appropriate methodology, including information and communication technology (ICT), to answer geological questions and solve geological problems
- carry out fieldwork, experimental and investigative activities in a range of contexts to include the collection, compilation and analysis of Earth science data from the field and subsurface, and appropriate risk management
- manipulate and extrapolate these sometimes incomplete data sets in both two and three-dimensions
- evaluate methodology, evidence and partial data sets, and resolve conflicting evidence
- communicate information and ideas in appropriate ways (including geological maps and cross-sections) using appropriate terminology, SI units and their prefixes and the ability to express in standard form
- know that scientific knowledge and understanding develops over time, consider applications and implications of science in geology, and evaluate their associated benefits and risks
- evaluate the role of geology within the scientific community in validating new knowledge and ensuring integrity.

Areas of the specification which exemplify the scientific skills are shown in Appendix D.



## Summary of content

This specification covers all the requirements of AS Geology as specified by the Department for Education (DfE). The knowledge, understanding, skills and techniques are set out in the two columns in the pages that follow. Learners should expect to be assessed on the details of both columns and also to answer questions that set the content in novel situations not explicit in the specification.

The content of the specification for WJEC Eduqas AS in Geology has a structure based on four topics 1-4 which form the fundamentals of Geology. The four topics are further subdivided into Key Ideas which provide a framework for the learner to appreciate the context and purpose of study of the content.

### **Topic 1 Elements, minerals and rocks**

Key Idea 1: The Earth is composed of rocks which have distinctive mineralogies and textures

### **Topic 2 Surface and internal processes of the rock cycle**

Key Idea 1: The mineralogy and texture of sedimentary rocks are the result of the surface process part of the rock cycle, driven by external energy sources

Key Idea 2: The formation and alteration of igneous and metamorphic rocks result from the Earth's internal energy

Key Idea 3: Deformation results when rocks undergo permanent strain in response to applied tectonic stresses and can be interpreted using geological maps

### **Topic 3 Time and change**

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

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

### **Topic 4 Earth structure and global tectonics**

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

Key Idea 2: The Earth's internal heat is the underlying cause of lithospheric plate motions that control global geological processes

Items labelled 'P' in the geological techniques and skills column represent opportunities for the development of required practical techniques (see Appendix B).

Items in italics in the geological techniques and skills column represent opportunities for the development of required mathematical skills (see Appendix C).

## Details of the components

The subject content for AS Geology is assessed across two components. The context in which the content is assessed across the two components differs.

### Component 1: Geological Enquiries

Written examination: 1 hour 30 minutes  
40% of the qualification  
60 marks

A practical investigation confined to the geology of an area on a simplified geological map given on a resource sheet. The component involves the interpretation of hand specimens (sent to centres by WJEC) and photographs of minerals, rocks and fossils. In addition this assessment includes the interpretation of the simplified geological map and the construction of a geological cross-section. Learners are required to complete data and stimulus response questions using short, structured and extended answers.

### Component 2: Foundation Geology

Written examination: 1 hour 30 minutes  
60% of the qualification  
90 marks

Questions in Component 2 are based on knowledge and understanding outlined in the whole of the content of the specification. This component involves questions which require learners to respond to aspects of geology shown in photographs, maps, diagrams and graphs. Learners are required to complete data and stimulus response questions using multiple-choice, short, structured and extended answers.

A mineral data sheet accompanies Component 1 and on occasions may accompany Component 2. Learners should become familiar with the use of this during their study of AS Geology.

Topic 1: <b>ELEMENTS, MINERALS AND ROCKS</b>	
Key Idea 1: <b>The Earth is composed of rocks which have distinctive mineralogies and textures</b>	
Knowledge and understanding	Geological techniques and skills
<p>a. The Earth's elements may be classified according to the <b>Goldschmidt system</b> (lithophile, siderophile, chalcophile, atmophile) which aids subdivision of the Earth on the basis of geochemistry (atmosphere, hydrosphere, crust, mantle and core).</p> <p>b. The bulk composition of the Earth is comparable with that of undifferentiated meteorites (chondrites).</p> <p>c. The Earth's crust is composed of eight main elements.</p> <p>d. Silicates are the commonest rock-forming minerals and are built from silicon-oxygen tetrahedra (single, chain, sheet and framework silicates).</p> <p>e. Minerals are naturally occurring inorganic chemical compounds or elements, with compositions that may be expressed as chemical formulae. Minerals have distinct chemical compositions, atomic structures and physical properties by which they may be identified.</p> <p>f. Rocks are composed of aggregates of minerals, pre-existing rocks or fossils.</p>	<p>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.</p> <p>Simple analysis of silicate mineral structures from models and diagrams.</p> <p>P1: Investigation of diagnostic properties of minerals: colour, crystal shape, cleavage, fracture, hardness, relative density, streak, lustre, reaction with cold dilute (0.5 mol dm<sup>-3</sup>) hydrochloric acid.</p> <p>P2: Measurement of the density of minerals.</p> <p>Recognition, using appropriate tests, of the following rock-forming minerals (<i>as specified on the mineral data sheet available for use in the examination</i>) from their diagnostic properties: quartz, calcite, feldspars (orthoclase, plagioclase), augite, hornblende, olivine, micas (biotite, muscovite), haematite, galena, pyrite, chalcopyrite, fluorite, barite, halite, gypsum, garnet, chiastolite/andalusite.</p> <p>P3: Application of classification systems using distinguishing characteristics to identify unknown minerals.</p>

Knowledge and understanding	Geological techniques and skills
<p>g. Igneous, sedimentary and metamorphic rocks display differences of composition and texture that reflect their mode of origin.</p>	<p>Observation and investigation of hand specimens of a variety of rocks (including sampling in the field) in order to:</p> <ul style="list-style-type: none"> <li>• identify and interpret component composition</li> <li>• interpret colour and textures (crystalline/clastic; crystal or grain size/shape; sorting; foliation; mineral alignment/bedding/crystalline banding) and hence</li> <li>• deduce the mode of origin of the rock as igneous, metamorphic or sedimentary.</li> </ul> <p>P4: Production of scaled annotated scientific drawings of rock samples from hand samples using a light microscope, or hand lens observation.</p> <ul style="list-style-type: none"> <li>• <i>Use and manipulation of the magnification formula</i></li> </ul> $\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$

<b>Topic 2: SURFACE AND INTERNAL PROCESSES OF THE ROCK CYCLE</b>	
<b>Key Idea 1: The mineralogy and texture of sedimentary rocks are the result of the surface process part of the rock cycle, driven by external energy sources</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. External energy: solar heating of the Earth's surface drives the water cycle and influences weathering and erosional processes.</p> <p>b. Physical and chemical weathering of rocks occurs at the Earth's surface and provides the raw materials for new sedimentary rocks:</p> <ul style="list-style-type: none"> <li>• physical weathering, (insolation, freeze/thaw) breaks rock down into smaller fragments</li> <li>• chemical weathering of silicate and carbonate rocks (hydrolysis, carbonation, solution and oxidation) produces a range of new minerals and solutions together with residual, resistant minerals</li> <li>• biological weathering involves physical and chemical changes.</li> </ul> <p>c. Surface materials are transported by a range of erosional agents and are deposited as sediments:</p> <ul style="list-style-type: none"> <li>• erosion (abrasion, attrition)</li> <li>• transport (traction, saltation, suspension, solution)</li> <li>• deposition 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.</li> </ul> <p>d. Different sedimentary environments may be identified by diagnostic sedimentary structures, rock textures, mineralogy and fossil content.</p>	<p><i>Recognition and use of appropriate units in calculations.</i></p> <p><i>Construction and interpretation of frequency tables and diagrams, bar charts and histograms.</i></p> <p><i>Finding of arithmetic means.</i></p> <p><i>Understanding of the principles of sampling as applied to scientific data.</i></p> <p><i>Understanding of the measures of dispersion, including standard deviation and interquartile range.</i></p> <p>Description of sedimentary rocks in hand specimen, rock exposures and diagrams/photographs from observation of their colour, texture (use of sediment comparators to determine grain size, shape and sphericity), (coarse &gt;2 mm, fine &lt;1/16 mm), reaction with 0.5 mol dm<sup>-3</sup> hydrochloric acid, mineralogy and other diagnostic features.</p>

Knowledge and understanding	Geological techniques and skills
<p>e. A study of fluvial, marine, and aeolian sediments demonstrates these differences.</p>	<p>Investigation of textures of sediments from different depositional environments.</p> <p>P5: Production of full rock description of macro and micro features from hand specimens and unfamiliar field exposures of sedimentary rocks in order to interpret component composition, colour and textures, to identify rock types and to deduce their environment of deposition.</p> <p>P6: Construction of graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures to record data relevant to an investigation.</p> <p>P7: Use of photomicrographs to identify minerals and rock textures of sedimentary rocks in order to identify rock types and to deduce their environment of deposition.</p> <p>Interpretation of maps, photographs and graphic logs showing the following sedimentary features: bedding, cross-bedding, graded bedding, lamination, desiccation features, ripple marks (symmetrical and asymmetrical), sole structures (load/flame, flute cast).</p> <p>Identification in hand specimen of the following sedimentary rocks from their composition, texture and other diagnostic features: sandstones (orthoquartzite, arkose, greywacke), shale/mudstone, limestones (shelly, oolitic, chalk), conglomerate, breccia.</p> <p>Investigation of contrasts between fluvial, marine and aeolian sediments.</p> <p><i>Construction and interpretation of frequency tables and diagrams, bar charts and histograms.</i></p> <p><i>Understanding of the terms mean, median and mode.</i></p> <p><i>Plotting of two variables from experimental or other linear data.</i></p>
<p>f. Sedimentary rocks may result from the accumulation of organic material (limestone, coal) or by precipitation of solid material from solution (evaporites).</p>	<p>Analysis of biogenic components in sedimentary rocks.</p>

<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>g. Sedimentary rocks exhibit differences in texture which influences porosity and permeability: grain angularity, sphericity, size, sorting, which reflects:</p> <ul style="list-style-type: none"> <li>• the nature of rocks from which they were derived</li> <li>• conditions of climate, weathering, erosion and deposition operating during their formation</li> <li>• post-depositional factors as sediments are formed into sedimentary rocks: diagenesis and lithification (compaction, recrystallisation, cementation, pressure solution).</li> </ul>	<p>Investigation of the concept of 'sediment maturity'. Immature sedimentary rocks characterised by a wide range of mineral compositions and/or lithic clasts; mature sedimentary rocks with restricted mineralogies dominated by mineral species resistant to weathering and erosional processes.</p> <p><i>Understanding that <math>y = mx + c</math> represents a linear relationship.</i></p>

<b>Topic 2: SURFACE AND INTERNAL PROCESSES OF THE ROCK CYCLE</b>	
<b>Key Idea 2: The formation and alteration of igneous and metamorphic rocks result from the Earth's internal energy</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. Internal energy: The Earth's internal geological processes result from the transfer of energy derived from radiogenic and primordial heat sources. Heat is transferred from the mantle to the surface by conduction and convection, with temperatures of rocks remaining below melting point (except locally).</p> <p>b. Igneous rocks are the products of cooling of magma in bodies of various sizes and shapes and pyroclastic events.</p>	<p>Interpretation of evidence for surface heat flow and temperature variation with depth through simple analysis of the geothermal gradient (geotherm).</p> <p><i>Calculation of the rate of change from a graph showing a linear relationship.</i></p> <p>The recognition of plutons, dykes, sills, lava flows and pyroclastic deposits by interpretation of maps, sections and photographs. Observation and investigation of igneous rocks to deduce the cooling history:</p> <ul style="list-style-type: none"> <li>• crystal size: coarse (&gt;3 mm), medium (1-3 mm), fine (&lt;1 mm)</li> <li>• crystal shape: euhedral, subhedral, anhedral</li> <li>• texture: equicrystalline, porphyritic, vesicular, glassy, fragmental (tuff)</li> <li>• structure: pillow structure, aa/pahoehoe surfaces, columnar joints.</li> </ul> <p>P8: Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of igneous rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce their cooling history. Identification in hand specimen of the following igneous rocks from their composition, texture and other diagnostic features:</p> <ul style="list-style-type: none"> <li>• Silicic: granite</li> <li>• Mafic: gabbro, dolerite, basalt</li> <li>• Ultramafic: peridotite.</li> </ul> <p>P9: Use of photomicrographs to identify minerals and rock textures of igneous rocks to identify rock type and to deduce their cooling history.</p>



Knowledge and understanding	Geological techniques and skills
<p>c. Partial melting of rock at depth to form magma occurs in a number of different interplate and intraplate tectonic settings:</p> <ul style="list-style-type: none"> <li>• beneath divergent plate margins - partial melting of mantle rocks generates basaltic magma</li> <li>• near to convergent plate margins - partial melting of subducted oceanic lithosphere and overlying lithospheric wedge generates andesitic magma</li> <li>• in mantle plumes (hotspots) - partial melting of mantle rocks generates basaltic magma</li> <li>• in deeply buried lower continental crust during orogeny – melting and assimilation of crustal material generates granitic magma.</li> </ul> <p>d. Volcanic hazards result from:</p> <ul style="list-style-type: none"> <li>• blast/explosion</li> <li>• ash fall, pyroclastic flows (nuées ardentes) and gases</li> <li>• lava flows</li> <li>• debris flows and mudflows (lahars).</li> </ul> <p>e. The nature of the volcanic hazard is linked to the composition, viscosity and gas content of the magma.</p> <p>f. Metamorphism involves mineralogical and/or textural change of pre-existing rocks in response to changes in temperature and/or pressure.</p>	<p><i>Use of ratios, fractions and percentages.</i></p> <p><i>Construction and interpretation of frequency tables and diagrams, bar charts and histogram.</i></p> <p>Investigation of the role of rising convection cells in decompression melting.</p> <p>Investigation of global distribution of mantle plumes from maps.</p> <p>Investigation, using geological data from a wide variety of volcanic monitoring techniques (including ground deformation, gravity and thermal anomalies, gas emissions and seismic activity) of the risk of volcanic hazards and the extent to which they can be managed and controlled in order to reduce risk.</p> <p>Interpretation of the following metamorphic features using simplified geological maps and photographs: contact aureoles, metamorphic foliations.</p>

Knowledge and understanding	Geological techniques and skills
<p>g. Contact (thermal) and regional metamorphism produce distinctive mineralogical and textural changes:</p> <ul style="list-style-type: none"> <li>• non-foliated in contact metamorphism</li> <li>• foliation (slaty cleavage, schistosity and gneissose banding) in regional metamorphism.</li> </ul>	<p><i>Understanding that <math>y = mx + c</math> represents a linear relationship.</i></p> <p>P10: Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of metamorphic rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>P11: Use of photomicrographs to identify minerals and rock textures of metamorphic rocks to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>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.</p>

<b>Topic 2: SURFACE AND INTERNAL PROCESSES OF THE ROCK CYCLE</b>	
<b>Key Idea 3: Deformation results when rocks undergo permanent strain in response to applied tectonic stresses and can be interpreted using geological maps</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. Rock deformation can be interpreted by reference to Hooke's Law: Simple stress - strain curves showing elastic/brittle and ductile/plastic behaviour; elastic limit, permanent strain and fracture point.</p> <p>b. Evidence of rock deformation includes dipping beds, folding, faulting and unconformities.</p> <p>c. Dipping beds are the results of tectonic/gravity induced stresses, caused by plate movement, that distort beds from the horizontal.</p> <p>d. Folding results when compressional stresses exceed the yield strength of a rock.</p>	<p>Measurement and description of evidence obtained by sampling of rock deformation in the field (or from photographs). Use of simple calculations to establish the amount of deformation (percentage of crustal shortening)</p> <p>Recognition and interpretation of structural features through study of photographs, diagrams, sections, geological maps and in the field.</p> <p>P12: Location of geological features onto a base map.</p> <p>P13: Identification of the location of geological features in the field using six figure grid references on maps.</p> <p>P14: Production of scaled, annotated field sketches at unfamiliar field exposures to record data relevant to an investigation</p> <p>P15: Measurement of dip and strike elements: dip angle, dip and strike directions of planar surfaces, including valid sampling, relevant to an investigation.</p> <p>Recognition of fold elements: limb, hinge, axis, axial plane trace, fold symmetry (as a function of limb length), antiform, synform, anticline, syncline.</p>

<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>e. Faulting results when applied compressional, tensional or shear tectonic stresses, caused by plate movement, exceed the fracture strength of a rock.</p> <p>f. Unconformities represent a hiatus in the geological record resulting from a combination of Earth movements, erosion and sea level changes.</p> <p>g. The nature of outcrop patterns formed by the intersection of geological structures with a topographic surface are displayed on geological maps.</p>	<p>Recognition of fault characteristics:</p> <ul style="list-style-type: none"> <li>• dip-slip: normal, reverse, thrust; throw - amount, relative movement of footwall/hanging wall</li> <li>• strike-slip: left/ sinistral, right/dextral</li> <li>• fault displacement (= net slip).</li> </ul> <p>Recognition of unconformities and their use in relative dating.</p> <p>Use of geological maps, block diagrams, boreholes, cross-sections and photographs to interpret the geology of an area.</p> <p>Construction of geological sections from simplified geological maps.</p> <p>Ordering the geological sequence of events in an area from the study of a simplified geological map and/or section.</p>

Topic 3: <b>TIME AND CHANGE</b>	
Key Idea 1: <b>Study of present day processes and organisms enables understanding of changes in the geological past</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. Much of the rock record can be interpreted in terms of geological processes that are operating today by applying the Principle of Uniformitarianism: the present is the key to the past.</p> <p>b. The study of modern environments enables an interpretation of the sedimentary rock record within the rock cycle model.</p> <p>c. The basic unit of sedimentary geology is the <i>facies</i> which reflects the depositional environment: lithofacies, biofacies.</p> <p>d. Fossils are evidence of former life preserved in rocks. They provide information on the nature of ancient organisms and palaeoenvironmental conditions.</p>	<p>Investigation of the development of <i>uniformitarianism</i> and the <i>rock cycle model</i> over time and the contributions of James Hutton and William Smith.</p> <p>Appreciation of the basic distinctions between the following fossil groups based on their hard parts:</p> <ul style="list-style-type: none"> <li>• <b>brachiopods (marine)</b>: shell shape and symmetry, pedicle and brachial valves, foramen, hinge line, muscle scars</li> <li>• <b>bivalves (marine/freshwater)</b>: shape and symmetry of valves, number and size of muscle scars, hinge line, teeth and sockets, gape, pallial line and sinus, umbones</li> <li>• <b>cephalopods (marine)</b>: suture line, coiled and chambered shell</li> <li>• <b>corals (marine)</b>: colonial, solitary, septa</li> <li>• <b>trilobites (marine)</b>: cephalon, glabella, genal spines, eyes, thorax, number of thoracic segments, pygidium</li> <li>• <b>graptolites (marine)</b>: stipes, thecae</li> <li>• <b>plants (terrestrial)</b>: leaf, stem, root</li> <li>• <b>trace fossils</b> (tracks and trails, burrows, coprolites).</li> </ul> <p>P16: Application of classification systems using distinguishing characteristics to identify unknown fossils.</p> <p>P17: Production of scaled, annotated scientific drawings of fossils, using a light microscope, or hand lens observation.</p>

Knowledge and understanding	Geological techniques and skills
<p>e. Fossil morphology is used to interpret function/mode of life:</p> <ul style="list-style-type: none"> <li>• bivalves (burrowers/non burrowers)</li> <li>• trilobites (benthonic/pelagic)</li> </ul> <p>f. 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.</p> <p>g. Fossils accumulations may be preserved without appreciable transportation (life assemblages) or preserved after transportation (death assemblages), or as derived fossils re-deposited in later sediment.</p> <p>h. The fossil record is:</p> <ul style="list-style-type: none"> <li>• biased, in favour of marine organisms, with body parts resistant to decay, that lived in low energy environments, and suffered rapid burial</li> <li>• incomplete, as natural processes can distort or destroy fossil evidence (predation, scavenging, diagenesis, bacterial decay, weathering, erosion, metamorphism).</li> </ul>	<p>Analysis of modern and fossil assemblages to interpret the degree of transportation prior to burial.</p>

Topic 3: <b>TIME AND CHANGE</b>	
Key Idea 2: <b>Geological events can be placed in relative and absolute time scales</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>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.</p> <p>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 Potassium – Argon (<math>^{40}\text{K} - ^{40}\text{Ar}</math>), Samarium – Neodymium (<math>^{147}\text{Sm} - ^{143}\text{Nd}</math>).</p> <p>c. Fossils are used in relative dating.</p> <p>d. The factors contributing to good zone fossils for relative dating/correlation are: wide and plentiful distribution, ready preservation, rapid evolutionary change, a high degree of facies independence, easy identification of index fossils.</p> <ul style="list-style-type: none"> <li>• the utility of graptolites and cephalopods as zone fossils assessed in relation to the above factors.</li> </ul> <p>e. The geological column provides a means of:</p> <ul style="list-style-type: none"> <li>• placing geological events in their correct time sequence</li> <li>• defining the absolute age of some events.</li> </ul> <p>f. The rock record indicates changing conditions and rates of processes with long periods of slow change interrupted by sudden catastrophism causing mass extinctions through geological time.</p>	<p>Interpretation of age relations of rocks and rock sequences using maps, cross-sections.</p> <p>P18: The application of one or more criteria of relative age (evolutionary change in fossils, superposition of strata, unconformities, cross-cutting relationships, included fragments, 'way-up' criteria) in the field to place geological events in relative time sequences.</p> <p>Simple use of the principles of radiometric dating (decay rates and the half-life concept) to calculate the absolute age of a sample.</p> <p>Evaluation of the assumptions, accuracy and limitations inherent in the radiometric dating method.</p> <p>Observation and identification of appropriate morphological features and their changes through time:</p> <ul style="list-style-type: none"> <li>• <b>graptolites</b> - number and position of stipes, thecal shape in the Early Palaeozoic.</li> <li>• <b>cephalopods</b> - suture lines in the Late Palaeozoic and Mesozoic (goniatite, ceratite and ammonite).</li> </ul> <p>Interpretation of the ages of geological events using the geological column.</p>

<b>Topic 4: EARTH STRUCTURE AND GLOBAL TECTONICS</b>	
<b>Key Idea 1: The Earth has a concentrically zoned structure and composition</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. The Earth has a layered structure: crust, mantle, outer and inner core. Each layer has a distinctive composition and/or rheological properties. Direct and indirect evidence is derived from meteorite (stony, iron) compositions, mantle xenoliths, mean density calculations and geophysical measurements (seismology, geomagnetism, gravity, conductivity).</p>	<p>Analysis of seismological evidence for the internal structure of Earth: P and S body waves, surface waves, time-distance curves, shadow zones, velocity-depth models of Earth structure, density distribution with depth. Investigation of densities of representative samples of Earth layers.</p> <p><i>Translation of information between graphical, numerical and algebraic forms.</i></p> <p>P19: Measurement of the densities of representative samples of Earth layers (e.g. granite, basalt).</p> <p>Simple analysis of geomagnetic evidence for core composition and processes.</p>
<p>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.</p>	<p>Interpretation of geophysical data on crustal structure (seismic, gravity, magnetic) from continental and oceanic areas.</p> <p>Analysis of ocean drilling data to re-interpret the Mohorovičić discontinuity (Moho) at the base of the crust (e.g. Joides Resolution 360).</p>



<b>Topic 4: EARTH STRUCTURE AND GLOBAL TECTONICS</b>	
<b>Key Idea 2: The Earth's internal heat is the underlying cause of lithospheric plate motions that control global geological processes</b>	
<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>a. The uppermost part of the mantle and the overlying crust form a rigid outer shell of the Earth known as the lithosphere, forming tectonic plates, underlain by a weaker upper mantle zone known as the asthenosphere. The asthenosphere is evidenced by the seismological low velocity zone (LVZ).</p> <p>b. The lithosphere consists of several plates in relative motion. Three types of plate boundary are recognised; divergent, convergent (involving subduction) and conservative. There is a relationship between seismicity, volcanicity and plate boundaries.</p> <p>c. Forces driving plates are a matter of current debate involving thermal convection of the mantle together with gravitational forces and ocean lithosphere density differences at subduction zones.</p> <p>d. 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.</p>	<p>Investigation of how the plate tectonics paradigm developed over time, from continental drift, through active mantle convection carrying passive tectonic plates, to modern theories of the causes of plate movement (slab pull and ridge push).</p> <p>Interpretation of the evidence for plate tectonic theory from:</p> <ul style="list-style-type: none"> <li>• direct measurement – ocean floor drilling, relative movement using GPS</li> <li>• global maps of the distribution of continents, volcanoes, earthquake epicentres/foci, ocean trenches and ridges, orogenic belts and palaeoecological /palaeoenvironmental zones</li> <li>• seismic tomography</li> <li>• an investigation of the geomagnetic/geoelectrical properties of rocks and minerals</li> <li>• geothermal data (hot spots, heat flow).</li> </ul> <p>P20: Investigation of the relationships between earthquake data (focal depth, magnitude and distance from plate boundaries) using data on Google Earth™.</p> <p><i>Use of a scatter diagram to identify a correlation between two variables.</i></p> <p>Evaluation of the possible mechanisms for plate movement (role of mantle convection, slab pull, ridge push).</p>

<b>Knowledge and understanding</b>	<b>Geological techniques and skills</b>
<p>e. 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.</p> <p>f. The various elements of the rock cycle may be linked directly to plate tectonic processes:</p> <ul style="list-style-type: none"><li>• Igneous - basaltic magmatism at oceanic spreading centres; basaltic and andesitic magmatism at convergent margins; granitic magmas in orogenic belts</li><li>• Sedimentary - erosional processes and depositional environments influenced by tectonic movements</li><li>• Regional metamorphism in subduction zones and orogenic belts at plate boundaries.</li></ul>	

# 3 ASSESSMENT

## 3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must:

### AO1

Demonstrate knowledge and understanding of geological ideas, skills and techniques

### AO2

Apply knowledge and understanding of geological ideas, skills and techniques

### AO3

Analyse, interpret and evaluate geological ideas, information and evidence, to make judgements, draw conclusions, and develop and refine practical design and procedures

The table below shows the weighting of each assessment objective for each component and for the qualification as a whole.

	<b>AO1</b>	<b>AO2</b>	<b>AO3</b>	<b>Total</b>
<b>Component 1</b>	7%	23%	10%	40%
<b>Component 2</b>	28%	22%	10%	60%
<b>Overall weighting</b>	35%	45%	20%	100%

For each series:

- The weighting for the assessment of mathematical skills will be a minimum of 10%.
- The weighting for the indirect assessment of practical skills and techniques will be a minimum of 15%.

The ability to select, organise and communicate information and ideas coherently using appropriate scientific conventions and vocabulary will be tested across the assessment objectives.

## 4 TECHNICAL INFORMATION

### 4.1 Making entries

This is a linear qualification in which all assessments must be taken at the end of the course. Assessment opportunities will be available in the summer series each year, until the end of the life of this specification. Summer 2018 will be the first assessment opportunity.

A qualification may be taken more than once. Candidates must resit all examination components in the same series.

The entry code appears below.

WJEC Eduqas AS Geology: B480QS

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

### 4.2 Grading, awarding and reporting

AS qualifications are reported as a grade on the scale from A to E. Results not attaining the minimum standard for the award will be reported as U (unclassified).

AS qualifications are free-standing and are awarded in their own right. Assessments at AS cannot contribute to an A level grade.

# APPENDIX A

## Working scientifically

The lists below outline the range and extent of practical skills and techniques required by WJEC Eduqas AS in Geology. These represent the skills and techniques outlined in the *Department for Education GCE AS and A level subject content for Geology* document (Appendix 1a, 1d and 1c as appropriate).

Part 1 identifies the practical skills identified for indirect assessment through written examinations.

Part 2 identifies the techniques to be undertaken by learners in order to develop practical skills and which may also contribute to indirect assessment through written examinations.

### **Part 1 - Practical skills identified for indirect assessment and developed through teaching and study**

Question papers will assess learners' abilities to:

#### **Independent thinking**

- solve problems set in geological contexts
- apply geological knowledge to practical contexts

#### **Use and application of scientific methods and practices**

- comment on investigation design and evaluate scientific methods
- present data in appropriate ways
- evaluate results and draw conclusions with reference to measurement uncertainties and errors
- identify variables including those that must be controlled

#### **Numeracy and the application of mathematical concepts in a practical context**

- plot and interpret graphs
- process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix (see Appendix C)
- consider margins of error, accuracy and precision of data

#### **Instruments and equipment**

- know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification

## **Part 2 – Use of apparatus and techniques**

The practical work specified in Appendix B has been chosen to facilitate learners in developing the skills and acquiring the techniques listed below.

### **Practical techniques to be completed by learners:**

- location of geological features in the field using traditional navigation and basic field survey skills without the use of GPS\*
- identification of geological structures in the field recording observations as field sketches\*
- use of a compass clinometer to measure two and three-dimensional geological data across a range of scales such as the dip and strike of planar surfaces, or the apparent dip of fold limbs exposed on a hillside or cliff section\*
- construct graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures\*
- use sampling techniques in fieldwork\*
- apply classification systems using distinguishing characteristics to identify unknown minerals and fossils
- produce annotated scientific drawing of fossils, or small scale features, from hand samples using a light microscope, or hand lens observation
- produce full rock description of macro and micro features from conserved hand samples and unfamiliar field exposures\*
- use of photomicrographs to identify minerals and rock textures
- use of physical and chemical testing to identify minerals to include:
  - density test
  - Mohs hardness test
- use methods to increase accuracy of measurements, such as timing over multiple observations, or use of a fiducial (scale in photograph/field sketch)
- use of ICT to:
  - compile and analyse geological data sets through to visualization using geographic information system (GIS)
  - collect, process and model geological data
- the measurement and description of the diagnostic properties of rocks in the field (colour, composition, grain/crystal size and grain/crystal shape, and sorting/texture)\*
- the collection of valid data in the field relating to the igneous, metamorphic or sedimentary processes that formed the rocks, including valid sampling\*
- the measurement and description of rock deformation in the field including valid sampling\*
- the use of geochronological principles in the field to place geological events in relative time sequences.\*

\* Fieldwork skills indicated in the list above are to be carried out at unfamiliar field exposures.

Questions in the two components could ask learners to either undertake, or refer to their knowledge of, any of the skills and techniques listed in part (1) or part (2).

# APPENDIX B

## Practical technique requirements and exemplification

Appendix B has been divided into three parts.

- Part 1 lists practical activities which provide opportunities for the development of required practical techniques. The code aids mapping of the practical activity within the 'Geological techniques and skills' column of the subject content within the specification
- Part 2 lists the practical technique requirements and maps them against the specified practical activities
- Part 3 lists the apparatus required to fulfil the exemplified practical activities

### Part 1 Practical activities which provide opportunities for the development of required practical techniques

Code	Practical activity which exemplifies the required practical techniques
P1	Investigation of diagnostic properties of minerals: colour, crystal shape, cleavage, fracture, hardness, relative density, streak, lustre, reaction with cold dilute (0.5 mol dm <sup>-3</sup> ) hydrochloric acid in order to identify minerals.
P2	Measurement of the density of minerals.
P3	Application of classification systems using distinguishing characteristics to identify unknown minerals.
P4	Production of scaled annotated scientific drawings of rock samples from hand samples using a light microscope, or hand lens observation.
P5	Production of full rock description of macro and micro features from hand specimens and unfamiliar field exposures of sedimentary rocks in order to interpret component composition, colour and textures, to identify rock types and to deduce their environment of deposition.
P6	Construction of graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures to record data relevant to an investigation.
P7	Use of photomicrographs to identify minerals and rock textures of sedimentary rocks in order to identify rock types and to deduce their environment of deposition.
P8	Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of igneous rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce their cooling history.
P9	Use of photomicrographs to identify minerals and rock textures of igneous rocks to identify rock type and to deduce their cooling history.

P10	Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of metamorphic rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce the temperature and pressure conditions of their formation.
P11	Use of photomicrographs to identify minerals and rock textures of metamorphic rocks to identify rock type and to deduce the temperature and pressure conditions of their formation.
P12	Location of geological features onto a base map.
P13	Identification of the location of geological features in the field using six figure grid references on maps.
P14	Production of scaled, annotated field sketches at unfamiliar field exposures to record data relevant to an investigation.
P15	Measurement of dip and strike elements: dip angle, dip and strike directions of planar surfaces, relevant to an investigation.
P16	Application of classification systems using distinguishing characteristics to identify unknown fossils.
P17	Production of scaled, annotated scientific drawings of fossils, using a light microscope, or hand lens observation.
P18	The application of one or more criteria of relative age (evolutionary change in fossils, superposition of strata, unconformities, cross-cutting relationships, included fragments, 'way-up' criteria) in the field to place geological events in relative time sequences.
P19	Measurement of densities of representative samples of Earth layers (e.g granite, basalt).
P20	Investigation of the relationships between earthquake data (focal depth, magnitude and distance from plate boundaries) using data on Google Earth™.



## Part 2

### Practical technique requirements and exemplification

Practical Technique	Practical activities which exemplify the practical technique
Location of geological features in the field using traditional navigation and basic field survey skills without the use of GPS.	<p>P12: Location of geological features onto a base map.</p> <p>P13: Identification of the location of geological features in the field using six figure grid references on maps.</p>
Identification of geological structures in the field recording observations as field sketches.	P14: Production of scaled, annotated field sketches at unfamiliar field exposures to record data relevant to an investigation.
Use of a compass clinometer to measure two and three-dimensional geological data across a range of scales such as the dip and strike of planar surfaces, or the apparent dip of fold limbs exposed on a hillside or cliff section.	P15: Measurement of dip and strike elements: dip angle, dip and strike directions of planar surfaces, relevant to an investigation.
Construct graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures.	P6: Construction of graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures to record data relevant to an investigation.
Use sampling techniques in fieldwork.	P6: Construction of graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures to record data relevant to an investigation.
Apply classification systems using distinguishing characteristics to identify unknown minerals and fossils.	<p>P16: Application of classification systems using distinguishing characteristics to identify unknown fossils.</p> <p>P3: Application of classification systems using distinguishing characteristics to identify unknown minerals.</p>
Produce annotated scientific drawing of fossils, or small scale features, from hand samples using a light microscope, or hand lens observation.	<p>P17: Production of scaled, annotated scientific drawings of fossils, using a light microscope, or hand lens observation.</p> <p>P4: Production of scaled annotated scientific drawings of rock samples from hand samples using a light microscope, or hand lens observation.</p>

<p>Produce full rock description of macro and micro features from conserved hand samples and unfamiliar field exposures.</p>	<p>P8: Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of igneous rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce their cooling history.</p> <p>P10: Production of full rock description of macro and micro features from hand specimens and/or unfamiliar field exposures of metamorphic rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>P5: Production of full rock description of macro and micro features from hand specimens and unfamiliar field exposures of sedimentary rocks in order to interpret component composition, colour and textures, to identify rock types and to deduce their environment of deposition.</p>
<p>Use of photomicrographs to identify minerals and rock textures.</p>	<p>P9: Use of photomicrographs to identify minerals and rock textures of igneous rocks to identify rock type and to deduce their cooling history.</p> <p>P11: Use of photomicrographs to identify minerals and rock textures of metamorphic rocks to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>P7: Use of photomicrographs to identify minerals and rock textures of sedimentary rocks in order to identify rock types and to deduce their environment of deposition.</p>
<p>Use of physical and chemical testing to identify minerals to include:</p> <ul style="list-style-type: none"> <li>• density test</li> <li>• Mohs hardness test.</li> </ul>	<p>P1: Investigation of diagnostic properties of minerals: colour, crystal shape, cleavage, fracture, hardness, relative density, streak, lustre, reaction with cold dilute (0.5 mol dm<sup>-3</sup>) hydrochloric acid in order to identify minerals.</p> <p>P2: Measurement of the density of minerals.</p>

<p>Use methods to increase accuracy of measurements, such as timing over multiple observations, or use of a fiducial (scale in photograph/field sketch).</p>	<p>P14: Production of scaled, annotated field sketches at unfamiliar field exposures to record data relevant to an investigation.</p> <p>P17: Production of scaled, annotated scientific drawings of fossils, using a light microscope, or hand lens observation.</p> <p>P4: Production of scaled annotated scientific drawings of rock samples from hand samples using a light microscope, or hand lens observation.</p>
<p>Use of ICT to:</p> <ul style="list-style-type: none"> <li>• compile and analyse geological data sets through to visualization using geographic information system (GIS)</li> <li>• collect, process and model geological data.</li> </ul>	<p>P19: Investigation of the relationships between earthquake data (focal depth, magnitude and distance from plate boundaries) using data on Google Earth™.</p>
<p>The measurement and description of the diagnostic properties of rocks in the field (colour, composition, grain/crystal size and grain/crystal shape, and sorting/texture).</p>	<p>P8: Production of full rock description of macro and micro features from unfamiliar field exposures of igneous rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce their cooling history.</p> <p>P10: Production of full rock description of macro and micro features from unfamiliar field exposures of metamorphic rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>P5: Production of full rock description of macro and micro features from unfamiliar field exposures of sedimentary rocks in order to interpret component composition, colour and textures, to identify rock types and to deduce their environment of deposition.</p>

<p>The collection of valid data in the field relating to the igneous, metamorphic or sedimentary processes that formed the rocks, including valid sampling.</p>	<p>P8: Production of full rock description of macro and micro features from unfamiliar field exposures of igneous rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce their cooling history.</p> <p>P10: Production of full rock description of macro and micro features from unfamiliar field exposures of metamorphic rocks in order to interpret component composition, colour and textures, to identify rock type and to deduce the temperature and pressure conditions of their formation.</p> <p>P5: Production of full rock description of macro and micro features from unfamiliar field exposures of sedimentary rocks in order to interpret component composition, colour and textures, to identify rock types and to deduce their environment of deposition.</p> <p>P14: Production of scaled, annotated field sketches at unfamiliar field exposures to record data relevant to an investigation.</p> <p>P6: Construction of graphic logs using appropriate scale and symbol sets for unfamiliar geological sequences and exposures to record data relevant to an investigation.</p>
<p>The measurement and description of rock deformation in the field including valid sampling.</p>	<p>P15: Measurement of dip and strike elements: dip angle, dip and strike directions of planar surfaces, relevant to an investigation.</p>
<p>The use of geochronological principles in the field to place geological events in relative time sequences.</p>	<p>P18: The application of one or more criteria of relative age (evolutionary change in fossils, superposition of strata, unconformities, cross-cutting relationships, included fragments, 'way-up' criteria) in the field to place geological events in relative time sequences.</p>

## Part 3

### List of apparatus

The following list documents the apparatus required to undertake the exemplified practical activities which meet the practical technique requirements for AS Geology.

- hand lens
- streak plate/unglazed tile
- steel pin/needle, e.g biology dissection pin or steel nail (5.5 on Mohs' Scale)
- copper coin
- cold, dilute hydrochloric acid  $0.5 \text{ Mol dm}^{-3}$
- water and a means of adding it dropwise to a sample, e.g. dropping bottle/teat pipette, etc.
- spring balance (or eureka can and electronic balance)
- light microscope (optional)
- grain size card
- tape measure or metre rule
- compass
- clinometer

## APPENDIX C

### Use of mathematical skills

The list below outlines the range and extent of mathematical skills required by WJEC Eduqas AS in Geology. The specific exemplifications are to aid understanding and could be developed in other areas of the specification content. Learners will be expected to apply mathematical skills in novel contexts.

Mathematical skills	Exemplification in the context of AS Geology
<b>Number</b>	
Recognise and make use of appropriate units in calculations	<ul style="list-style-type: none"> <li>• convert between units e.g. km to mm</li> <li>• work out the unit for a rate e.g. sedimentation rate</li> </ul>
Recognise and use expressions in decimal and standard form	<ul style="list-style-type: none"> <li>• use an appropriate number of decimal places in calculations e.g. for a mean</li> <li>• carry out calculations using numbers in standard and decimal form e.g. use of magnification</li> <li>• convert between numbers in standard and decimal form</li> <li>• understand that significant figures need retaining when making conversions between standard and decimal form e.g. 0.063 mm is equivalent to <math>6.3 \times 10^{-2}</math> mm</li> </ul>
Use an appropriate number of significant figures	<ul style="list-style-type: none"> <li>• report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures. i.e. the answer is expressed to the same number of significant figures as the numbers involved in the calculation e.g. <math>5.71 \times 1.26 = 7.19</math>. If the numbers involved have a different number of significant figures then it is the lowest number of significant figures used that the answer is expressed to e.g. <math>5.7 \times 1.26 = 7.2</math></li> <li>• understand that calculated results can only be reported to the limits of the least accurate measurement</li> </ul>
Use ratios, fractions and percentages	<ul style="list-style-type: none"> <li>• calculate percentage crustal shortening</li> <li>• calculate surface area to volume ratio</li> <li>• use scales for measuring</li> </ul>
Make order of magnitude calculations	<ul style="list-style-type: none"> <li>• use and manipulate the magnification formula magnification = <math>\frac{\text{size of image}}{\text{size of real object}}</math></li> </ul>
Estimate results	<ul style="list-style-type: none"> <li>• estimate results to sense check that the calculated values are appropriate</li> </ul>

<b>Statistics and probability</b>	
Find arithmetic means	<ul style="list-style-type: none"> <li>find the mean of a range of data e.g. the mean clast size</li> </ul>
Construct and interpret frequency tables and diagrams, bar charts and histograms	<ul style="list-style-type: none"> <li>represent a range of data in a table with clear headings, units and consistent decimal places</li> <li>interpret data from a variety of tables e.g. data relating intrusive dykes</li> <li>plot a range of data in an appropriate format e.g. grain size distribution as a cumulative frequency graph</li> <li>interpret data for a variety of graphs e.g. explain seismograph traces</li> </ul>
Understand the principles of sampling as applied to scientific data	<ul style="list-style-type: none"> <li>estimate optimum sample size from a plot of number of clasts sampled against running mean of mean b-axis length</li> </ul>
Understand the terms mean, median and mode	<ul style="list-style-type: none"> <li>calculate or compare the mean, median and mode of a set of linear data e.g. Folk and Ward graphic statistics from sieve analysis of sand samples from different sedimentary environments</li> </ul>
Understand measures of dispersion, including standard deviation and interquartile range	<ul style="list-style-type: none"> <li>calculate the standard deviation</li> <li>understand why interquartile range might be a more useful measure of dispersion for a given set of data than standard deviation e.g. where there is an extreme observation which is part of the inherent variation</li> </ul>
Plot two variables from experimental or other linear data	<ul style="list-style-type: none"> <li>select an appropriate format for presenting data: bar charts, histograms, graphs, triangular diagrams and scatter diagrams (scattergrams)</li> </ul>
Use a scatter diagram to identify a correlation between two variables	<ul style="list-style-type: none"> <li>interpret a scatter diagram (scattergram) e.g. rate of plate motion against total length of subducting plate margin</li> </ul>
<b>Algebra and graphs</b>	
Understand and use the symbols: =, <, <<, >>, >, α and ~	
Change the subject of an equation	<ul style="list-style-type: none"> <li>use and manipulate equations e.g. magnification, velocity, density</li> </ul>

Translate information between graphical, numerical and algebraic forms	<ul style="list-style-type: none"> <li>understand that data may be presented in a number of formats and be able to use these data e.g. time distance curves for earthquakes</li> </ul>
Understand that $y = mx + c$ represents a linear relationship	<ul style="list-style-type: none"> <li>predict/sketch the shape of a graph with a linear relationship e.g. burial curves in a sedimentary basin or the effect of intrusion size on the width of the baked margin</li> </ul>
Calculate rate of change from a graph showing a linear relationship	<ul style="list-style-type: none"> <li>calculate a rate from a graph e.g. geothermal gradient through the lithosphere</li> </ul>
<b>Geometry and measures</b>	
Visualize and represent 2D and 3D forms, including 2D representations of 3D objects	<ul style="list-style-type: none"> <li>draw geological cross-sections interpreted from geological maps</li> <li>interpret block diagrams to show geological structures in 3D</li> <li>interpret field exposures and record 3D geological structures using a field sketch</li> </ul>



# APPENDIX D

## Scientific skills

Scientific skill	Areas of the specification which exemplify the scientific skill (assessment is not limited to the examples below)
Use theories, models and ideas to develop geological explanations	1.1d 2.2a 2.3a 3.1a 3.1b 3.2a 3.2b 4.1a 4.2b
Use knowledge and understanding to pose scientific questions, define geological problems, present scientific arguments and geological ideas	1.1g 2.1d 2.1e 2.1g 2.2b 2.2e 2.3a 2.3f 3.1b 3.1d 3.1g 3.2a 3.2b 4.1a 4.1b 4.2b
Use appropriate methodology, including information and communication technology (ICT), to answer geological questions and solve geological problems	1.1g 2.1d 2.1e 2.1g 2.2b 2.2e 2.3a 2.3f 2.3g 3.1b 3.1d 3.1g 3.2a 3.2b 4.1a 4.1b 4.2b
Carry out fieldwork, experimental and investigative activities in a range of contexts to include the collection, compilation and analysis of Earth Science data from the field and subsurface, and appropriate risk management	1.1e 2.1d 2.2b 2.2c 2.2e 2.3a 3.2a 4.1a
Manipulate and extrapolate these sometimes incomplete data sets in both two and three-dimensions	2.3
Evaluate methodology, evidence and partial data sets, and resolve conflicting evidence	2.1d 2.1e 2.1g 2.2b 2.2e 2.3a 2.3f 3.1b 3.1d 3.1g 3.2a 3.2b 4.1a 4.1b 4.2b
Communicate information and ideas in appropriate ways (including geological maps and cross-sections) using appropriate terminology, SI units and their prefixes and the ability to express in standard form	2.2a 2.3 4.1a 4.1b 4.2b
Know that scientific knowledge and understanding develops over time, consider applications and implications of science in geology, and evaluate their associated benefits and risks	4.2a 4.2b
Evaluate the role of geology within the scientific community in validating new knowledge and ensuring integrity	4.2a 4.2b

# APPENDIX E

## SI units in geology

The International System of Units (Système International d'Unités), which is abbreviated as SI, is a coherent system of base units. The six which are relevant for AS and A level geology are listed below. We also list eight of the derived units (which have special names) selected from the SI list of derived units in the same source.

### Base units

These units and their associated quantities are dimensionally independent: metre (m), kilogram (kg), second (s), ampere (A), kelvin (K) and mole (mol).

### Some derived units with special names

Frequency hertz (Hz), force newton (N), energy joule (J), power watt (W), pressure pascal (Pa), electric charge coulomb (C), electric potential difference volt (V) and electric resistance ohm ( $\Omega$ ).

### Some non-standard units used in geology

Time day (d), time year - annum (a) and mass tonne (t).