GEOLOGY
Higher

Seventh edition – published March 2010

NOTE OF CHANGES TO ARRANGEMENTS SEVENTH EDITION PUBLISHED MARCH 2010

COURSE TITLE:	Geology (Higher)
COURSE NUMBER:	C043 12

National Course Specification:

Course Details:	Minor corrections to general advice on fieldwork reports held over from previous editions; no change to actual specifications

National Unit Specifications:

All Units	No changes

National Course Specification

GEOLOGY (HIGHER)

COURSE NUMBER C043 12

COURSE STRUCTURE
This course has four mandatory units as follows:

D8XK 12	***Minerals and Rocks***	***1 credit (40 hours)***
D250 12	***Earth Physics, Structural Geology and Plate Tectonics***	***1 credit (40 hours)***
D251 12	***Fossils and Stratigraphy***	***0.5 credit (20 hours)***
D252 12	***Economic Geology***	***0.5 credit (20 hours)***

It is recommended that the units be taught in the order given above.

All courses include 40 hours over and above the 120 hours for the component units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained Intermediate 2 Geology or its component units. It would, however, be possible for able students to enter the course with no prior knowledge of geology. Previous experience of a science or Geography at Credit or Higher Level would be advantageous.

Administrative Information

Publication date: March 2010

Source: Scottish Qualifications Authority

Version: 07

National Course specification (cont)

COURSE: Geology (Higher)

CORE SKILLS

This course gives automatic certification of the following:

Complete core skills for the course	Problem Solving	Higher
Additional core skills components for the course	Using Graphical Information	Higher

For information about the automatic certification of core skills for any individual unit in this course, please refer to the general information section at the beginning of the unit.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Course specification: course details

COURSE: Geology (Higher)

RATIONALE

Geology at Higher level builds on and extends knowledge, understanding, skills and attitudes already developed in Intermediate 1 and Intermediate 2 Geology.

- Candidates will acquire detailed knowledge of a range of topics, such as Earth materials, Earth resources, and Earth history
- Candidates will develop understanding and appreciation of concepts such as evolution, plate tectonics, and reversals of the Earth's magnetic field
- Skills such as those of observation, interpretation, analysis, problem solving and communication will be improved
- Through study of problems of overuse and misuse of resources, candidates will acquire positive attitudes towards concepts such as conservation and sustainable development
- Through the vehicle of fieldwork, candidates will develop a greater awareness of the need to care for their local environment
- Geology is a subject with a strong Scottish dimension. By studying Geology at Higher level, candidates will gain insight into our natural, historical and industrial heritage
- Geology draws on aspects of chemistry, physics, biology, geography, civil engineering, and economics. Because of its wide-ranging nature, geology contributes to a sound general education

Aims of the course

The main aims of the course are to:

- provide candidates with a broad-based scientific education
- develop practical and analytical skills
- foster positive attitudes towards caring use of Earth resources
- develop greater awareness of the natural environment and of the processes which have shaped it.

COURSE CONTENT

The four units will cover the following topics:

Minerals and Rocks (40 hours)

Minerals (identification; chemical composition; atomic structure). The formation of igneous, sedimentary and metamorphic rocks. The study of minerals and rocks under the polarizing microscope. The study of rocks in the field.

Earth Physics, Structural Geology and Plate Tectonics (40 hours)

Earthquakes and the internal structure of the Earth. Isostasy; the Earth's magnetic field; the Earth's internal heat. Geological structures; geological maps; continental drift and sea-floor spreading; the study of geological structures in the field.

Fossils and Stratigraphy (20 hours)

Uses of fossils in stratigraphy; palaeoecology; evolution; measurement of geological time; principles of stratigraphy; aspects of British stratigraphy.

Economic Geology (20 hours)

Resources and reserves. The formation of ores, fossil fuels and evaporates. Finding and extracting resource materials.

National Course Specification: course details (cont)

COURSE: Geology (Higher)

MINERALS AND ROCKS

CONTENT	NOTES
Minerals	
Silicates: feldspars (orthoclase, microcline, plagioclase), amphibole, pyroxene, olivine, mica (biotite, muscovite), garnet, chlorite, clay mineral. *Oxides*: quartz, haematite, magnetite, cassiterite.	The chemical groups to which the minerals belong should be known. For mineral identification, the following properties and tests should be studied: colour, streak, lustre, hardness, relative density, fracture, cleavage, crystal shape, reaction with acid, flame tests, magnetism.
Sulphides: pyrite, chalcopyrite, sphalerite, galena. *Halides*: halite, fluorite. *Sulphates*: gypsum, barite. *Carbonates*: calcite, dolomite, malachite. *Elements*: diamond, graphite, sulphur, copper, silver, gold.	The uses of minerals should be mentioned: eg, barite in drilling muds; diamonds in drill bits; ore minerals.
Properties of atoms and the atomic structures of minerals Atomic number, relative atomic mass, ionic radius, ionic and covalent bonding, SiO_4 tetrahedra, ionic substitution in olivine and plagioclase, polymorphism, isomorphism, solid solution.	To study crystal shapes, crystals of sodium chloride or copper sulphate may be grown from solution. Alums and Tutton salts provide good examples of isomorphism; for example, chrome alum will continue to grow on a crystal of potash alum and the coloured Tutton salts continue to grow on crystals of each other.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
The atomic structures of quartz, diamond, graphite, halite, mica and pyrite should be related to hardness, cleavage, fracture, relative density and crystal shape.	From atomic models or diagrams, a candidate should be able to say that halite and pyrite form cubic crystals, and that graphite forms hexagonal crystals. Similarly, from a comparison of diamond and graphite models, candidates should surmise that diamond is denser, harder and has less well-developed cleavage than graphite. Candidates would not be expected to identify the crystal systems to which quartz, mica and diamond belong.
Rocks	
Colour, grain size, constituents (minerals, rock fragments, fossils and fossil fragments). Texture (grain size, grain shape, grain orientation, crystalline or fragmental); structures (eg, bedding, foliation, lineation, flow banding, trace fossils).	
The following rocks should be studied: granite, felsite, rhyolite, pitchstone, obsidian, trachyte, diorite, andesite, gabbro, dolerite, basalt, peridotite, tuff, breccia, conglomerate, sandstone, orthoquartzite, greywacke, arkose, siltstone, clay, mudstone, shale, limestone, chalk, shelly limestone, coral limestone, crinoidal limestone, oolitic limestone, evaporite, ironstone, coal, chert, flint, slate, phyllite, schist, gneiss, migmatite, marble, hornfels, metaquartzite, fault breccia, mylonite.	Care should be exercised in the choice of specimens to ensure that they show clearly visible properties. (For example, the rhyolite should show flow banding; the greywacke should be sufficiently coarse-grained to show obvious lithic fragments; and the migmatite should show evidence of partial melting.) Different types of granite, conglomerate, sandstone, shale, marble, schist and gneiss should be shown. For thermally metamorphosed rocks, specimens showing the progressive increase in metamorphic grade towards the intrusion should be used.

CONTENT	SUPPLEMENTARY NOTES
Minerals and rocks under the microscope	
Shape, colour, transparency and opacity, relief, cleavage, fracture, pleochroism, polarization colours, twinning, extinction, isotropism and anisotropism.	The optical properties of minerals would ideally be studied by means of thin sections and a polarizing microscope. Alternatively, a slide projector or biological microscope can be appropriately modified. Photographic slides may also be used.
Candidates should be able to describe and identify the following minerals: quartz, microcline, plagioclase, amphibole, pyroxene, olivine, garnet, biotite, muscovite, calcite.	
The following properties of rocks should be studied. *Constituents*: minerals, glass, rock fragments, fossil fragments. *Texture*: grain shape, grain size, grain orientation, crystalline or fragmental.	Thin sections of minerals and rocks should show obvious properties. For example, plagioclase and microcline should show obvious twinning; olivine should show some black cracks; arkose should show obvious feldspar; limestone should show fossil fragments; the schist should preferably contain garnet; and the marble should consist entirely of calcite.
Candidates should be able to describe and identify the following rocks: granite, diorite, gabbro, dolerite, porphyritic basalt, sandstone, arkose, greywacke, limestone, schist, marble.	
Igneous rocks	
Classification: in terms of grain size and mineralogy. Acidic, intermediate, basic and ultrabasic igneous rocks.	Where possible, rocks should be studied in the field.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Crystallisation and differentiation of magmas; factors controlling grain size; supercooling and the formation of glasses.	Crystallisation from a melt may be studied by microscopic examination of cooling molten acetamide on a glass slide. The effect of cooling rate on crystal size can be seen by slowly and quickly cooling molten urea on glass slides or molten Wood's metal. Supercooling can be shown by recording the temperature of molten sodium thiosulphate as it cools from a temperature of about 80 °C. It remains liquid below its freezing point of 49 °C. The addition of a small seed crystal allows crystallisation to occur.
Pegmatites.	Formation of pegmatite magma. Dry granite magma would normally have about 0.2% water by mass. Crystallisation of anhydrous minerals results in the formation of a watery residue (water content >5% by mass) which is enriched in elements such as fluorine, boron, lithium, tin, tungsten and uranium. Large crystals grow from this mobile, water-rich magma.
Magmatic hydrothermal solutions.	Magmatic hydrothermal solutions may hold 25% by mass of dissolved minerals scavenged directly from the magma. It should be pointed out that magmas are not the only source of hydrothermal solutions.
Magma types: chemical composition, origin and distribution of basaltic, andesitic and granitic magmas; tectonic significance of distribution of magma types.	The chemical compositions of rocks and magmas should be expressed in terms of oxides. It should be strongly pointed out, however, that the appearance of an oxide in an analysis does not mean that the oxide is present in the rock as an oxide mineral. Candidates should appreciate the links between major oxide concentration (SiO_2, MgO, FeO, Fe_2O_3, CaO, K_2O, Na_2O) and rock type. The ways in which the main magma types form should be known. Basaltic magma: formed by partial melting of peridotite. Andesitic magma: formed by partial melting of subducted oceanic crust and by fractionation of basaltic magma which has itself come from partial wet melting of peridotite in the mantle wedge above a subduction zone. Granitic magma: formed by fractionation of basaltic and andesitic magmas; by partial melting of diorite intrusions emplaced above subduction zones; and by partial melting of continental crustal rocks at destructive margins.

CONTENT	SUPPLEMENTARY NOTES
	The distribution of the main magma types should be related to constructive and destructive plate margins. Large-scale basaltic activity away from plate margins (eg Hawaii) and sometimes coincident with plate margins (eg, Iceland) results from partial melting in a mantle plume.
Volcanoes: Eruptions (central vent, fissure; explosive, effusive); role of gases in volcanicity.	Candidates should realise that magmas are often rich in volatiles. In non-explosive basaltic volcanic activity (eg, Hawaii) the magma has a low viscosity so the gas can easily escape. In explosive andesitic and rhyolitic activity, the gas is trapped by the viscous lava. The build-up of gas pressure causes explosions. Candidates should be aware of the fact that the viscosity of a magma increases rapidly on cooling so that gas may be trapped as bubbles. Specimens of vesicular basalt and pumice could usefully be examined here.
Ignimbrites. Caldera formation. Predicting volcanic eruptions.	Ignimbrites often come from granite magmas produced by partial melting of gneisses at destructive margins. Ignimbrites are deposited from ash-flows (hot clouds of gas and pumice). Reference could be made to the eruption of Katmai, Alaska, in 1912. Calderas may form by the collapse of a volcano into an evacuated magma chamber (Crater Lake, Oregon) or by the blowing away of a volcanic cone (Krakatoa, Indonesia). Candidates should study these or other examples. A brief consideration should be given to the topic of predicting eruptions. The following should be considered: seismic activity; use of tiltmeters and laser ranging to detect ground movement.
Intrusions: necks, ring dykes, cone sheets.	Volcanic necks, ring dykes and cone sheets can be shown by means of models and maps. Maps of areas such as Ardnamurchan, Arran, Mull and Glen Coe should be inspected.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Contact metamorphism. Contact metasomatism.	It should be mentioned that intrusive igneous activity may alter country rocks in two ways: in contact or thermal metamorphism the rocks are heated and they may partly or wholly recrystallise; the overall chemistry of the rock does not change to any great extent. In contact metasomatism fluids from the magma carry chemicals into the surrounding rock; the chemistry of the country rock is changed. Contact metasomatism is more commonly produced by wet granitic magmas than by dry gabbroic magmas. Limestones react with the acidic magmatic fluids. This causes a reduction in volume which gives space for the deposition of minerals which may be of economic significance (eg, magnetite and sulphides of Zn, Pb, Cu).
Sedimentary rocks	
Classification: in terms of grain size, composition and origin.	There will be no need for candidates to know the diameters of fragments such as cobbles, pebbles and sand grains. Relative sizes should, however, be known.
Origin of sedimentary rocks: physical, chemical and biological weathering; entrainment, transport and deposition of sediment by water, wind and ice. Hjulstrom diagram.	Experiments on weathering processes could be carried out (eg, freeze-thaw action on shale and sandstone; solution of limestone by weak acids). Gravestones, being dated, are particularly useful for showing how different rocks respond to weathering. To show entrainment, transport and deposition by water, a stream table could be used. Sediment movement by air can be shown by using a hair dryer. Transport by ice can be simulated by means of a stream of syrup or other very viscous liquid. A turbidity current can be shown by running a cold, salty suspension of $CaCO_3$ into a tilted cylinder of warm water. Grain-size analysis should be carried out by sieving. The characteristics of sediments (eg, grain size, degree of sorting) from different environments should be compared.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Sediments formed from organic remains. Sediments formed by chemical and biochemical precipitation.	The processes by which the following rocks were formed should be considered: coal, chalk, coral limestone, crinoidal limestone, shelly limestone, evaporites, oolitic limestone, banded ironstone.
Turbidites.	Turbidites are deposited by turbidity currents. As a turbidity current slows it would ideally deposit a sequence which would be coarse-grained and massive at the base through medium-grained layers to mud at the top. Sole marks and graded bedding are common in turbidite deposits. It should be noted that the terms 'greywacke' and 'turbidite' are not synonymous. Some greywackes were deposited by turbidity currents while others were not so deposited.
Diagenesis, compaction and cementation.	Clear distinctions should be drawn between the terms 'diagenesis,' 'compaction' and 'cementation': diagenesis describes all of the changes which affect a sediment after deposition whereas compaction and cementation are two of many diagenetic processes.
Sedimentary structures: bedding (regular, cross, graded, convolute), ripple marks, mudcracks, sole markings, rainprints, trace fossils.	A circular flume can be used to show the modes of formation of structures such as ripple marks, cross-bedding and graded bedding.
Environments of deposition: glacial, glaciofluvial, fluvial (alluvial fan and alluvial plain), desert, deltaic, lacustrine, marine (beach, continental shelf, oceanic). Environmental facies as the total set of features possessed by a sediment deposited in a particular environment.	Candidates should realise that rocks of different ages deposited in similar environments will have similar characteristics.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Metamorphic rocks	
Classification: in terms of origin, mineralogy and texture (random or preferred grain orientation).	
Contact metamorphism: characteristics of rocks formed by this process; metamorphic aureole; metamorphism of shale, slate, sandstone and limestone; metamorphic grade.	Examples such as the aureoles of the Comrie Diorite and the Skiddaw Granite could be considered.
Regional metamorphism: characteristics of rocks formed by this process; association with orogenesis; metamorphic grade; index minerals; chlorite, biotite and garnet zones of the Scottish Highlands.	Metamorphism of Dalradian, Moinian and Lewisian rocks should be discussed.
Dynamic metamorphism: characteristics of rocks formed by this process; association with movements along faults and shear zones.	It should be noted that the mylonites in the northwest Highlands were formed in shear zones long before movements took place on the major thrusts. Dynamic metamorphism associated with the Outer Isles Thrust Zone could be discussed.
The rock cycle.	Specific examples of changes within the rock cycle could be given: eg, the quartz in sandstone could have come from rocks such as granite, gneiss or other sandstones; granite may have been produced by the partial melting of pre-existing rocks; schist may have been a rock such as mudstone, tuff or basalt.

National Course Specification: course details (cont)

EARTH PHYSICS, STRUCTURAL GEOLOGY AND PLATE TECTONICS

CONTENT	SUPPLEMENTARY NOTES
Earthquakes	
Properties of earthquakes: focus, epicentre, intensity, isoseismal lines, magnitude.	
Properties of P and S waves. Mention of surface waves.	The characteristics of P and S waves can be shown by means of a loose 'slinky' spring. Candidates should be aware of the facts that P waves travel about twice as fast as S waves and that S waves will not travel through liquids. Surface waves result from the interaction between the ground surface and P and S waves.
Reflection and refraction.	The reflection, refraction and focusing of earthquake waves may be modelled by means of mirrors and lenses.
Recording earthquakes. Drawing travel-time curves.	Candidates should know that the seismogram is the record while the recording instrument is the seismometer or seismograph. (Strictly speaking, the seismometer is the detector while the seismograph is the detector plus the recording apparatus. There is no need to distinguish between these terms.)
Plotting epicentres. Mention of Richter and modified Mercalli scales.	It should be pointed out that the Mercalli scale is an intensity scale based on observation. The much more useful Richter magnitude scale is based on the energy released by an earthquake.
Low speed layer.	The low speed layer (also called the low velocity zone) is found within the depth range 50-220 km. Reduction in the speeds of P and S waves may be due to the fact that this layer is slightly molten. (The degree of partial melting is not certain. Some sources say about 10%; others say the melt may make up only about 0.01% of the layer.) Note that the terms 'asthenosphere' and 'low speed layer' are not synonymous. However, some authorities define these layers as being coincident.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Isostasy Simple qualitative treatment of gravity anomalies; isostatic adjustments to glaciation and deglaciation.	Isostatic movements of the lithosphere can be modelled by means of a floating wooden block slowly loaded with ice. As the ice melts, the readjustment of its floating position can be noted. Reference should be made to: isostatic depression of Greenland and Antarctica; raised shorelines around the British Isles; and uplift of the Gulf of Bothnia.
The Earth's magnetic field	
Simple treatment of the Earth's magnetic field.	Candidates should know that the field is, to a first approximation, axial and dipolar. They should also know that the field is produced by electrical currents flowing in the outer core. (A conventional current flowing east-west under the equator would produce the Earth's field.)
Remanent magnetism.	While candidates may determine the fields of bar magnets, they should realise that the Earth's field is not based on a permanent magnet.
Reversals of the magnetic field.	When a rock forms, its magnetic minerals become lined up with the existing magnetic field. The rock (especially iron-rich igneous rocks, such as basalt) provides a record of the strength and direction of the ancient magnetic field. Studies of remanent magnetism allow apparent polar wander curves to be constructed and they show that the field has periodically reversed. A detailed explanation of why the field reverses is not required. Suffice it to say that the electrical currents in the outer core change direction.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
The Earth's internal heat	
Main heat source.	At present, most heat is generated by the decay of long-lived radioisotopes (mainly U, Th and ^{40}K). About half of the Earth's heat flow is of radiogenic origin. Most of the remaining heat was generated when the Earth formed (eg, from accretion, core formation and the decay of short-lived radioisotopes).
Heat flow.	Mention that heat flows through the lithosphere by conduction. Differences in heat flow in different areas (normal oceanic and continental crust; oceanic ridges; continental volcanic areas; oceanic trenches) should be noted.
Geothermal gradients.	Exercises in which temperature is plotted against depths should be given. Candidates should be able to explain why some gradients are steep and some are shallow. Areas where steep and shallow gradients prevail should be noted. There is no need to mention the thermal conductivities of rocks.
Effect of pressure on the melting points of rocks.	Candidates should realise that the melting points of rocks increase with pressure. Deep in the Earth they may be very hot but they generally remain solid. Reduction in pressure (eg, under oceanic ridges) causes partial melting and magma generation. Plots of temperature and melting point against depth could usefully be drawn. Partial melting would occur only where the melting point curve lay above the geothermal gradient.
Geothermal energy	Mention should be made of the two main sources: hot igneous rocks (eg, Iceland; Larderello, Italy) sedimentary basins (eg, Paris Basin).

CONTENT	SUPPLEMENTARY NOTES
The structure of the Earth	
Internal structure and composition of the Earth.	This should come mainly from a study of the behaviour of earthquake waves.
Brief study of meteorites.	Meteorites should be mentioned as having come from differentiated bodies (irons have come from the core; stony-irons have come from the core-mantle boundary; and stones have come mostly from the mantle).
Structural geology	
Stress and strain; elastic, plastic, ductile and brittle behaviour; creep.	Stress should be seen as being akin to pressure, while strain is change in shape of a body under stress. The behaviour of various materials should be studied (eg, rubber, modelling clay, chewing gum, blackboard chalk). Creep can be shown by using pitch or silicone putty. The effect of temperature should be noted (eg, toffee is brittle at low temperature, but it becomes plastic on warming). Graphs of stress against strain should be drawn for various materials. It should be noted that some materials (eg, copper wire) are elastic at low levels of stress but they become plastic as stress is increased.
Strike and dip.	
Faults: normal, reverse, thrust, tear. Slip and throw. Slickensides, fault breccia, Rift valleys, nappes.	
Folds: anticline; syncline; dome; basin; antiform; synform; similar and parallel folds. Plunge. *Igneous bodies*: lava flow; sill; dyke; volcanic plug; stock; ring dyke; cone sheet.	There is no need to distinguish between concentric and parallel folds. Folding experiments may be carried out on materials such as layered modelling clay and foam rubber sheets. The card deck model should be used for similar folds and the phone book model should be used for parallel folds.

CONTENT	SUPPLEMENTARY NOTES
Unconformity.	In this unit igneous bodies and unconformities should be viewed as structural entities. Candidates should be able to identify them on maps and in sections.
Lineation: grain-elongation; cleavage-bedding intersection.	Candidates will not be asked to explain their modes of formation.
Foliation: fracture cleavage; slaty cleavage; schistosity; gneissose banding.	Modelling clay with inscribed circles and embedded rice grains can be squeezed to show how foliation may develop.
Joints: columnar, sheet, shear, tension.	The formation of columnar joints may be modelled by allowing a layer of mud to dry. Structures akin to tension joints can be produced by pulling rubber previously painted with typing correction fluid.
Drawing and using straight structure contours.	Contours should be drawn on planar structures and used to find the direction and angle of dip; the throw on a fault; and the area under which opencast mining may take place when a depth restriction applies to mining. Problem maps should sometimes use borehole data instead of, or in combination with, topographic contours.
Plate tectonics	
Evidence for continental drift; apparent polar wander curves; sea-floor spreading; magnetic stripe anomalies; characteristics of transform faults; properties of plates and plate boundaries; lithosphere and asthenosphere; gravity anomalies associated with destructive margins; mechanisms of plate movement.	The evidence for continental drift should be drawn from the continents bordering the Atlantic (eg, matching geology, cratons and orogenic belts; fit of continents along 1000m depth contour; fossils such as *Mesosaurus*; area covered by south polar ice cap 300 Ma ago). Types of igneous activity at constructive and destructive margins; and regional metamorphism at destructive margins should be mentioned. For information: Lithosphere thickens away from oceanic ridges. Old oceanic lithosphere is about 100km thick. Continental lithosphere is about 200km thick. Plates attached to subduction zones move relatively quickly because of the pulling effect of the sinking slab.

National Course Specification: course details (cont)

FOSSILS AND STRATIGRAPHY

CONTENT	SUPPLEMENTARY NOTES
Fossils	
Palaeoecology: knowledge of basic ecological terms (environment, habitat, community, ecosystem, niche, producer, consumer, food chain, food web, pyramid of biomass); fossils as indicators of palaeoenvironments; how the study of modern forms can help us to interpret past environments.	A brief study of the geologically significant effects of life on Earth (eg, all of the oxygen in the atmosphere has come from photosynthesis; fossil fuels have an organic origin; removal of CO_2 from the atmosphere and oceans by plants and animals; thick organic limestones). Fossils as the remains and traces of organisms preserved in rocks.
	A useful study could be made of how the forms of shoreline animals relate to their lifestyles. Comparisons could be drawn among *Echinus*, *Echinocardium* and *Clypeaster* and among *Solen*, *Mytilus* and *Pecten.* It should be pointed out that fossilisation is a highly selective process and that complete communities will never be preserved.
Characteristics of life and death assemblages.	A shoreline study could show how these assemblages may form. Burrowing animals (eg, *Cerastoderma* and *Mya*) may form fossil life assemblages while attached and mobile animals on rocky shores (eg, *Mytilus*, *Littorina* and *Patella*) would not form life assemblages.
Evolution	
Changes in *Micraster* related to improved adaptation to burrowing.	Specimens of *Micraster leskei*, *M. cortestudinarium* and *M. coranguinum* should be studied. The following changes should be noted: (i) change in shape of the test and in position of mouth; (ii) lengthening of petaloid ambulacra; and (iii) deepening of anterior groove. The evolutionary significance of these changes should be pointed out. *Micraster* could usefully be compared with *Echinocardium*.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Zones	
The zone as a biological unit used in stratigraphy: characteristics of good zone fossils.	It should be pointed out that a zone is defined by the presence of one or more distinctive fossils. Good zone fossils should have these characteristics: • They should have a wide, preferably inter-continental, distribution • They should have a narrow vertical range so they define a very restricted part of the stratigraphical column. This means that they have evolved rapidly, and quickly become extinct • They should be common. This means that zone fossils generally have hard parts which allowed for easy preservation • They should be independent of facies. This means that planktonic or free-swimming marine organisms make the best zone fossils. It should be noted that plant spores, pollen grains and fresh-water fish may be used to zone terrestrial deposits. Problems of correlating marine and terrestrial zones in Devonian, Carboniferous and Quaternary sequences should be mentioned.
The use of graptolites in zoning the Lower Palaeozoic; and ammonoids in zoning the Late Palaeozoic and Mesozoic.	In graptolites, the following evolutionary changes should be studied: • reduction in the number of stipes on the rhabdosome • stipes changing from being pendent to scandent • reduction in the number of thecae. The increasing complexity of the ammonoid suture line from goniatites through ceratites to ammonites should be noted.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Stratigraphy	
The geological column. Stratigraphical units.	A clear distinction should be drawn among the various stratigraphical units. *Time units*: eg, era, period, age. It should be pointed out that these units do not have fixed lengths. *Rock units*: eg, bed, formation. Such units have no time connotations. *Rock-time units*: eg, system. A system is all the rocks formed during a period. *Biological units:* eg, zone. A zone is defined by its fossil content. This unit has no lithological or time connotations.
Principles of stratigraphy	
Laws and principles of stratigraphy: original continuity; original horizontality; superposition; cross-cutting relationships; faunal succession; faunal assemblage, included fragments; uniformitarianism.	Candidates should understand the ideas which underpin these laws and principles. They will not be expected to name or define any of them. For information, the definitions are briefly as follows: *Original continuity*: a bed continues laterally in all directions till it thins out as a result of non-deposition or until it reaches the edge of the basin of deposition. *Original horizontality*: sediments are deposited in layers which are horizontal or nearly so. *Superposition*: when a sequence of sedimentary rocks is deposited, the oldest bed is at the bottom and the youngest bed is at the top. *Cross-cutting relationships*: a rock or structure is younger than any rock or structure through which it cuts. *Faunal succession*: fossil forms succeed one another in a definite and habitual order. *Faunal assemblages*: similar assemblages of fossils indicate similar ages for the rocks which contain them. *Included fragments*: a rock is younger than the fragments which it contains. *Uniformitarianism*: 'present is the key to the past'. The processes operating today have always operated. This does not mean that present-day conditions have always existed. It does not exclude the possibility of catastrophic events, such as asteroid and comet impacts. It means that the same physical and chemical laws have operated throughout the history of the Earth.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Stratigraphic relationships: unconformity; overlap; diachronism. Cyclothems.	
Way-up criteria. Environmental facies and facies fossils. *Correlation*: matching up sequences in different areas on the basis of lithology or chronology; use of time marker horizons characterised by distinctive lithology or fossils; use of zones; use of varves in dating the Quaternary; correlation by means of geophysical, geological, and palaeontological borehole logs. *Radiometric dating*: radioactive isotopes; half-lives; final decay products. *Decay schemes*: K/Ar; Rb/Sr; U/Pb; ^{14}C / ^{14}N. Materials used in dating: eg mica and some rocks for K/Ar and Rb/Sr; zircon for U/Pb; peat and bone for ^{14}C. Dating metamorphic events.	Environmental facies refers to the total set of characteristics possessed by a sediment deposited in a particular environment. It would include a description of rock types and rock properties; sedimentary structures and fossils. The limited use of facies fossils in zoning and correlation should be noted. A clear distinction should be drawn between rock and time correlation. Problems caused by diachronous beds should be discussed. Candidates are not required to know how geophysical logs are produced. They should, however, understand the need for precise correlation in the search for fossil fuels. It should be noted that different decay schemes are used to date different events; eg, ^{14}C is used to date part of the Quaternary while Rb/Sr is often used to date Precambrian rocks. The reason for such a difference should be understood. It should also be noted that minerals may be younger than the rocks in which they lie; eg, metamorphism of a granite would allow metamorphic minerals to crystallise. Dating these minerals would give the date of metamorphism. Dating the whole rock would give the time when the granite was intruded.

CONTENT	SUPPLEMENTARY NOTES
Problems of dating sedimentary rocks.	Sedimentary rocks are difficult to date because the fragments they contain are older than the rock.
The age of the Earth. Dating meteorites.	
Geological history of the local area	
The principles of stratigraphy should be applied to a study of the local area.	Since no two areas are the same only a selection of the following would apply.
Times when the rocks were formed.	For example, were the rocks formed during Precambrian, Devonian or Carboniferous times?
Major rock units.	For example, Lewisian Gneiss, Carboniferous Limestone, Tertiary lavas, Pleistocene boulder clay.
Environments of deposition.	What sedimentary structures (eg cross bedding, mud cracks) indicate about ancient environments. Fossils. Palaeoecology What study of volcanic products (eg pillow lavas, bedded tuffs) indicates about ancient environments.
Geological History	
Sedimentary relationships	Sequence of deposition. Inversion of sequence. Diachronism. Overlap. Unconformable relationships.
Igneous processes	Types and relative ages of intrusions and volcanic products.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Metamorphic events	Relative ages of phases of regional and contact metamorphism.
Tectonic events	Types and relative ages of faults, folds, plastic deformation (eg stretching of pebbles in conglomerate), brittle deformation (eg joints, boudinage).

National Course Specification: course details (cont)

ECONOMIC GEOLOGY

CONTENT	SUPPLEMENTARY NOTES
Resources and reserves	
Physical and biological resources. Renewable and non-renewable resources. Reserves. Lifetimes of resources and reserves. Place value.	Physical resources (eg, metals, salts, solar energy) come from non-living sources. It should be noted that, despite their organic origins, fossil fuels are classified as physical resources. Reserves are resources which can be profitably extracted. The term 'reserves' does not represent a fixed quantity. Reserve figures are subject to frequent alteration (eg, as exploration and extraction techniques improve and as prices change). Materials (eg, diamonds) which are worth transporting over long distances have a low place value. Materials (eg, sand and gravel) which are not worth transporting over long distances have high place values. Consideration should be given to problems associated with the overuse and misuse of non-renewable physical resources.
Ore deposits	
Definition of ore mineral; ore; ore deposit; gangue minerals; grade; cut-off grade.	An ore mineral is a mineral from which a metal can be economically extracted. An ore is a rock from which a metal or metals may be economically extracted. An ore consists of valuable ore minerals plus worthless gangue minerals. An ore deposit or ore body is a mass of rock containing enough ore to make it economically workable. (Note that in the present context the term *rock* includes materials such as sand, gravel and soil.) The grade of an ore is the percentage of metal which it contains. The cut-off grade is the lowest grade which can be profitably mined. Candidates should realise that the cut-off grade varies with economic circumstances. Also, economies of scale apply so that modern large-scale mining methods allow very low-grade ores to be economically extracted.

CONTENT	SUPPLEMENTARY NOTES
Chemical names of ore minerals. Bauxite—hydrated aluminium oxide; chromite—iron and chromium oxide; chalcopyrite—copper and iron sulphide; malachite and azurite —hydrated copper carbonate; native copper; native gold; haematite and magnetite — iron oxide; limonite—hydrated iron oxide; siderite —iron carbonate; galena— lead sulphide; sphalerite——zinc sulphide; cassiterite—tin oxide.	All ore minerals should be examined. For information: strictly speaking, bauxite is a rock which contains the ore minerals gibbsite and diaspore; pyrite (iron sulphide) is not an ore mineral.
The uses of metals should be briefly considered. Crustal abundances and concentration factors.	The concentration factor of a metal is the number of times it has to be concentrated above its percentage crustal abundance to reach its cut-off grade. Examples of abundant and rare metals should be given, eg: *Iron*: cut-off grade 55%; crustal abundance 7.1%; concentration factor 7.7. *Aluminium*: cut-off grade 30%; crustal abundance 8.4%; concentration factor 3.6. *Copper*: cut-off grade 0.5%; crustal abundance 0.0075%; concentration factor 67. *Mercury*: cut-off grade 0.2%; crustal abundance 0.000 008%; concentration factor 25 000. Candidates should realise that metals occur in many minerals which are not ore minerals.
Formation of ores by internal and surface processes:	
Internal processes: Magmatic segregation.	*Magmatic segregation*: formation of chromium and iron deposits by settling of dense chromite and magnetite from gabbroic magma. Examples: Bushveld, South Africa; Great Dyke, Zimbabwe; Stillwater Complex, Montana.
Contact metasomatism.	*Contact metasomatism*: replacement of limestone by ore minerals deposited by acidic solutions given off by intruded acidic magma. Such deposits tend to be small but of high grade. Examples: magnetite deposits of Iron Springs, Utah; copper deposits of Mackay, Idaho.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Deposition by hydrothermal fluids.	*Hydrothermal deposits*: sources of water which may form hydrothermal brines—magmatic, meteoric, sea, formation. Types of hydrothermal deposit: porphyry, vein, sea-floor sulphide. *Porphyry deposits*: the separation of water and steam from a wet acidic magma produces a stockwork of fine mineralised fractures. Convecting meteoric water adds to the mineralisation. Porphyry copper deposit of Bingham Canyon, Utah. *Vein deposits are of two types*: 1 convecting meteoric water heated by an intrusion, scavenges metals from the sedimentary rocks and from the solid intrusion, eg, the tin deposits of Cornwall 2 hot formation water squeezed from sediments such as mudstones, deposits minerals in permeable limestones or sandstones, eg, lead and zinc deposits of the North Pennines and Derbyshire. *Sea-floor sulphide deposits*: at constructive margins, heated sea water which has circulated through pillow lavas and dykes emerges through black smokers. Insoluble sulphide minerals are deposited in mounds beneath the smokers; eg, copper deposits of Cyprus. The fluids which run onto the sea floor also deposit sulphides in areas where the dense brines form pools on the sea bed. Such deposits are currently forming on the floor of the Red Sea.
Pegmatites.	*Pegmatites*: anhydrous minerals such as feldspar and quartz crystallise from a granitic magma to leave a watery pegmatitic magma rich in metals such as beryllium, caesium, lithium, tin and uranium which have been unable to enter the early-formed minerals. The magma crystallises to form a very coarse-grained rock, often containing gemstones such as aquamarine and topaz. For example: lithium deposits, Greenbushes Pegmatite (Western Australia); tantalum, lithium and niobium deposit, Tanco Pegmatite, Bernic Lake (Manitoba); uranium deposit, Rossing (Namibia).

CONTENT	SUPPLEMENTARY NOTES
Surface processes: Placers.	Placers are surface accumulations of resistant, dense ore minerals such as cassiterite, magnetite, rutile (titanium oxide), gold and platinum. Diamonds also commonly occur in placers. Such accumulations may occur in places such as beaches, river terraces, point bars, below stream junctions and in hollows in stream beds; eg, tin deposits of Malaysia; gold deposits of Alaska; titanium deposits of Stradbroke Island, Queensland.
Residual deposits.	Residual deposits are concentrations of metals left in insoluble tropical weathering residues; eg, bauxite deposits of Jamaica; nickel deposits on weathered peridotite, New Caledonia.
Precipitates.	Types of precipitate: 1 Banded iron formations: early Precambrian deposits which consist of alternating layers of chert and haematite. At this time the atmosphere was rich in CO_2. Iron was transported in acidic surface waters as Fe^{2+}. In shallow marine basins, oxygen given off by photosynthesising blue-green bacteria caused the Fe^{2+} to be precipitated as Fe^{3+} Examples: Western Australia; Lake Superior; Russia; Brazil 2 Phanerozoic ironstones: in reducing swamp waters, iron can go into solution as Fe^{2+}. The iron may precipitate on meeting oxidising conditions to form siderite in water rich in hydrogen carbonate. Carboniferous blackband ironstones. Alternatively, the reduced iron may be trapped in organic colloids to be precipitated offshore as hydrated iron silicate. Example: Jurassic ironstones of England 3 Manganese nodules: these are currently forming on the deep sea floor by the precipitation of hydrated iron and manganese oxides.
Secondary enrichment.	The effects of secondary enrichment on an ore body containing chalcopyrite should be considered. In the zone above the water table, the chalcopyrite is oxidised to form insoluble hydrated iron oxide (which forms the gossan) and soluble Cu^{2+} ions which are carried downwards by percolating water. In the oxidising conditions just above the water table, copper carbonates are precipitated. In the reducing conditions below the water table, the Cu^{2+} ions displace iron from the primary chalcopyrite to produce secondary sulphides which are enriched in copper. For example, enriched porphyry copper deposits at Chuquicamata, northern Chile, and at Miami, Arizona.

CONTENT	SUPPLEMENTARY NOTES
Fuels	
Coal: origin; increase in rank. Cyclothems. Reasons for restricted stratigraphic range of coals. Environmental conditions which prevailed when Carboniferous coals were being formed. Analogy with coastal swamps of southeast USA and Ganges Delta. Brief consideration of coal in Britain. Uses of coal.	Formation of peat in a subsiding area; burial and compaction; removal of volatiles (mainly water, carbon dioxide and methane) results in an increase in rank (carbon %) and calorific value from peat through lignite and bituminous coals to anthracite.
Petroleum. *Oil*: formation of oil from marine plankton (mainly phytoplankton). *Gas*: formation as for oil and liberation from coal seams. Characteristics of source, cap and reservoir rocks. Stratigraphic and structural traps. Brief consideration of North Sea oil and gas. Uses of petroleum.	Organic matter which accumulates rapidly in low-energy marine basins cannot be completely oxidised so the organic remains form kerogen ('wax producer') in oil shales. Oil shales form source rocks such as those of the Kimmeridge Formation in the North Sea. On burial and heating, the kerogen breaks down to form petroleum (solid bitumen, liquid crude oil, or natural gas). Petroleum generation begins at depths of about 1—2 km. Maximum oil generation (with some gas) takes place at about 3 km. At greater depths (4—5 km) the oil breaks down to form gas. The oil and gas migrate into reservoir rocks.
Uranium: primary and secondary deposits. Use of uranium in nuclear reactors.	*Primary deposits*: pegmatites; hydrothermal deposits; and granites. (A uranium-rich granite would form a type of deposit called a disseminated magmatic deposit. The minerals which contain the uranium are evenly distributed throughout the rock.) *Secondary deposits*: uranium is soluble in oxidising conditions but insoluble under reducing conditions. Types of secondary deposit: 1 Uraninite in early Precambrian conglomerates. The atmosphere was reducing so the uranium did not go into solution 2 Roll-type deposits in sandstones. Uranium is precipitated from oxygen—and uranium-rich groundwater where this water meets a deeper zone of oxygen-poor groundwater 3 Uranium is found in sediments which are rich in organic matter (eg, black shales). These were deposited in oxygen-poor conditions where uranium could precipitate.

CONTENT	SUPPLEMENTARY NOTES
Evaporites Formation. Uses of gypsum and halite. Brief consideration of English Permian and Triassic evaporites.	When sea water is evaporated, evaporite minerals are precipitated in sequence (calcite, gypsum, halite, and salts of magnesium and potassium). In natural evaporite sequences, the highly soluble salts of sodium, magnesium and potassium are under-represented relative to their abundance in sea water. The reason for this should be explained. Thick evaporite sequences are formed under tropical conditions in shallow subsiding basins partly cut off from the sea. The basins are frequently replenished with sea water.
Finding and extracting resource materials Candidates should be aware of the following techniques used in finding resources.	
Remote sensing.	*Remote sensing*: aerial and satellite photographs; multispectral remote sensing and false colour images; airborne magnetic, electromagnetic and radiometric surveys.
Geological, geophysical and geochemical exploration.	*Geological exploration*: reconnaissance and detailed mapping. *Geophysical exploration*: seismic reflection, gravity, magnetic, electrical, electromagnetic and radiometric surveying. Gravity (eg, using shipborne gravimeters) and magnetic surveys are useful for finding sedimentary basins. Improvements in seismic techniques have meant that gravity surveying is no longer used by oil companies for detailed surveying. Gravity surveys can, however, be used to determine ore tonnages. Electrical (eg, induced polarization and self-potential methods) and electromagnetic surveys are used to find ore bodies. Radiometric surveys are used for finding uranium deposits. *Geochemical exploration*: soil, stream water, stream sediment, and vegetation surveys.

National Course Specification: course details (cont)

CONTENT	SUPPLEMENTARY NOTES
Drilling; borehole logging.	*Borehole logging*: a log is a record of all the information that can be gathered from a borehole. For example, lithology, formation thickness, dip, porosity, permeability, oil saturation and fossils would be recorded. To obtain an unfragmented section of rock for detailed analysis, a core barrel would be used. In drilling through an ore body, the types, thicknesses and grades of ore would be recorded. In geophysical logging, electronic instruments are lowered into the borehole. These can produce a detailed record of properties such as rock density, radioactivity (black shales are highly radioactive), water and oil saturation, porosity and permeability.
Methods of extracting ores, coal, oil, gas and evaporites.	Only a brief treatment is required. Mining (underground, opencast and open pit methods); dredging. *Oil and gas*: primary recovery brings 30—40% of the oil to the surface; secondary recovery (injection of water and gas) increases total extraction to about 50%; enhanced recovery (injection of steam or detergents) may increase recovery to about 90%. *Evaporites*: extraction by underground and solution mining.

National Course Specification: course details (cont)

COURSE: Geology (Higher)

ASSESSMENT

To gain the award of the course, the candidate must achieve all the component units of the course as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When units are taken as component parts of a course, candidates will have the opportunity to demonstrate achievement beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates, and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment are provided in the document *Assessment* (HSDU, 1996) and in *Managing Assessment* (HSDU, 1998).

DETAILS OF THE INSTRUMENTS FOR EXTERNAL ASSESSMENT

The external assessment consists of:

1. an examination paper
2. a fieldwork report.

The externally assessed set and assessed question paper will be one paper of 2½ hours with a total of 95 marks. The paper will consist of:

Part 1 (40 marks) will consist of structured, short-answer questions. All questions will be compulsory. Questions may test knowledge and understanding from more than one unit;

Part 2 (15 marks) will require an extended answer. Candidates will choose one of three questions. Questions may test knowledge and understanding from more than one Unit ;

Part 3 (40 marks) will examine practical and problem solving aspects of Geology, and will require candidates to apply knowledge to unfamiliar situations. Questions may be based on given information, maps, diagrams and photographs.

Information on the requirements for the fieldwork report is contained in the Unit *Earth Physics, Structural Geology and Plate Tectonics(Higher).* The fieldwork report is internally assessed, and detailed marking guidelines are contained in the Unit *Earth Physics, Structural Geology and Plate Tectonics(Higher).* The fieldwork report is externally moderated, and marks scaled out of a total of 15.

The Course award will be based on the total score achieved in the examination paper (95 marks) and the fieldwork report (15 marks)

National Course Specification: course details (cont)

COURSE: Geology (Higher)

GRADE DESCRIPTIONS

Grade Descriptions at C
Candidate can:

- Demonstrate ability to integrate knowledge, understanding and skills acquired in the component units of the course.
- Demonstrate ability to retain knowledge over an extended period of time.
- Apply knowledge and understanding to demanding aspects of situations.
- In demanding aspects of problem solving situations, draw valid conclusions which are supported by reference to the evidence.
- Apply problem solving skills to the elucidation of structures and histories of demanding geological maps.
- Apply knowledge, understanding and problem solving skills to the interpretation of the origins of geological structures.
- Demonstrate knowledge, understanding and communication skills in extended responses.

Grade Descriptions at A
Candidate can:

- Demonstrate a high level of ability to integrate knowledge, understanding and skills acquired in the component units of the course.
- Demonstrate a high level of ability to retain knowledge over an extended period of time.
- Apply knowledge and understanding to complex aspects of situations.
- In complex aspects of problem solving situations, draw valid conclusions which are supported by reference to the evidence.
- Apply problem solving skills to the elucidation, using more complex inter-relationships of structures and histories of demanding geological maps.
- Apply knowledge, understanding and problem solving skills to the interpretation of the origins of complex geological structures.
- Demonstrate high levels of knowledge, understanding and communication skills in extended responses.

The overall assessment proposed for the course i.e., the combination of internal and external assessment, should provide the necessary evidence for the core skills where an automatic award is proposed. Confirmation of this will be provided at a later date.

COURSE: Geology (Higher)

APPROACHES TO LEARNING AND TEACHING

Integration

It is important that every opportunity is taken to integrate knowledge and understanding from the separate units. There are many places where such integration could take place.

- Plate tectonics can be seen as unifying the theories of continental drift and sea-floor spreading.
- Styles of volcanism and the formation of the main magma types can be related to processes taking place at plate margins.
- Metamorphic processes can be related to igneous activity, mountain-building and movement on faults.
- Mountain-building can be related to plate collision.
- Ancient environments and ecological niches can be related to those which currently exist.
- The formation of fossil fuels can be related to biological processes.
- The history of the British area can be related, in part, to plate movements which gave it a general northward drift.
- Field studies and visits to quarries, opencast mines and construction sites provide an excellent means of bringing together many disparate aspects of knowledge and understanding.

National Course specification: course details (cont)

COURSE: Geology (Higher)

Use of the additional 40 hours

The following beneficial activities could be carried out:

- Making field visits improves understanding of the processes which form rocks and rock structures. Some of this additional time could be devoted to the production of field reports. Extra information may be required so it may be necessary to revisit critical exposures.
- Reviewing the more demanding parts of the units would be useful. For example, additional practice could be given in drawing geological sections; in drawing and using structure contours; and in the use of the polarizing microscope.
- Candidates should view geological structures seen in photographs. The structures should be identified, and their modes of origin described.
- Practice could be given in answering the types of questions which are liable to appear in the external assessment. Some of these questions may be of a more demanding type than are required for a pass in a unit assessment. Such questions may, for example, require the integration of knowledge and understanding from separate units. Candidates should build up a folio of such answered questions in case they are needed for appeal procedures following the course exam.
- Candidates could improve their essay writing skills. One question in the external assessment will require a response in the form of an essay.

Fieldwork studies

In conducting field visits, the following points should be borne in mind.

- Every precaution must be taken to ensure the complete safety of candidates.
- The guidance set out in *A Code for Geological Fieldwork*, published by the Geologists' Association, should be followed.
- Teachers and lecturers should visit field sites beforehand. Candidates should be briefed on field procedures and on possible hazards.
- Candidates should produce their own detailed records of observations and interpretations. At Higher level, candidate worksheets should not be used.
- All who go on field visits should be properly equipped with the necessary materials and clothing.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Minerals and Rocks (Higher)

NUMBER D8XK 12

COURSE Geology (H)

SUMMARY

This unit seeks to develop knowledge and understanding of the properties of minerals and rocks. The unit will develop skills in interpreting the features of rocks seen in the field.

OUTCOMES

1 Demonstrate knowledge and understanding related to minerals and rocks.
2 Solve problems related to minerals and rocks.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained Intermediate 2 Geology or its component units. It would, however, be possible for able students to enter the course with no prior knowledge of geology. Previous experience of a science or Geography at Credit or Higher Level would be advantageous.

CREDIT VALUE

1 credit at Higher.

Administrative Information

Superclass: RD

Publication date: July 2002

Source: Scottish Qualifications Authority

Version: 01

National Unit Specification: general information (cont)

UNIT Minerals and Rocks (Higher)

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None	
Additional core skills components for the unit	Critical Thinking	Higher
	Using Graphical Information	Higher

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

National Unit Specification: statement of standards

UNIT Minerals and Rocks (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to minerals and rocks.

Performance criteria

(a) The description of atomic properties and atomic bonding is correct
(b) The chemical classification of minerals is correct
(c) The properties of minerals are correctly related to their atomic structures
(d) The description of the structures and modes of formation of igneous, sedimentary and metamorphic rocks is correct.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria.

OUTCOME 2

Solve problems related to minerals and rocks.

Performance criteria

(a) Relevant information is selected and presented in an appropriate format
(b) Information is accurately processed using calculations where appropriate
(c) Valid conclusions are drawn and explanations given are supported by evidence
(d) Predictions and generalisations are made based on the available evidence.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria, including the interpretation and communication of graphical information at the appropriate level. With reference to PCs c and d, the candidate's answers must include valid conclusions and explanations based on an evaluation of supporting evidence.

National Unit Specification: support notes

UNIT Minerals and Rocks (Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit, and on learning and teaching approaches, is given in the table in the Content section of the course details.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2 will be assessed by means of an integrated end of unit assessment. The end of unit assessment has no specified mark allocation. However, the following approximate percentage mark allocations are recommended. (Note that the numbers given express a ratio of marks allocated. Candidates would not be expected to undertake test items with the actual mark allocations shown.)

Outcome 1	**(knowledge and understanding)**	**60%**
PC:		
(a)	Atomic properties and bonding	(4)
(b)	Chemical classification of minerals	(4)
(c)	Mineral properties related to their atomic structures	(8)
(d)	Rocks (structures and modes of formation).	
	Igneous rocks.	(16)
	Sedimentary rocks.	(16)
	Metamorphic rocks.	(12)

Outcome 2	**(problem solving)**	**40%**
PC:		
(a)	Selecting and presenting information	(5)
(b)	Processing information	(10)
(c)	Drawing conclusions and explaining	(15)
(d)	Making predictions and generalisations.	(10)

Test items should be constructed to allow candidates to generate evidence relating to the performance criteria as follows:

(a) Selecting and presenting information
- sources of information include text, tables, charts, graphs, maps, diagrams
- formats of presentation include written responses, tables, graphs, diagrams

(b) Calculations include percentages, averages and ratios. Significant figures, rounding and units should be used appropriately

(c) Conclusions drawn should include some justification and explanations should be supported by evidence

(d) From given situations, candidates should be able to predict and generalise eg by predicting the effects of change on structures, by generalising a relationship between pebble shape and water flow.

National Unit Specification: support notes

UNIT Minerals and Rocks (Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT	Earth Physics, Structural Geology and Plate Tectonics (Higher)
NUMBER	D250 12
COURSE	Geology (Higher)

SUMMARY

This unit seeks to develop knowledge and understanding of Earth structure and Earth movements.

OUTCOMES

1 Demonstrate knowledge and understanding related to Earth physics, structural geology and plate tectonics
2 Solve problems related to Earth physics, structural geology and plate tectonics
3 Collect and analyse information related to structural geology obtained by practical work.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained Intermediate 2 Geology or its component units. It would, however, be possible for able students to enter the course with no prior knowledge of geology. Previous experience of a science or Geography at Credit or Higher Level would be advantageous.

CREDIT VALUE

1 credit at Higher.

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	Problem Solving	Higher
Additional core skills components for the unit	Using Graphical Information	Higher

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

Administrative Information

Superclass: RD

Publication date: July 2002

Source: Scottish Qualifications Authority

Version: 05

National Unit Specification: statement of standards

UNIT Earth Physics, Structural Geology and Plate Tectonics (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to Earth physics, structural geology and plate tectonics.

Performance criteria

(a) The principles of geophysics are correctly explained
(b) The description of geological structures is correct with reference to their forms and modes of origin
(c) The explanation of major Earth movements is correct with reference to plate tectonic processes.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria.

OUTCOME 2

Solve problems related to Earth physics, structural geology and plate tectonics.

Performance criteria

(a) Relevant information is selected and presented in an appropriate format
(b) Information is accurately processed using calculations where appropriate
(c) Valid conclusions are drawn and explanations given are supported by evidence
(d) Predictions and generalisations are made based on the available evidence
(e) The geological structure and history of an area on a map are elucidated
(f) Geological sections are drawn on given topographic profiles
(g) Structure contours are drawn, interpreted and used.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria, including the interpretation and communication of graphical information at the appropriate level. With reference to PCs c and d, the candidate's answers must include valid conclusions and explanations based on an evaluation of supporting evidence.

OUTCOME 3

Collect and analyse information related to structural geology obtained by practical work.

Performance criteria

(a) Geological structures and igneous bodies are identified and described
(b) The modes of origin and cross-cutting relationships are described
(c) Fieldwork is planned, organised, conducted and reviewed effectively.

National Unit Specification: statement of standards

UNIT Earth Physics, Structural Geology and Plate Tectonics (Higher)

Evidence requirements

Candidates should submit a fieldwork report of about 1000 words, illustrated by apposite forms of graphical information, reflecting the observation, recording, identification and interpretation undertaken. The nature of the field area will determine which structures and igneous bodies are described.

The teacher/lecturer responsible must attest that the report is the individual work of the candidate derived from active participation in the fieldwork. This includes setting objectives for the fieldwork, planning of appropriate tasks, identifying and obtaining the necessary resources, carrying out the fieldwork and evaluating all stages. Conclusions and recommendations should be justified by reference to evidence drawn from the fieldwork.

National Unit Specification: support notes

UNIT Earth Physics, Structural Geology and Plate Tectonics (Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit, and on learning and teaching approaches, is given in the table in the Content section of the course details.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2 will be assessed by means of an integrated end of unit assessment. The end of unit assessment has no specified mark allocation. However, the following approximate percentage mark allocations are recommended. (Note that the numbers given express a ratio of marks allocated. Candidates would not be expected to undertake test items with the actual mark allocations shown.)

Outcome 1	**(knowledge and understanding)**	**60%**
PC:		
(a)	Earthquakes and the behaviour of earthquake waves	(6)
	Gravity anomalies	(3)
	Principle of isostasy	(4)
	Earth's magnetic field	(4)
	Earth's internal thermal properties	(3)
	Modelling internal physical and chemical properties of the Earth.	(8)
(b)	Folds, faults, joints, foliations and lineations	(4)
	Modes of formation of folds, faults, joints, foliations and lineations	(5)
	Geological structures and igneous bodies on maps.	(4)
(c)	The evidence for continental drift and sea-floor spreading	(8)
	Description of plate structure and plate movement	(8)
	Description of plate movements in ancient times.	(3)

Outcome 2	**(problem solving)**	**40%**
PC:		
(a)	Selecting and presenting information	(2)
(b)	Processing information	(4)
(c)	Drawing conclusions and explaining	(6)
(d)	Making predictions and generalisations	(3)
(e)	Elucidating the geological structure and history of an area on a map	(10)
(f)	Drawing geological sections	(5)
(g)	Drawing, interpreting and using structure contours.	(10)

National Unit Specification: support notes (cont)

UNIT Earth Physics, Structural Geology and Plate Tectonics (Higher)

Explanatory notes for PCs for Outcome 2

(a) Selecting and presenting information
- sources of information include text, tables, charts, maps, diagrams
- formats of presentation include written responses, tables, graphs, diagrams, geological sections, structure contours

(b) Processing information may include: establishing sequence in a series of cross-cutting relationships; and performing calculations which include the use of trigonometric ratios to find dip

(c) Conclusions drawn should include some justification and explanations should be supported by evidence

(d) From given situations, candidates should be able to make predictions and generalisations eg predicting the speed of waves in rock layers

(g) Only straight structure contours need be drawn. Candidates may be required to: draw outcrops of strata and faults; find the direction and amount of dip of strata and fault planes; find the amount of throw on a fault; identify a fault as being normal or reversed; and delineate the area under which opencast extraction of a coal seam or planar ore body may take place where a depth restriction applies to extraction.

Outcome 3

The candidate should produce a fieldwork report of about 1000 words, illustrated by apposite maps, diagrams, photographs and other forms of graphical information and reflecting the observation, recording, identification and interpretation undertaken. If it is not possible to make fieldwork visits, the account should be based on simulated fieldwork that involves the candidate in all of the stages and decisions of a visit. In all cases the following aspects of assessment of fieldwork report apply.

1. Gathering of information (Total 10 marks)

- *Planning and organisation of work (2 marks)*
  Planning of the tasks and necessary resources should be appropriate to the objectives of the fieldwork eg
  - prior research such as obtaining and studying relevant maps
  - collection of necessary resources such as maps, safety and measuring equipment, recording equipment (clipboard, papers, pencils camera etc.)

  In the field, the candidate should be able to amend or extend the original plan of approach, eg by returning to areas previously visited in the light of later observations.
- *Observations (5 marks)*
  Marks in this category are awarded for skills shown by the candidate in making disciplined accurate observations of whatever is under investigation. Each student should play an active part in carrying out the investigation. The mark awarded may be drawn partly from follow-up laboratory work carried out by the student.
- *Recording (3 marks)*
  Marks awarded should be based on the ability of the student to record, in an appropriate and complete form, observation, measurements, calculations and interpretations drawn from fieldwork and any further practical work.

National Unit Specification: support notes (cont)

UNIT Earth Physics, Structural Geology and Plate Tectonics (Higher)

2. Processing Information (Total 10 marks)

- *Identification (4 marks)*
  There should be evidence of recognition of specific features and of their description to an appropriate degree of detail. Marks should be awarded for the quantity of identification from the possible range of features and for the quality of the description given.
- *Overall content (4 marks)*
  The mark should take account of the quality of the geological content of the report and the degree to which relevant illustrations such as maps, diagrams, photographs and graphs are integrated into the report.
- *Presentation of report (2 marks)*
  The report is of a scientific investigation and its structure and accessibility to the reader should reflect this. At all levels the report should have:
  - a title
  - a specification of the locality of the area or areas studied
  - illustrations eg maps, diagrams, photographs, graphs
  - an account of observations, measurements and interpretations.

  At Higher, there should also be
  - recommendations for adjusting the approach, extending the study or further research
  - reference to limitations of the methods used in the investigations.

3. Interpretation (Total 10 marks)

- *Interpretation (10 marks)*
  Under this heading the assessor should consider the quality of the interpretations made, and the extent to which interpretations are justified.
  At Higher candidates should show an appreciation of the limitations of particular methods of investigations, the conclusions drawn from them and should make recommendations for improvements.

The field study for this unit is the only fieldwork required at Higher, and the mark for fieldwork contributes to the final external mark. The fieldwork report may also afford the candidate opportunities to demonstrate achievement beyond that required to attain the unit outcomes.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Fossils and Stratigraphy (Higher)

NUMBER D251 12

COURSE Geology (H)

SUMMARY

This unit seeks to develop knowledge and understanding relating to fossils and stratigraphy. It will also include an understanding of the principles of ecology as they are applied to the study of ancient environments.

OUTCOMES

1 Demonstrate knowledge and understanding related to fossils and stratigraphy
2 Solve problems related to fossils and stratigraphy.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained Intermediate 2 Geology or its component units. It would, however, be possible for able students to enter the course with no prior knowledge of geology. Previous experience of a science or Geography at Credit or Higher Level would be advantageous.

CREDIT VALUE

0.5 credit at Higher.

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Administrative Information

Superclass: RD

Publication date: July 2002

Source: Scottish Qualifications Authority

Version: 05

National Unit Specification: general information (cont)

UNIT Fossils and Stratigraphy (Higher)

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None	
Additional core skills components for the unit	Critical Thinking	Higher
	Using Graphical Information	Intermediate2

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Unit Specification: statement of standards

UNIT Fossils and Stratigraphy (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to fossils and stratigraphy.

Performance criteria

(a) The principles of stratigraphy are correctly explained with particular reference to the geological history of the local area
(b) The measurement of geological time is correctly explained with reference to relative and radiometric timescales
(c) The value of fossils is correctly explained with reference to relative age dating, correlation, evolution and palaeoecology.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria.

OUTCOME 2

Solve problems related to fossils and stratigraphy.

Performance criteria

(a) Relevant information is selected and presented in an appropriate format
(b) Information is accurately processed using calculations where appropriate
(c) Valid conclusions are drawn and explanations given are supported by evidence
(d) Predictions and generalisations are made based on the available evidence.

Evidence requirements

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria, including the interpretation and communication of graphical information at the appropriate level. With reference to PCs (c) and (d), the candidate’s answers must include valid conclusions and explanations based on an evaluation of supporting evidence.

National Unit Specification: support notes

UNIT Fossils and Stratigraphy (Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

Guidance on the content and context for this unit, and on learning and teaching approaches, is given in the table in the Content section of the course details.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

This unit will be assessed by means of an end-of-unit assessment which integrates Outcomes 1 and 2. The mark allocation for each performance criterion should be approximately as follows. (Note that the numbers given express a ratio of marks allocated. Candidates would not be expected to undertake test items with the actual mark allocations shown.)

Outcome 1 (knowledge and understanding) 60%

PC

(a) On principles of stratigraphy (30)
(b) On geological time (15)
(c) On fossils. (15)

Outcome 2 (problem solving) 40%

PC

(a) Selecting and presenting information (5)
(b) Processing information (10)
(c) Drawing conclusions and giving explanations (15)
(d) Making valid predictions and generalisations. (10)

Test items should be constructed to allow candidates to generate evidence relating to the performance criteria as follows:

(a) Selecting and presenting information
- sources of information include text, charts, graphs, diagrams
- formats of presentation include written responses, tables graphs, diagrams

(b) Calculations include percentages, averages and ratios. Significant figures, rounding and units should be used appropriately
(c) Conclusions drawn should include some justification and explanations should be supported by evidence
(d) From given situations, candidates should be able to predict and generalise eg by expressing a general relationship between the shape of shells and their environment.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Economic Geology (Higher)

NUMBER D252 12

COURSE Geology (H)

SUMMARY

This unit seeks to develop knowledge and understanding of how resources are classified and of the formation, discovery, extraction and use of ores, fuels and evaporites.

OUTCOMES

1 Demonstrate knowledge and understanding related to economic geology
2 Solve problems related to economic geology.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained Intermediate 2 Geology or its component units. It would, however, be possible for able students to enter the course with no prior knowledge of geology. Previous experience of a science or Geography at Credit or Higher Level would be advantageous.

CREDIT VALUE

0.5 credit at Higher.

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	None	
Core skills components for the unit	Critical Thinking	H
	Using Graphical Information	Int 2

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001).

Administrative Information

Superclass: RD

Publication date: November 1999

Source: Scottish Qualifications Authority

Version: 04

National Unit Specification: statement of standards

UNIT Economic Geology (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to economic geology.

Performance criteria

(a) The classification of resources is correct in terms of their being biological or physical; and renewable or non-renewable
(b) The formation, discovery, extraction and use of physical resources is correct with respect to ores, fossil fuels and evaporites.

Evidence requirement

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria.

OUTCOME 2

Solve problems related to economic geology.

Performance criteria

(a) Relevant information is selected and presented in an appropriate format
(b) Information is accurately processed using calculations where appropriate
(c) Valid conclusions are drawn and explanations given are supported by evidence
(d) Predictions and generalisations are made based on the available evidence.

Evidence requirement

Evidence is produced from a closed book test which demonstrates successful achievement of all of the above performance criteria, including the interpretation and communication of graphical information at the appropriate level. With reference to PCs (c) and (d), the candidate's answers must include valid conclusions and explanations based on an evaluation of supporting evidence.

National Unit Specification: support notes

UNIT Economic Geology (Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

Guidance on the content and context for this unit, and on learning and teaching approaches, is given in the table in the Content section of the course details.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

This unit will be assessed by means of an end of unit assessment which integrates Outcomes 1 and 2. The mark allocation for each performance criterion should be approximately as follows. (Note that the numbers given express a ratio of marks allocated. Candidates would not be expected to undertake test items with the actual mark allocations shown.)

Outcome 1	**(knowledge and understanding)**	**60%**
PC:		
(a) On classification of resources		(4)
(b) Ores		(26)
(c) Fuels		(22)
(d) Evaporites.		(8)
Outcome 2	**(problem solving)**	**40%**
PC:		
(a) Selecting and presenting information		(5)
(b) Processing information		(10)
(c) Drawing conclusions and giving explanations		(15)
(d) Making valid predictions and generalisations.		(10)

Test items should be constructed to allow candidates to generate evidence relating to the performance criteria as follows:

(a) Selecting and presenting information
- sources of information include text, tables, charts, graphs, diagrams
- formats of presentation include written responses, tables, graphs, diagrams

(b) Calculations include percentages, averages and ratios. Significant figures, rounding and units should be used appropriately

(c) Conclusions drawn should include some justification and explanations should be supported by evidence

(d) From given situations, candidates should be able to predict and generalise eg by expressing a general relationship between the depth of burial and the rank of coal.

National Unit Specification: support notes

UNIT Economic Geology (Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).