GCE MARKING SCHEME

GEOLOGY
AS/Advanced

SUMMER 2015

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE GEOLOGY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

GCE GEOLOGY - GL1

SUMMER 2015 MARK SCHEME

1. (a) (i) 1 mark for each 3 points plotted correctly – 6 plots = 2 marks

Deduct 1 mark if points are not joined up with a curved line

(ii) Edge of intrusion **A** = rapid cooling (1) small crystals (1)

Centre of intrusion **B** = slow cooling (1) larger crystals (1)

(b) (i) Augite (1)

(ii) Mafic , Equigranular, Crystalline
2 correct = 1, all 3 correct = (2)

(iii) Gabbro (1)

(c) (i) Obviously crystalline – straight edges (1)**R**

Appropriate size (1) (1.5 mm) no more than 10-30 crystals

Triple point junctions (120 degrees) (1)

Crystals 'roughly' the same size (1)

(ii) Mineralogy both the same (quartz) (1)

Orthoquartzite mineralogically very simple – quartz recrystallizes – no 'new minerals' (1)

Texture orthoquartzite clastic, metaquartzite crystalline (1)

Orthoquartzite finer grained than metaquartzite or metaquartzite coarser (1)

Orthoquartzite may show sedimentary structures, metaquartzite no structures/homogeneous (1)

2. (a) (i) **P** Stipe (1)

Q Theca/Thecae (1)

(ii) Reduction in number of stipes (1)

Change from hanging down/pendent to pointing upwards/scandent

Thecae became more elaborate/complex/curved (1)

Thecae spaced further apart / fewer thecae / larger thecae (1)

Thecae facing inwards to outwards (1)

(b) (i) Pyrite (1)

(ii) Petrification/pyritization (1)

Original organic material dissolved (1) by percolating waters (1)

Original material replaced by pyrite (1) under anaerobic conditions (1)

Reference to mould and cast (1)

(iii) Rapid evolutionary changes (1)**R**

Each type of graptolite had a short range-confined to limited thickness of sediment (1)

Geographically widespread (1)

Facies free – floaters (1)

Abundant/common (1)

Easily identifiable (1)

(c) No marks for saying it is overturned

Any reference to being the correct way up scores 0 out of 3

Earliest graptolite at top of sequence/youngest at the bottom (1)

Carboniferous coral younger than graptolites (Ordovician/Silurian) (1)

Graded bedding – coarsest is at the top (1)

Cross bedding truncation surface is at the base of the bed (1)

Cross beds convex up instead of concave up (1)

3. (a) (i) Divergent (1)

(ii) Symmetrical pattern about the ridge (1)

Reference to normal and reversed polarity (1)

Stripes linear (1)

Parallel to the mid ocean ridge (1)

(iii) As basalts cool (1)

Magnetite crystals (1) orientate themselves with respect to the Earth's magnetic field (1)

Reference to Curie point (1)

Normal or reversed field is locked in (1)

Holistic

(iv) New ocean floor/basalt formed by injection of magma into the ridge (1)

Subsequent activity splits the older material in half and moves it sideways (1)

Right side is spreading faster (1)

Process is sea floor spreading (1)

(b) (i) In the range 650 000-850 000 years or 0.65-0.85 million years (1)

(ii) 5 events (1)

Mean duration 400 000 years or 0.4 million years (1)

Accept 4 events (1) and 500 000 years or 0.5 million years (1)

(iii) Unequal rates of magma intrusion along the ridge (1) accounts for variation in width / distorts the pattern (1)

Stripes not continuous (1)

Stripes offset by movement of transform faults (1)

Holistic

4. (a) (i) Syncline (1)

Northern limb dips at less than 60° (1)

(ii) Line in correct position in any section of the map (1)

Both sections with APT in correct place (2)

(b) (i) Core of syncline is thinner on the upthrown side (1) due to upthrown side being eroded (1)

Core of syncline is wider on the downthrown side (1) due to downthrown side not being eroded (1)

(ii) Hanging wall has gone up/Footwall has gone down (1)
Compressional (1)

Shallow angle of dip (18°) (1) (Less than 45°)

(c) (i) Core of syncline (1) is the same width on both sides of the fault (1)

All beds (1) displaced in same direction / match up if they slide back across fault (1)

(ii) 48-62 metres (1)

To the right/dextral (1)

(d) F1 and Fold - Yes the same type of stress (1) both formed by compression (1)
At different times (1) as directions of principal stresses are different (1)
Fault cuts fold (1) so fold must be older (1)
(Max 3)

F1 and F2 - Cannot tell (1) whether F1 or F2 is younger as no cross cutting relationship (1)

WJEC GEOLOGY – May 2015
Mark Scheme for GL2a – 1212/01

Notes:

- This scheme shows the minimum acceptable answer(s) for each mark point. It cannot give every possible alternative so that an equivalent phrasing/drawing should be accepted; use your professional judgement, but if in doubt, seek guidance from the e-mail address gl2a@wjec.co.uk (**quoting your name and centre number**).
- Marking needs to take into account the quality of communication used. The nature of this paper means that continuous prose is not compulsory – answers given in note/diagram form are just as acceptable. Correct spelling of geological terms is desirable; use your professional judgement as to how close the candidate is!

- A forward slash, /, indicates an alternative response; brackets, ( ), indicate a more complete response but is not awarded further credit.
- ® is a reserved mark which must be given for full marks to be awarded.

- **Always mark in red ink and ensure that every page has some ink on it to show that you have read it, even if no marks have been awarded.**
- **Do not correct students' work.**
- **Instructions for marking "ticked boxes" are given where appropriate within this mark scheme.**
- **Put a tick close to the key word, phrase or drawing which gains one mark.**
- **Write the total for each part-question in the margin close to the brackets showing the available mark.**
- **Do not exceed the total for each part-question and do not re-distribute marks between sections.**
- **Write the question total in the box at the end of each question and transfer this to the front cover.**
- **Insert the total for the paper on the front cover.**

A marked example is available for download from the WJEC secure website

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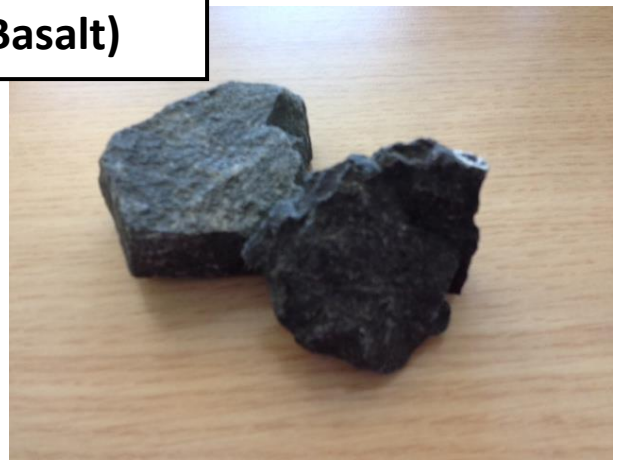
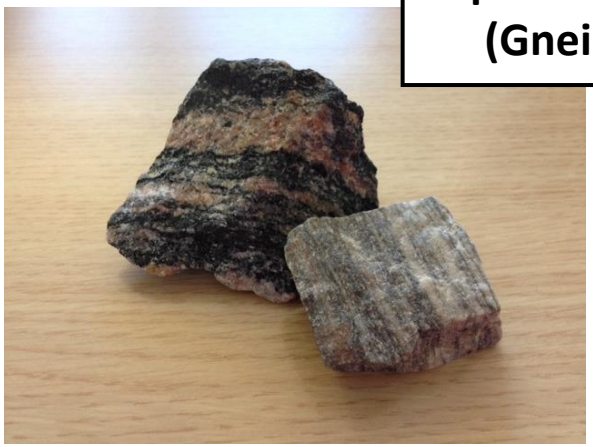
GCE AS Geology

GL2a (1212/01) Specimens 2015

Specimen C (Basalt)



Specimen G (Gneiss)



Specimen H (Goniatites)

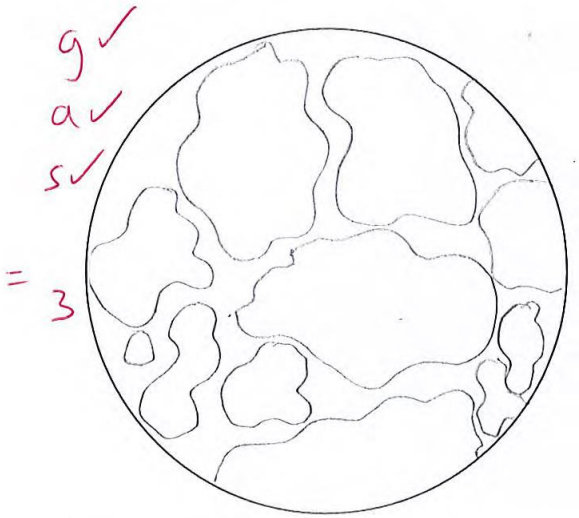
Specimen J (Haematite)

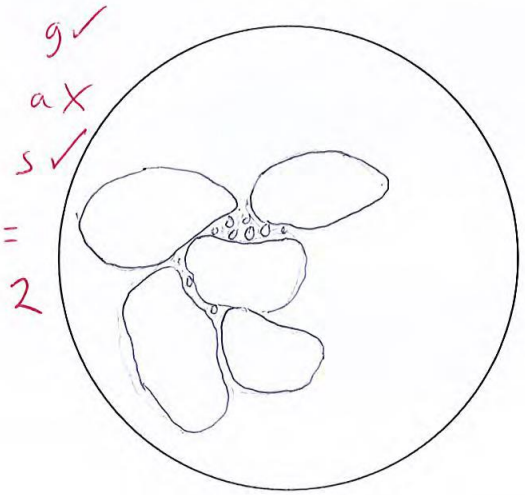
Q1	Marks	Expected Answer	Acceptable Answer	Do Not Accept
(a)	(3)	• It is the product of regional metamorphism • It formed under the influence of high temperature and pressure • It is dominated by crystals		• If more than 3 boxes are ticked, deduct 1 mark for each box which is wrongly chosen to a minimum of 0
(b)		any 2 for (1) each		
	(1)	• Schistocity in **F** *		• Any reference to composition e.g. **F** contains garnet
	(1)	• Gneissose banding **G** * *Credit schistocity and gneissose banding for two marks even if they are both written in one "difference" answer		
	(1)	• Different sizes of crystals **F** **or** all same size crystals **G** or equivalent	• Porphyroblastic **F** **or** equicrystalline/equigranular/granoblastic **G**	• Any answer that refers to sorting, clasts, phenocrysts or porphyritic • Relative sizes of crystals e.g. **F** is coarser than **G** or **G** is coarser than **F** • Stated crystal sizes in mm
	Total 5			

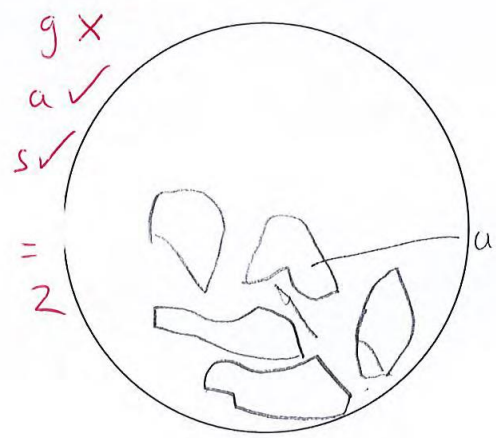
Q2	Marks	Expected Answer	Acceptable Answer	Do Not Accept
(a)	(1)	• Bed 3 within " fine" throughout, (including the boundary with "medium")	• Bed 3 drawn up fine/medium boundary	
	(1)	• Bed 2 within "coarse" throughout (including the boundary with "medium")	• Bed 2 drawn up medium/coarse boundary	
	(1)	• Bed 1 fining upwards from "medium" (including either of the boundaries) to "fine" (including the medium/fine boundary)	• Bed 1 fining upwards from medium (including either of the boundaries) to fine (including touching the "y axis"/left edge)	• Bed 1 drawn vertically up fine/medium boundary
	(1)	• Beds boundaries drawn at correct heights of 8m and 15m from base	• Boundaries at range 7.5m-8.5m and 14.5m-15.5m	• Only one boundary drawn at correct height
(b)	(1)	• Line decreasing in height from left to right i.e. fall in velocity from older to younger	• Line which has variation in descending gradient as it decreases in height to the right	• Line which rises anywhere • Entirely horizontal line

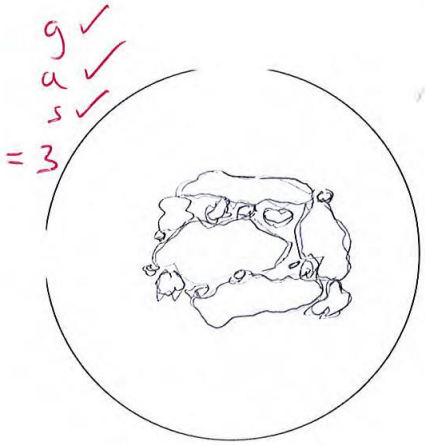
(c)(i)		**Maximum 1 of the marks below available if all boundaries are interlocking i.e. drawn as crystals**		
	(1) **g**	• Grains touching other grains other grains	• Minimum of one contact between grains	• Grains which show no contacts with any other grains. Ie all grains are "floating"
	(1) **a**	• Grains angular	• More of the grains are drawn angular than are drawn rounded	• Grains with smooth/rounded edges
	(1) **s**	• Grains with sufficient variety of size (poorly sorted) **or** Mean grain size 5 cm approx using scale provided **See examples in mark scheme** Please mark using ticks labelled with the corresponding letters **g, a** and **s** as shown in marked specimen paper	• Mean grain size within range 4-6 cm approx using scale provided	• All grains similar size
(c)(ii)	(1)	Breccia		
	Total 9			

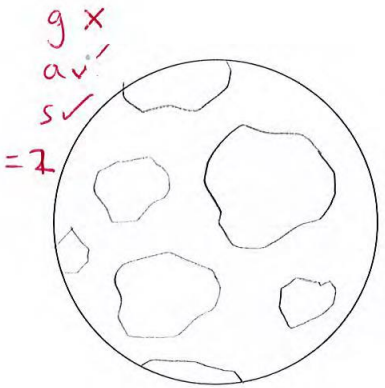
Marked examples of Figure 2c

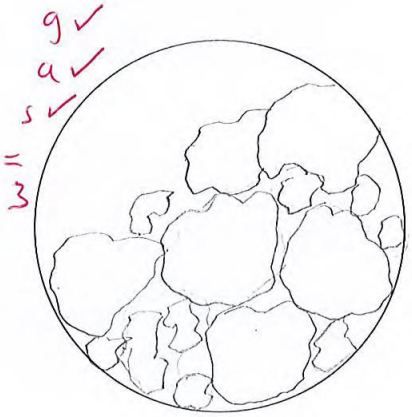


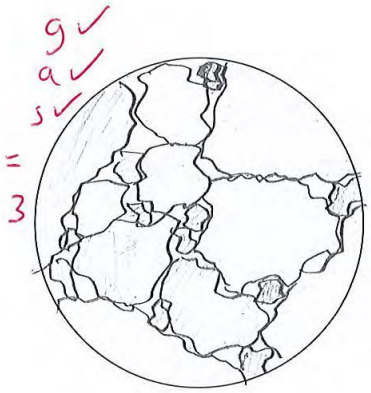


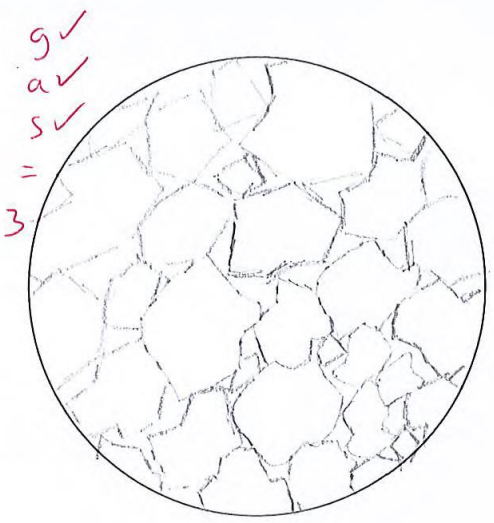


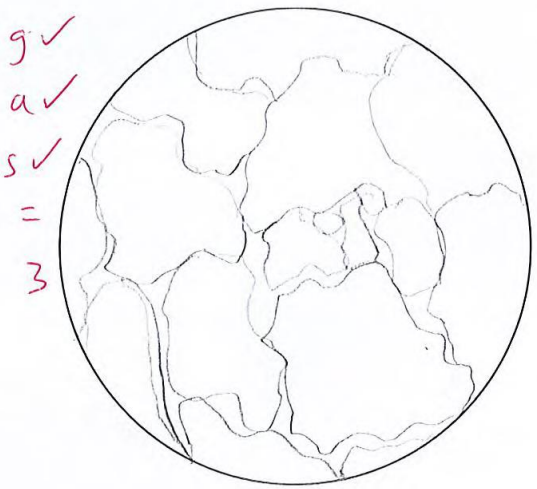


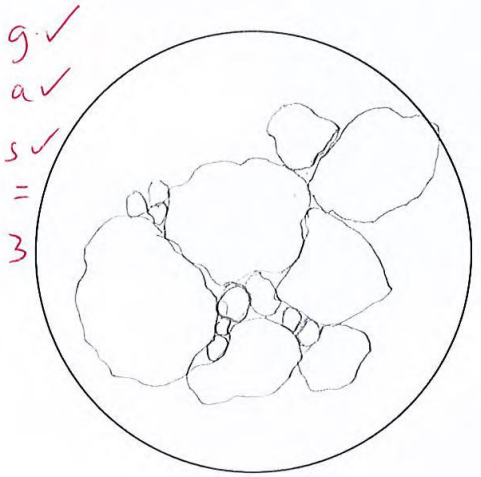


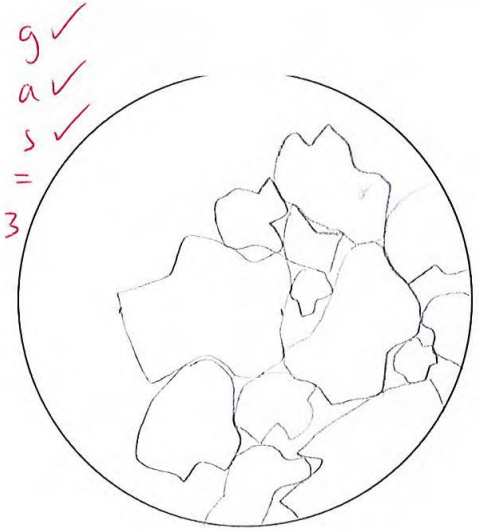






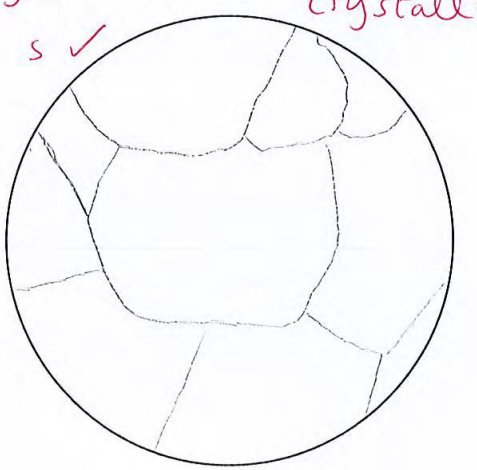


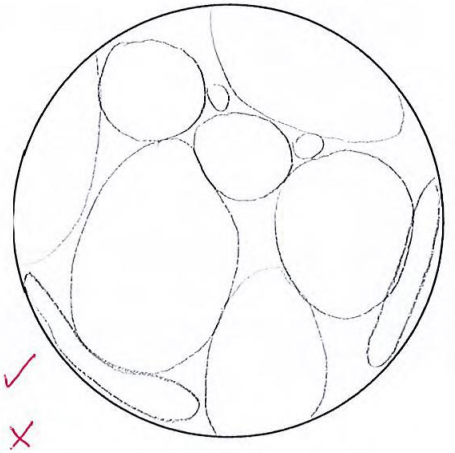




g ✗
a or s ✓

1 max because crystalline





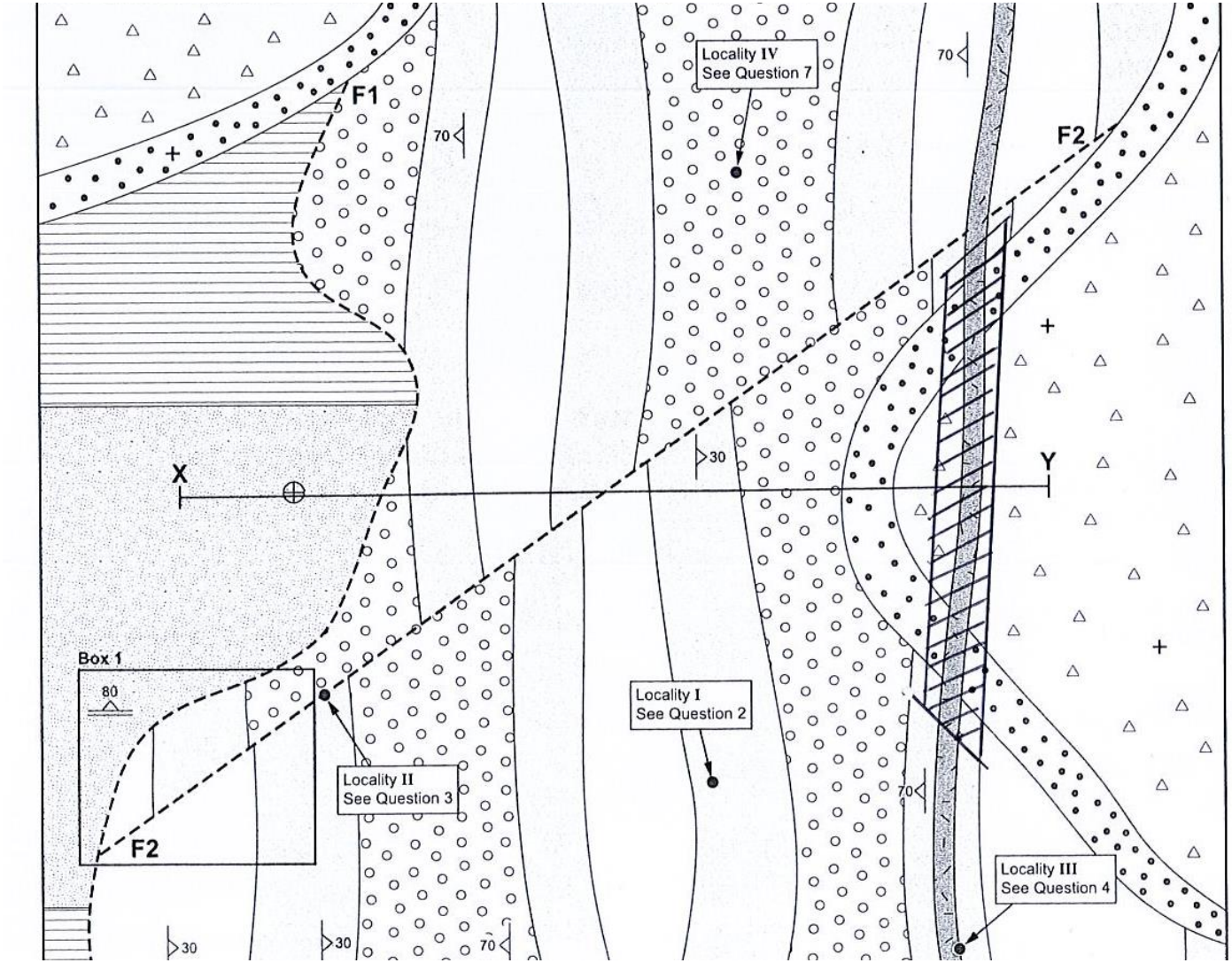
Q3	Marks	Expected Answer	Acceptable Answer	Do Not Accept
(a)	(1)	**Hardness test description** = • Scratch with copper coin or Scratch with a steel pin	• Any reference to copper coin or steel pin	• Scratch with a finger nail • Scratch with "coin"
	(1)	**Hardness test result** = • Did not scratch with a copper coin or Did not scratch with steel pin or equivalent	• Hardness greater than 3.5/harder than copper coin or Hardness greater than a value within the range 5.5-6.5/harder than a steel pin *Due to the natural variability of steel pins and the haematite samples, credit also candidates who state that* • *Did scratch with a steel pin/hardness less than value within the range 5.5-6.5/softer than a steel pin*	• Did scratch with a copper coin/softer than a copper coin/hardness less than 3.5 • Answers containing contradictions • The hardness is a stated value within the range 5.5-6.5 i.e. without the phrases "greater than" or "less than"
	(1)	**Diagnostic test** – one of • Streak • Colour • Habit • Density		• Cleavage • Fracture • Acid test

	(1) (1)	**Description of test** • Draw mineral across streak plate/tile • Observe/look at the colour • Habit =Shape of a group of crystals or equivalent • Description of "hefting" for density **Result of test** • Red/cherry red streak • Red colour • Kidney shape/reniform or fibrous habit • Feels dense/heavy	Also allow credit for **description** of the following even though no credit is given for the **choice** of these tests • Description of cleavage= look for regular planes of weakness within mineral, or equivalent • Description of fracture = look at how mineral breaks, or equivalent Also allow credit for **result** of the following even though no credit is given for the **choice** of these tests • Poor cleavage • Subconchoidal fracture	• Description of acid test • Does not react with acid
(b)	(1)	Haematite		
	Total 6			

Q4	Marks	Expected Answer	Acceptable Answer	Do Not Accept
(a)	(1) (1) (1)	**Composition reason** • Dark colour/mafic/basic **Crystal Size reason** • Fine crystal size/ less than 0.5mm/ cannot see crystals with naked eye or equivalent **Name** • Basalt (only if stated as fine crystal size as above)	• Contains augite or olivine • Medium crystal size/ 0.5-2mm/ a stated crystal size within or 0.5-2mm • Dolerite (only if stated as medium crystal size as above)	• Any reasons based solely on map evidence e.g. it is a dyke so it is medium crystal size • Crystalline/composed of crystals
(b)	(1)	• Sill and Lava flow **both** ticked		• Only one of sill or lava flow • All 3 ticked
(c)(i)	(1) (1)	**Arrow K location** • K at either of the two locations where **igneous body** rock unit C cuts the unconformity with rock unit D **Reason** **Only credit the reason if K is correctly located within the shaded area on map attached** • Recognition of the unconformity	• Any location where rock unit C is within outcrop of rock units A or D (within the shaded area on map attached) • Recognition that there is an unconformable relationship by reference to contrast in dip of beds, without use of term “unconformity”	

(c)(ii)	(1) (1) (1) (1) (1)	• It is a dyke • It is a linear/sheet like/narrow body • It is discordant or equivalent • It is younger than the unconformity/beds above unconformity because it cuts them • It is a sill where it is concordant with the beds beneath the unconformity or it is a sill because it is concordant		• It is a sill (without stating that it is concordant)
	Total 9			

Acceptable location of arrow K on Map - **must be in shaded area**

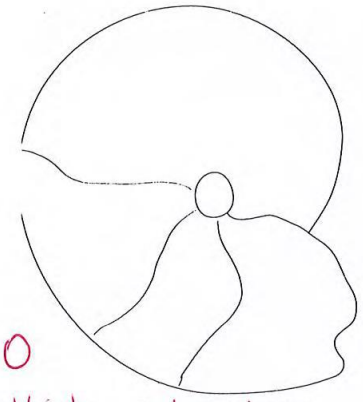


Q5	Marks	Expected Answer	Acceptable Answer	Do Not Accept
	(1)	• F2 Vertical or 90°		• F2 is a high angle/steep fault (without the use of "vertical" or 90°)
	(1)	• Left or sinistral	• Northern side moves to W or SW or S Or Southern side moves to E or NE or N	• "Rocks have moved to the North East or South West" without a statement of which side of the fault has moved in that direction
	(1)	• F1 = Thrust	• F1 = Reverse Thrust	• F1 = Reverse
	(1)	• F2 = Strike-slip	• Tear or Wrench or Transcurrent	• F2 = Strike-slip alongside any additional fault type e.g. Normal Strike-slip
	Total 4			

Q6	Marks	Expected Answer	Acceptable Answer	Do Not Accept
	(1)	• **E**, **B** and **H** in correct order (**E** older, **H** youngest)		
	(1)	• **G** oldest rock at base		
	(1)	• **F2** younger than **E**, **B** and **H**		
	(1)	• **F1** younger than **F2**		
	Total 4			

Q7	Marks	Expected Answer	Acceptable Answer	Do Not Accept
(a)(i)	(1) (1)	• Up to 2 marks for level of accuracy **(see examples)** Must have a maximum of 2 saddles or 2 lobes Must have accurate roundness/pointedness of saddles and lobes, and accurate "amplitude" of the suture line **Maximum of 1 mark if more than one suture line drawn** If more than one suture line drawn, select the most accurate suture line to determine if it can be credited a mark		
(a)(ii)	(1)	• Goniatite		
(b)	(1) (1) (1)	• **D** or **A** (must have this correct to gain the full 3 marks) Credit **2** of the following reasons • It is younger than specimen **H** • It has a more complex suture line or equivalent, or it is a ceratite • Correct map evidence for **D** or **A** being younger than rock unit **H** e.g. because it cross cuts **H** or lies above an unconformity etc		• It is an ammonite
	Total 6			

Marked examples of Figure 7



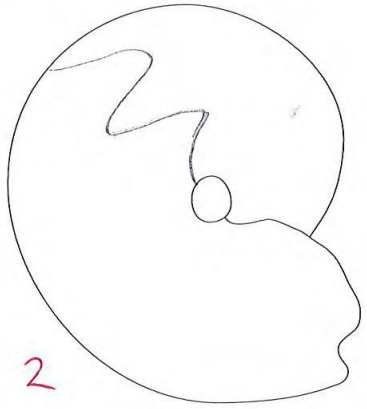
0

Multiple suture lines and too "shallow"

2

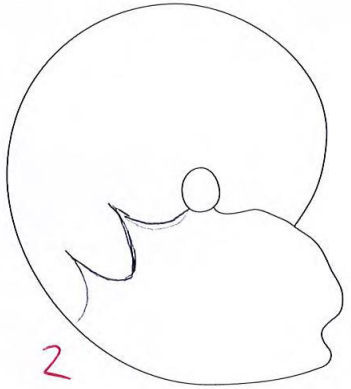
1

Lobe too rounded



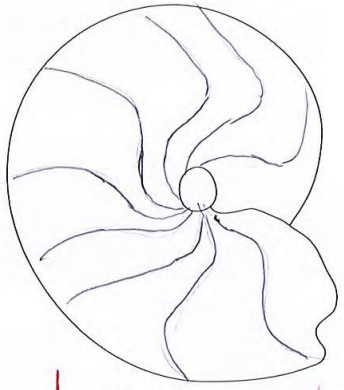
2

2



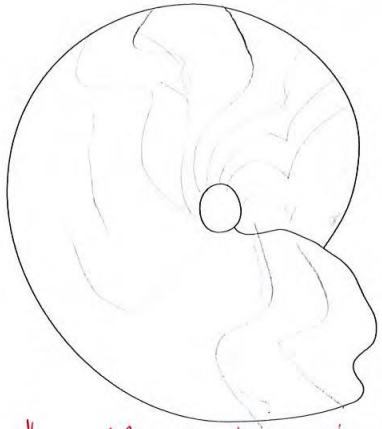
2

0 Multiple suture lines and too "shallow"

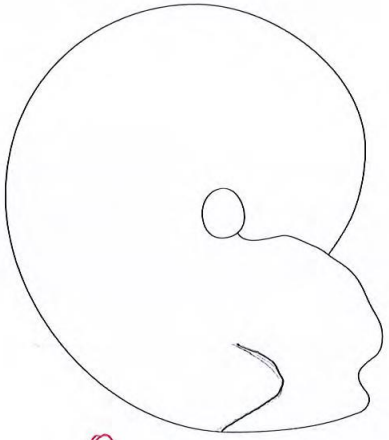


1 Multiple suture lines

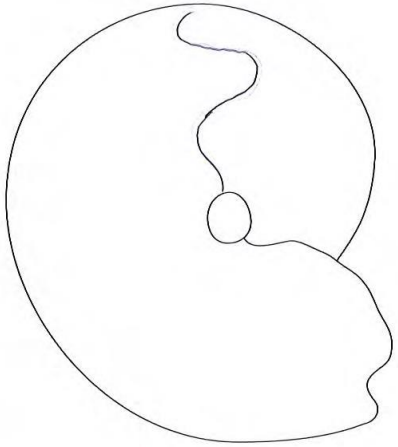
2



1 Multiple suture lines

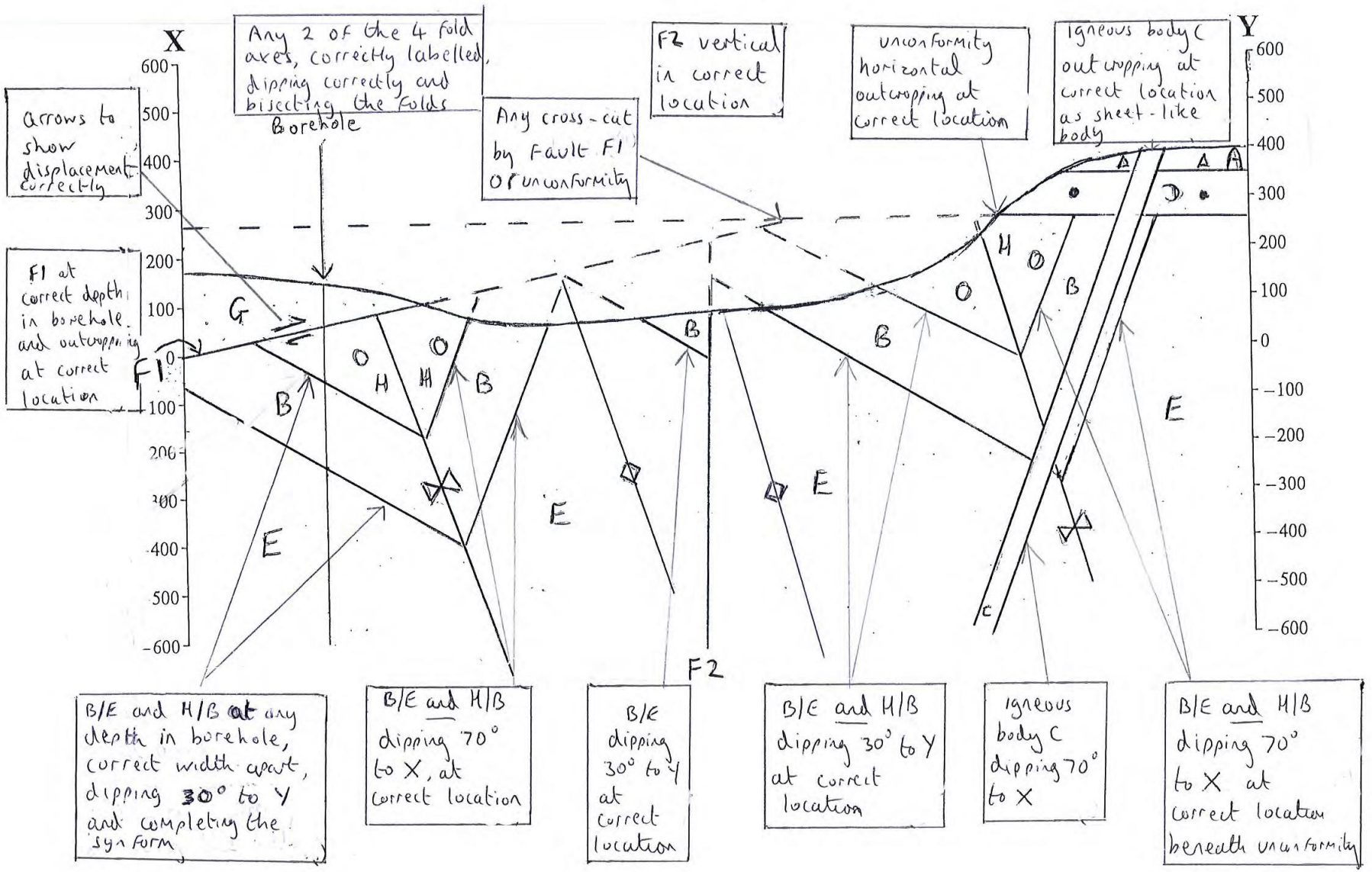


0 Not enough on the partial suture line



1 Lobe too rounded

Q8	Marks	Expected Answer	Acceptable Answer	Do Not Accept
	13	*Candidates are asked to complete a sketch cross section not to construct, so the mark scheme allows for some variations in dips/positions of beds* Use the annotated cross section as the mark scheme **Each "box" is worth one mark** Key points • Only **Two** of the four fold axes need to be shown as correctly located dipping steeply towards Y and **correctly labelled,** in order to gain the fold axes mark • Cross-cut by **F1** or by the unconformity above ground surface must show that it cuts off at least one feature below	• Approximate dip values for fold limbs (80°-60°) and (40°-20°) • Faults, unconformity, igneous body and bed outcrops within approximately **6 mm** of correct location on the surface	• Any dip > 5° on unconformity at base of **G** • Vertical APT of folds or APTs that do not approximately bisect fold limbs • An extension of unconformity or **F1** above the ground surface if it does not accurately show that its cuts off at least one feature below
	Total 13			


X
Y
600
500
400
300
200
100
0
100
200
300
400
500
600
Arrows to show displacement correctly
Any 2 of the 4 fold axes, correctly labelled, dipping correctly and bisecting the folds
Borehole
Any cross-cut by Fault F1 or unconformity
F2 vertical in correct location
unconformity horizontal outcropping at correct location
Igneous body C outcropping at correct location as sheet-like body
F1 at correct depth in borehole and outcropping at correct location
F1
F2
G
H
O
B
E
A
D
C
B/E and H/B at any depth in borehole, correct width apart, dipping 30° to Y and completing the syn form
B/E and H/B dipping 70° to X, at correct location
B/E dipping 30° to Y at correct location
B/E and H/B dipping 30° to Y at correct location
Igneous body C dipping 70° to X
B/E and H/B dipping 70° to X at correct location beneath unconformity

Q9	Marks	Expected Answer	Acceptable Answer	Do Not Accept
		Credit can only be gained from answers related to **one** fossil group Credit answers even if photograph 2 box has been ticked but photograph 3 written about or vice versa		• Credit for name of a fossil group • Credit for a field location • Uniformitarianism mark for direct application to extinct groups such as graptolites
	(1) **(R)**	• **Specific reference to concept of uniformitarianism (R)** i.e. must have this **reserved (R)** mark (or the acceptable answer version of it) to enable the full 4 marks to be awarded	• Reference to concept of uniformitarianism as follows (for example for bivalves but could be any fossil group with living relatives) "modern / present day bivalves… currently bivalves... bivalves live..... bivalves are.....	
		Up to 3 additional marks from below		
	(1)	• Relevant reference to marine/river/delta/beach/close to land etc based on uniformitarianism	• For features of environment derived from uniformitarianism, it is acceptable to credit up to 3 features of the environment e.g. marine, tropical and shallow water without the need to state the role of uniformitarianism more than once	
	(1)	• Relevant reference to water depth based on uniformitarianism		
	(1)	• Relevant reference to water temperature based on uniformitarianism		
	(1)	• Relevant reference to oxygen level s in water based on uniformitarianism		

	(1) (1) (1) (1) (1)	• Relevant reference to clear/cloudy water based on uniformitarianism • Reference to energy level linked to "completeness of preservation" e.g. unbroken fossil indicates low energy/ fragmented fossil indicates high energy • Reference to energy level based on orientation of the fossil e.g. aligned fossils indicates high energy, random orientation indicates low energy • Reference to interpretation of environment of deposition based on preservation e.g pyritisation indicates low oxygen, carbonisation indicates low oxygen • Reference to energy level based on sedimentary rock in which fossils preserved e.g low energy because preserved in shale/fine grained sediment		
	Total 4			

GCE GEOLOGY - GL3

SUMMER 2015 MARK SCHEME

Question 1

(a) Trench (1)
Island arc/volcanoes (1) [2]

(b) (i) $1600/2.0 = 800\ kmhr^{-1}$
Formula (D/T) (1) Answer (1) [2]

(ii) In shallow water
Waves slow (1)
Large wavelength – wave keeps coming (1)
Height of wave increases (1) due to friction (1)
Effect of coastal shape on funnelling in bay/estuary (1)
Debris (1)
Not easy to detect or predict for planning (1)
(Max 3 marks) [3]

(c) (i) **A** Thrust (reverse) (1)
B Strike slip/dextral/wrench/tear/transform (1) [2]

(ii) Holistic:
Horizontal/sideways movement
Water not moved vertically
Reference to energy dissipated
Energy not transferred as water does not shear
Reference to strike slip
Accept population better prepared etc. (max 1)
(2004 – vice versa)
(Max 3 marks) [3]

Total 12 marks

Question 2

(a) (i) [2]

Location **X**	Height of the groundwater surface	• **222**
	Direction of shallow groundwater flow	• **SSE (accept S or SE)**

(ii) Line between 222 and 206 [SEE DIAGRAM] [1]

(b) (i) Shape - 2 sides of plume (1) [SEE DIAGRAM]
Accuracy (1) [2]

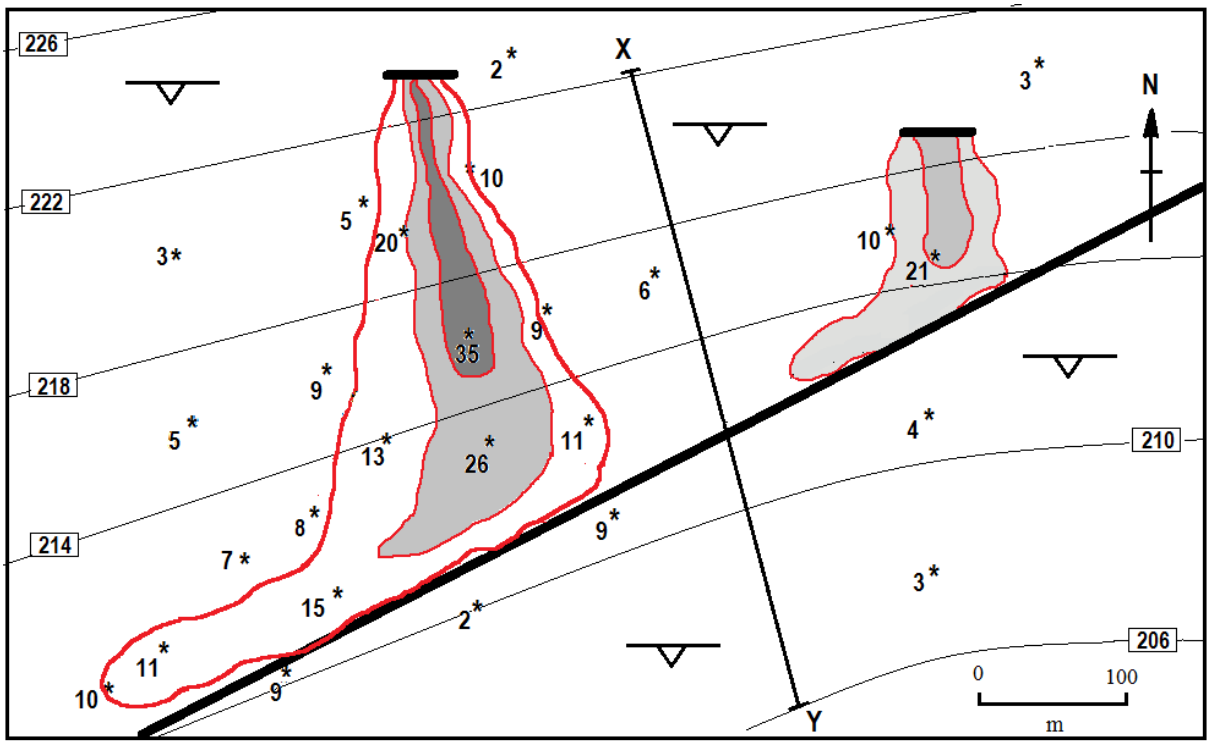
(ii) Accurate location along section (1) [SEE DIAGRAM]
Associated with the base of the plume (1) [2]

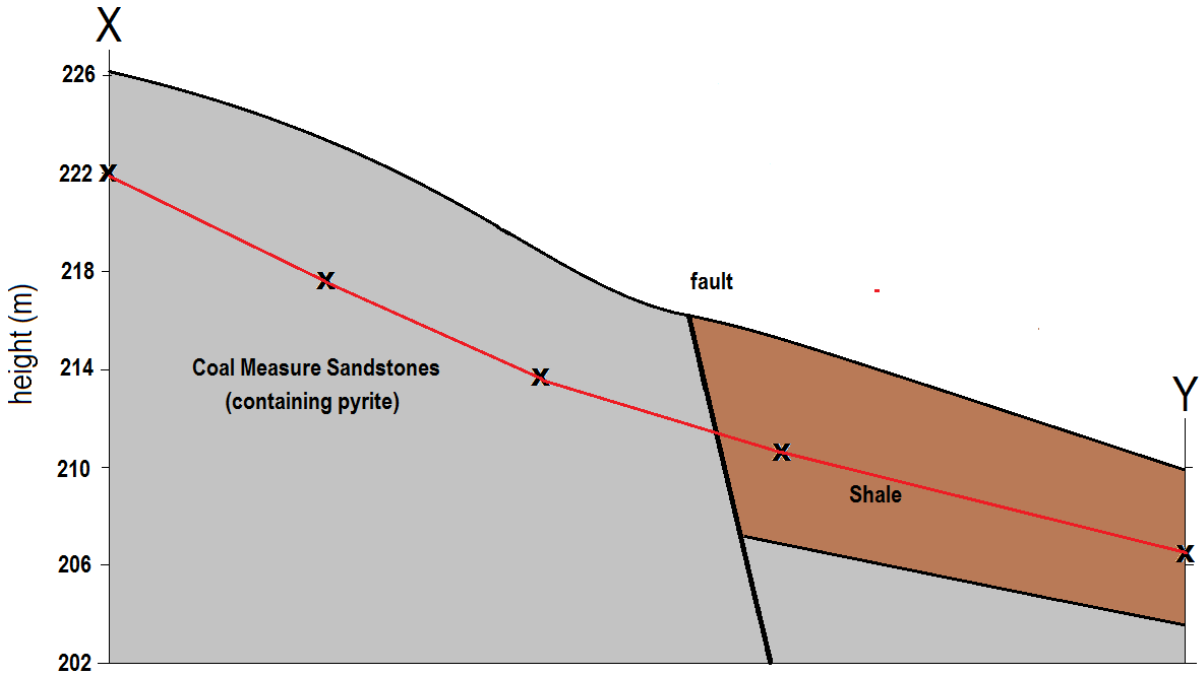
(iii) Holistic:
Flow downslope/dip (1)
Sandstone permeable (1)
Until fault diverts plume (1R)
Shale/impermeable/slower flow (1)
(Max 3 marks) [3]

(c) Pyrite (or other metal pollutants) (1R)
Water table lowered – weathered by contact with air and water (1) as more exposed by mining / increase in surface area (1)
As water table rises (1) weathered products dissolve (acid water - AMD) (1)
(Max 3 marks) [3]

Total 13 marks

DIAGRAMS





Question 3

(a) *Describe the factors that affect the risk of damage to property or loss of life in areas prone to natural geological hazards.*

Population size/density
Building type and density
Economic influences (MEDC v LEDC)
Social influences – apathy, indifference etc.
Levels of hazard planning/hazard prediction
Use of case studies as examples credited.
(Max 10 marks)

(b) *Explain the extent to which **two** of the following might be used to minimise the risk from the destructive effects of natural or human hazards:*

(i) *Slope stabilisation methods*

Reprofile to below stable angle (~35 degrees)
Rock steps – allows for steeper slope angle on short sections
Drainage control – drains, pipes etc. to remove surface water and improve cohesion
Planting trees – reduces interception, removes water and roots bind soil
Engineering structures – Gabions, retaining walls, shotcrete, rock bolts, grouting, netting etc.
Toe protection of existing landslides.
Coastal management schemes – groynes, beach replenishment, seawalls etc.
Evaluation – Failure inevitable when safety limit exceeded in storm/time/earthquake
(max 6 marks plus 1E plus 1)

(ii) *Control of lava speed and direction*

Evacuation, hazard mapping, diversion/blocks, dropping-spraying with water, explosion of flow margin, prediction devices
Case studies credited - Iceland, Etna etc.
Evaluation - Ultimately little management/control if people choose to live near volcanoes (max 6 marks plus 1E plus 1)

(iii) *Engineering of domestic landfill sites*

Clay lining by compaction of clay, plastic/geomembrane
Venting of methane gas – boreholes within the landfill
Leachate management system – porous pipes for removal/recycling of leachate
Monitoring for leachate plume – boreholes outside landfill
Evaluation – Good with time risk is reduced but expensive and even best landfill sites leak
(max 6 marks plus 1E plus 1)
(Max 15 marks)

Total 25 marks

Question 4

(a) *Describe **two** monitoring techniques used to assess slope instability in tunnels and cuttings.*

Two of the following described.

1. Ground levelling/surveying
   Changes in height/position - Rate of change increase
2. Micro seismic monitoring
   Microseismic events as rock begins to slide - Increase in number/size/ rate
3. Surface strain measurement
   Changes in the width of surface cracks - Increase in size/rate
4. Electronic distance measurement
   Laser beam measures distance between fixed points - Changes in distances
5. Tiltmeter
   Records changes rate of inclination of slope face
6. Borehole distortion meter
   Measure tilt/inclination of borehole - Greater distortion from vertical with strain changes
7. Air photos-satellite imagery - Changes with time
8. Groundwater pressures - Pore pressure changes with time

Credit examples
(Max 10 marks – 5 marks each)

(b) *Explain how the mechanisms and triggers of mass movements (e.g. rock avalanches, landslides and debris flows) are linked to natural processes and rock properties.*

Holistic expect:
Angle of slope - Slopes above 35 degrees are often unstable (exceptions – when saturated – solifluction). Friction is greater than forces of gravity – when reduced mass movement occurs. Rock slides/falls, rotational slip, slumping, debris flows.

Lithology/weathering - Competent rock (granite) is reduced to clay minerals – loses cohesion between grains/along joints. Shale, clay etc. are incompetent and will flow/slip under load pressure and lubrication – rotational slip.

Groundwater/rainfall - As pore pressure increases, reduction of friction between blocks and particles results mass movement.

Also *ground vibration* (earthquake), *shrinkage, expansion*(clay), *loading* (volcanic collapse, undercutting by river/sea).

Credit examples
(Max 15 marks)

Total 25 marks

Question 5

(a) Describe the factors that affect the porosity and permeability of sedimentary rocks.

PERMEABILITY (ability of a rock to transfer fluid/gas) depends upon
- Connectivity of pores
- Size of pores
- Joints and fractures
- Interconnected joints, faults, fractures, solution cavities

POROSITY (% of pore space between grains/fractures/cavities compared to the volume of solid grains) depends upon:
- Gaps between grains
- Packing of grains – cubic v rhombic
- Fracture/joint spacing
- Shape/orientation of grains – angular v rounded
- Sorting of grains – small fit in between larger.
- Effect of cementation

Examples sst/lmst/clay rocks
Credit diagrams

Max 7 for ONLY porosity OR permeability
(Max 10 marks)

(b) Explain the geological hazards that might result when engineering activities associated with the construction of a dam and reservoir fail to take account of geological factors and rock properties.

Hazards
Mass movement/landslip
Dam failure
Leakage as a result of unfavourable lithology and structure
Erosion and sedimentation rates

Explanation
Structure - zones of structural weakness – dip of strata/folding/cleavage faults/joints.
Rock strength of dam site – shale/sandstone/limestone
Interference with the hydrological system – surface and underground drainage.
Porosity and permeability of dam & reservoir site, water table, pore pressure.
Risk of vibration – seismic, traffic.
Case study e.g. Vaiont Dam disaster

(Max 15 marks)

Total 25 marks

MARK BAND CRITERIA FOR AS ESSAYS

Summary Description	Mark out of 25	Mark out of 15	Mark out of 10	Criteria
Excellent	21 - 25	13-15	9-10	Not the perfect answer but purposeful, demonstrating a secure grasp of knowledge and understanding and few significant omissions. Well-supported and illustrated with detailed examples selected from named geological situations. Ideas expressed fluently in logical form using appropriate geological terminology. Few errors in grammar, punctuation and spelling.
Good/Very good	16 - 20	10-12	7-8	Sound answers with relevant material providing evidence of good knowledge and understanding. May be limited in terms of supporting material and breadth of coverage but appropriate examples selected. Ideas expressed with clarity with only occasional errors in grammar, spelling and punctuation.
Modest/ Quite Good	11 - 15	7-9	5-6	A reasonably secure grasp of basics but some deficiencies in knowledge and understanding although use is made of geological terminology. Examples and illustrations may lack detail or may not relate to real geological situations. Reasonable use of language with adequate spelling and punctuation.
Weak/ Minimal	6 - 10	4-6	3-4	Answers show limited basic knowledge and understanding, lacking directness and organisation; tendency to rehash prepared material and answer by inference. Superficial use of examples. Deficiencies in use of language evident; weaknesses in spelling and punctuation apparent.
Very weak	1 - 5	1-3	1-2	Little evidence of knowledge and understanding with erroneous or repeated material evident. Candidate is unable to address the question. Largely irrelevant; possibly too brief. Language skills poor, with spelling, grammar and punctuation errors becoming obtrusive.

Incorporated into this mark scheme is the assessment of candidates on their ability to organise & present information, ideas, descriptions & argument clearly & logically, taking into account their use of spelling, punctuation & grammar.

GCE GEOLOGY - GL4

SUMMER 2015 MARK SCHEME

Question 1

(a) (i)

Temperature/depth	Temp (°C)	Depth (km)
Temperature at the mean base of the continental crust (30 km)	• 475-525	30
Predicted depth at which **wet** granite would begin to melt	600	• 38-42
Predicted temperature at which **wet** peridotite would begin to melt	• 950-1000	70

[3]

(ii) 400/20 (1)
= 20°C km^{-1} (1) [2]

(b) (i) Subduction (1)
Introducing hydrous minerals (clays) / water (1)
(Max 2 marks) [2]

(ii) Area beneath 600 isotherm (1)
Restricted to continental crust(1)
(Max 2 marks) [2]

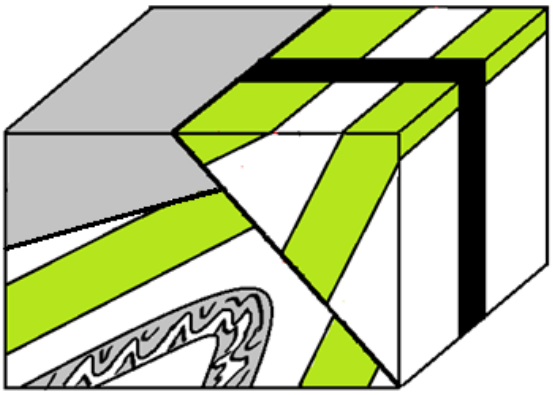
(iii) The rising magma falls below/crosses the melting point curve (1)
It will crystallise before reaching the surface (1)
~25 km from surface (1)
(2 max) [2]

(c) Holistic: Explanation of:
Parent rock – partial melt of Peridotite produces mafic magma
Evolution of magma
Differentiation
Gravity setting
Contamination – Xenoliths
Magma mixing (mafic and silicic)
Underplating/partial melt of continental crust/overlying lithos wedge
(Max 3) [3]

Total 14 marks

Question 2

(a)



Reverse (drawn offset or with arrows – but not normal offset) (1)
Correct dips of both sst. beds (1)
Surface outcrop sst. (1)
Horizontal bed on east face (1)
Dyke – Vertical (1)
Pre-Jurassic (1) [6]

(b) (i) Load/flame structure (1)
Cross bedding/dune bedding/cross lamination (1) [2]

(ii) Load/flame structure explained
Loading of coarser sediments is down into finer sediments
Flame is injected up into coarser sediments
or
Cross bedding explained
Formed on a slope by moving currents
Top eroded off – tapers to base in direction of flow
(Max 2 marks) [2]

(iii) Useless/of little value (1)
Fallen block on a beach could have come from anywhere (1) [2]

(c) (i) Internal folding (1)
Thickness (1)
Cleavage (1)
Shale – thins on limbs/ thickens in hinge area/ cleavage develops/ minor folds or convolute bedding
Sandstone – remains same thickness throughout/ fold does not cleave
(Max 2 marks) [2]

(ii) Shale – incompetent
Sandstone – competent
(Max 2 marks) [2]

Total 16 marks

Question 3

(a) 200°C (1)
Not enough energy for recrystallisation (1)
(or ref to sed processes – diagenesis) (1)
(Max 2 marks) [2]

(b) [3]

	Country rock temperature at 600 metres from pluton contact (°C)	Width of the metamorphic aureole (m)
Dry country rock	280	• 825-875
Wet country rock	• 140-160	• 490-510

(c) (i) Diagram/Explanation: metamorphism of shale/mudrock (also accept in the centre of the "outlier") (1)
High grade close to pluton (1)
[2]

(ii) Holistic
Description
- Narrower aureole (limestone) v wider aureole (shale)

Explanation
- Limestone is permeable – joints v shale is impermeable
- Water allows transfer of heat by convection away from pluton (permeable limestone) but water unable to transfer heat by convection as far in impermeable shale (dryer)
- Leaving insufficient/sufficient heat (or time) to allow metamorphic changes

(Max 4 marks) [4]

(d) (i) Holistic
Part of pluton closer to (but beneath) the surface
Irregular boundary of pluton
Reference to local topography
Thus lower grade metamorphic aureole exposed
Thermal conductivity of country rock
(Max 2 marks) [2]

(ii) Holistic reference to PLUTON only
Temperature of intrusion
Size of intrusion
Time since intrusion
Metasomatism/magma mixing/multiple injection
Accept depth of intrusion / angle of the contact with country rock
(Max 2 marks) [2]

Total 15 marks

Question 4

(a) (i) Subduction of ocean carbonates /
Partial melting
Eruption of CO_2 at volcanoes
(Max 2 marks) [2]

(ii) CO_2 locked in water vapour
Washed out of atmosphere by precipitation/rain
Products from chemical weathering of silicate rock to give carbonates/ carbonic acid
Washed into sea and incorporated into carbonate shells
Accept sequestration by plants/ marine algae (photosynthesis)
(Max 2 marks) [2]

(iii) More CO_2 – global warmer (greenhouse effect)
or
Less CO_2 – global cooler (greenhouse effect) [1]

(b) (i) Steady rise from 40 Ma (1)
Reduced rate (1)
from 16 Ma (R)
(Max 2 marks) [2]

(ii) B (1)
Moderate-good (1)
Both increase to 14Ma then at a slower rate (1)
Himalayas rate increases from 22 - 14 Ma/Sr ratio increases slightly (1)
(Max 3 marks – if C max 2 marks; if A max 1mark) [3]

(c) (i) Holistic
Global cooling related to:
Increase in height of Himalayas/Tibetan plateau leading to
- Increased rock fragmentation
- Increased surface area
- Increase in precipitation/snowfall
- Increase in chemical weathering
- Increase in CO_2 removal and thus global cooling
- Increase in Albedo effect (snow)

(Max 3 marks) [3]

(ii) Holistic
One of:
- Reduction in volcanism – less CO_2 for greenhouse effect
- Reduction in CO_2 by vegetation
- Other sensible alternatives – Albedo effect from ice/snow etc
- Milankovitch cycles
- Continental configuration/distribution
- More volcanic activity gives more ash in atmosphere so greater cooling

(max 2 marks) [2]

Total 15 marks

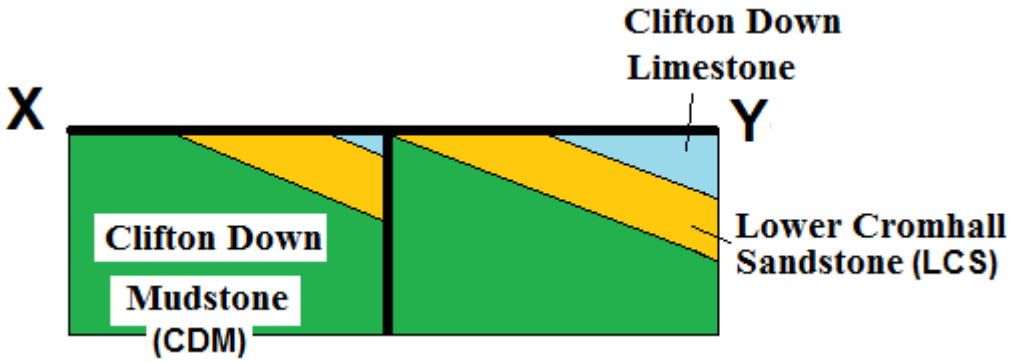
Question 5

(a) (i) 2.5 sq km (1) [1]

(ii) Describe (1):
Irregular/branching/fingers/tongues etc.
follows the valley sides/tributaries/contours
Explain (1)
Strata (near) horizontal/ shallow or gentle dip (1)
(Max 2 marks) [2]

(b) (i) Description of:
offset of beds (1)
dip and stike of the fault plane (1)
fault breccia (1)
slickensides (1)
drag folds (1)
topographic feature (scarp/ridge/valley) (1)
spring/water (1)
(Max 3 marks) [3]

(ii) Near vertical fault (1)
Both sides dip to Y (1)
Downthrow – West (arrow or displacement) (1) [3]



Total 9 marks

Question 6

(a) (i) Function – Vision (eyes) [1]

(ii) Holistic:
Eyes - on top of cephalon/can't see below
- see 360° around
- large
Indicates benthonic dweller in darker water
Genal spines - used for support in soft sediment
- or defence (not a predator)
Small size of cephalon (small animal) - scavenger
(Max 3 marks) [3]

(b) (i) Sea/marine - fossil brachiopod/coral/trilobite (1)
Warm tropical – coral and uniformitarianism (1)
carbonate mud/evaporation (1)
(Max 2 marks) [2]

(ii) Holistic
Evaluative statements for either argument
Lower bed (older)
Corals – higher energy environment
(turbulent water provides aeration/stirs up food)
Corals **may** or **may not** be in life position
Higher beds (younger)
Brachiopods in finer mud
Brachiopods in life position/ could be upside down
Trilobite not broken – lower energy/ could be broken

Credit - There are also larger (coral?) fragments in the higher bed.
Are the beds in situ and therefore the correct way up?
One brachiopod has a different orientation to the majority
Corals are reworked/ whole reworked
Not enough evidence/ too small scale

(Max 3 marks) [3]

Total 9 marks

Question 7

(a) 1. Synform – Beds dip towards each other/ centre (1)
2. Syncline – Youngest rock (coal measures) in centre (1)
3. Plunge – V shape/close to NNE/opposite direction to plunge
Or opens in direction of plunge (SSW)(1)
(Max 3 marks) [3]

(b) Negative - Positive ridge (1)
Steep drop towards K(1) [2]

(c) (i) Syncline contains greater thickness of lower density rock (1)
Compared to the Carboniferous Limestone - higher relative density (1)
Explain:
More/less mass – greater/less gravitational attraction – gravity high/low (R)
Triassic/Jurassic rocks least dense/least mass - lower negative anomaly
(Max 2 marks – R +1) [2]

(ii) Holistic
Sudden rapid change in gravity values
Contours close together
Suggests (R)
Sudden increase in lower density strata on East
Lower density material downthrown to East

Accept Linear contours - N/S trending fault plane = 1 mark)
(Max 2 marks – R +1) [2]

Total 9 marks

Question 8

(a) (i) 1. Dip = 36° (1)
2. Direction = West (1)
3. Clifton Down Limestone (CDL) (1)
(Max 3 marks) [3]

(ii) Apparent dip seen along the strike of the beds [1]

(iii) 2 cm × 96 (1) = 200m (1)
(Max 2 marks) [2]

(b) (i) Credit diagram showing correct dip (~36°)
Slopes on east
- gentle angle as dip is out of the slope (beds "daylight")
- prone to landslip
- 36° > critical stability angle

Slopes on west
- very steep as dip is into slope
- stable
- cut into rock steps to control stability

(Holistic – max 3 marks) [3]

(ii) Quarry A
East - Overburden/unconformity - Rhaetic clay (fg) and/or Lower Lmst Shale (d^{1a}) and Tintern Sandstone (c^3) dipping beneath
West - Lower Cromhall Sandstone (LCS) and Clifton Mudstone (CDM) (d^2)

OR

Quarry B
East - Lower Cromhall Sandstone (LCS) and Clifton Mudstone (CDM) (d^2)
West - Overburden/Triassic unconformity (f^6) (Dolomitic conglomerate/Keuper Marl)

Accept reference to
Width of outcrop/depth ratio (deeper more difficult/uneconomic)
Dip/thickness and water table issues

Do not accept non-geological (e.g. road/farm/ploughed field)
(Holistic – max 4 marks) [4]

Total 13 marks

GCE GEOLOGY - GL5 SUMMER

2015 MARK SCHEME

Thematic Unit 1 – Quaternary Geology

SECTION A

Question 1

(a) (i) poorly sorted (1) angular (1) reference to grain size of clasts (1)
texturally immature (1)

(ii) little attrition (1) glaciers transport clasts of all sizes (1)
freeze-thaw creates angular clasts (1)

(iii) ice retreated (1) exposed top surface of till (1)
for enough time for weathering to penetrate deposit (1)

(b) (i) attrition has rounded clasts (1) river flow has sorted clasts (1) graded bedding (1)
river has imbricated clasts (1)

(ii) climate warmed (1) ice retreated (1) meltwater/proglacial stream (1)
outwash rivers flowed over impermeable till (1)

(c) interglacial stage (1) warmer conditions (1) allowed plant growth (1)
waterlogged conditions (1) allowed peat to develop (1)
till on top of fluvioglacial deposit (1) indicates subsequent glacial episode (1)
froze the deposit (1) subsequent glaciation (1) pushed the deposit (1)
glacial bulldozing (1) caused faulting (1)
periglacial conditons (1) formation of ice-widened cracks/ice wedges (1)

Holistic mark

SECTION B

Question 2

(a) Explain the links between the continental ice sheets and sea level.

(b) Evaluate the how the geological evidence for sea level change can be used in the interpretation of Quaternary glacial and interglacial stages in Britain.

[25]

(a) Isostatic sea level change in response to mass of ice locally on the continents, displacing the mantle. Isostatic change is more localised phenomenon that can be more directly related to local quantity of continental ice.

Eustatic sea level changes in response to changing volumes of continental ice and seawater during glacial/interglacial cycles. Eustatic change is a global phenomenon.

Superimposition of the two cycles of sea level change (and their differing rates) whichcreate the landforms and evidence seen today.

Link is directly causal. However there are two ways in which the sea level is influenced by the continental ice whose effects must be considered together in order to interpret the landforms and deposits found around the coast.

Tectonic activity (such as in Alaska) can cause sea level change unrelated to continental ice sheets.

(b) Evidence for “lower” sea levels – raised beaches, inland sea clifs etc. Can calculate amount and rate of uplift of crust.

Evidence for “higher” sea levels – submerged features (rias/fjords, submerged forests)

Oxygen isotopes (from GL4 spec) can give evidence about global ocean volumes and sea levels. Evidence can be derived from oxygen isotopes for a global quantity of continental ice. This gives a complete record of change over long periods of the Quaternary

Must include evaluation

Credit diagrams and examples. Must evaluate for access to full marks.

Question 3

(a) *Explain how sediments typical of turbidite environments are the result of the physical processes in a turbidity flow.*

(b) *Evaluate the use of sedimentary structures in the interpretation of turbidite environments.*

[25]

(a) High density fluid (mixture of sediment and water) flows beneath less dense fluid (clear seawater). Flows down continental slope under gravity at high speed (~100 $kmhr^{-1}$)

Accumulation of sediment on continental shelf. Often offshore from major river mouths. Sediment becomes unstable (earthquakes, volcanic eruptions, mass movement, storms).

Cyclic changes in energy in a flow result in repeated cycles of sedimentation - Bouma sequences.

(b) *Must include evaluation of how useful the different types of evidence are in interpreting the processes.*

Graded bedding, flat laminations and cross lamination all give good data on the cyclic changes of energy in a turbidite environment.

Sole structures (prod/bounce/groove marks and flute casts) can give good data on the orientation of the flow. Flute casts and cross lamination can give accurate data on palaeocurrent direction.

Convolute bedding and load casts only give an indication of the post-depositional processes as the sediments de-water.

Question 4

"Geological structures and bodies result in a variety of relief forms."
Evaluate this statement with reference to the relationship between geology and topography.
[25]

Credit to be given for examples of landforms illustrating ideas
Dipping Strata
Cuesta (Downs)

Folds
Hills from anticlines (Pennines)
Mountains from core of synclines (Snowdonia)
Fold mountain chains (Himalaya)

Faults
Rift Valleys (Rhine, East Africa)
Faults as planes of weakness (Great Glen Fault)
Fault scarps (Craven Fault)
Thrust faults (Moine thrust)

Joints
Tors (Dartmoor)
Limestone Pavements (Yorkshire Dales)

Igneous Bodies
Plutons creating highland areas (Dartmoor, Mourne Mtns)
Volcanoes (Arthur's Seat, Deccan Plateau)

Resistant Rock
Monadnocks (Malvern Hills, Wrekin)
Coastal features

Discussion of other factors that might influence landscapes, such as glaciation.

Must evaluate the relationship between geology and topography for full marks

Credit examples given

Breadth v depth

Thematic Unit 2 – Geology of Natural Resources

SECTION A

Question 1

(a) (i) 231 × 0.0118 (1) = 2.725 Mt (1)
Accept 2.7-3.0 or 2,700,000 – 3,000,000 tonnes only if units are given

(ii) **Description**
large hole / visual impact (1)
steep/deep orebody (1) low grade of ore (1)
large quantity of waste material (1) quantified (1)
unstable waste tips (1) leached metal from waste tips (1) AMD (1)
interference with water table (1) pollution/contamination (1)

*Only credit **one** problem + development*

Explanation
bunding/banks built around site (1) shields from view (1)
uses waste material/overburden (1)
use waste rock as an aggregate (1)
vegetate waste tips (1) treat run-off water for contamination (1)
seal waste tips to prevent leaching (1)
divert water flow (1) filter for particulate waste etc (1)

Credit other reasonable answers

(b) (i) water table/top of bedrock inclined to west (1)

(ii) inside the limit of mineralisation (1)
values highest above orebody (1) Cu-rich groundwater flows to the surface (1)
groundwater flows through fracture zone (1) high secondary permeability (1)
warm water from depth dissolves more copper (1)

(iii) outside the limit of mineralisation (1)
fracture zone is more permeable than the conglomerate (1)
groundwater flow in conglomerate has little influence (1)
little dilution from groundwater (1) arid environment (1) little groundwater flow (1)
copper not as soluble in colder groundwater (1)
copper deposited before it reaches location B (1)

(c) (i) no surface outcrop or landscape feature (1)
can't be found by mapping or remote sensing (1)
no density anomaly (1) as ore concentration is low (1)
gravity survey won't identify it (1)
copper is not magnetic (1) magnetic survey can't detect it (1)
orebody is narrow (1) unlikely to find it just by drilling (1)
not used for initial prospecting (1)
desert environment (1) no vegetation to sample (1)
water passes through the orebody (1) Cu soluble in (warm) water (1)
water rises to surface (1) easy to sample across an area (1)

SECTION B

Question 2

(a) *Describe the geological factors that favour the formation and accumulation of large scale oil and gas reserves.*

(b) *Evaluate the use of seismic surveying techniques to identify potential traps for hydrocarbons (oil and natural gas).*

[25]

(a) Source rock – clay/shale organic content
Reservoir Rock – porosity/permability (sandstones)
Cap rock – impermeable clay/shale
Depth – temperature and length of time buried
Traps – anticline, fault, unconformity, salt domes

All factors must occur in correct sequence for economic accumulations of hydrocarbons.

Credit reference to examples

(b) Can use technique to search a wide area and can find structures that don't have a surface outcrop/deeply buried on land or at sea.

Can narrow areas for further investigation

Very useful for finding structures that may contain petroleum

However it cannot determine whether hydrocarbons are present in a potential trap even if the structure and geological sequence are suitable.

There is a need for further geological investigation to locate oil (drilling & downhole logging)

Credit diagrams and examples.

Must evaluate for access to full marks.

Question 3

(a) Describe the formation of coal deposits.

(b) Evaluate the use of the following techniques in the exploration of mineral/and or energy resources:

(i) geological mapping
(ii) remote sensing

[25]

(a) Swamps, plant material, hot and wet - maximum vegetation growth.
Warm - luxuriant growth
Fresh water - vegetation (indicated by freshwater bivalves), tropical.
Quiet - material not swept away.
Stagnant - rotting not complete.
Sinking - continued deposition.
Rapid burial, exclude oxygen/anaerobic, minimise rotting.
Burial raises temperature and pressure conditions.
Time factor.
Coalification proceeds from partially decomposing vegetable matter such as peat, through coal rank - lignite, bituminous coals to the highest grade of anthracite.
During this process, the percentage of carbon increases, and volatiles and moisture are gradually eliminated.

(b) General - The appropriate method depends upon the geometry and physical properties of the resource. Evaluation involves advantages and disadvantages of technique. Case study examples credited.

(i) geological mapping

Field work based – direct observation using trained geologists.

Advantages:
High level of accuracy to pinpoint resources at the surface prior to exploitation Can be very detailed – good to assess problems of exploitation and viability of resource Samples can be collected for accurate analysis

Disadvantages:
Labour intensive and time consuming Structural trends obscured on small scale Accuracy depends upon sample points and interpretation Possible problems of access in remote areas and lack of outcrops

(ii) satellite remote sensing

Radiation is absorbed and reflected in different ways by different materials (rocks, soils and vegetation)
Materials emit different types of radiation depending upon temperature and chemistry
Reflected radiation of several wavelengths (some in visible spectrum), and displayed as a visual image.
Suitable for major metalliferous deposits (e.g. copper, iron)

Advantages:
Provides a large scale image relatively cheaply without need of fieldwork Inaccessible areas studied easily Large scale structures show up which might be missed in the field. Satellites are generally in place – only need to buy image required

Disadvantages:
Used for only basic reconnaissance. Colours can be misleading

Must evaluate for full marks.

Question 4

"Sedimentary processes can produce metalliferous ores and non-metallic minerals of economic value."

Evaluate this statement with reference to the processes of formation of these resources.

[25]

Metalliferous ores: reference to placer deposits (e.g. gold), residual deposits (e.g. bauxite) and precipitated (e.g. lithium deposits) weathering (e.g. Malachite & Azurite). Processes concentrating metals into economically viable deposits.

Non-metallic minerals: chemical weathering (china clay), precipitation (barite) and clastic processes (sand & gravel)

Credit examples given and discussion of processes

Breadth v depth

Must evaluate the role sedimentary processes play for full marks

Thematic Unit 3 – Geological Evolution of Britain

SECTION A

Question 1

(a) box A – faulting; Shap Granite cuts across fault plane trace (1)
box B – contact metamorphism; fault offsets metamorphic aureole (1)
Credit explanation only if relative age is correct

(b) (on southern margin) Shap Granite cuts across cleavage (1)
(on northern margin) cleavage deflected by Shap Granite as it intruded/ radial cleavage (1)
No cleavage in the granite (1)
credit Shap Granite older and acted as a buttress during cleavage formation (1)

(c) rocks (max 3)
Andesites represent volcanics formed by partial melting at a subduction zone (1)
Turbidites represent deep marine/accretionary wedge sediments/Iapetus ocean (1)
Shap Granite represents silicic pluton formed by partial melting of subducted crust/ base of continental crust at dpm (1)
pyroclastics indicate subduction (1)
age (Ordovician to early Devonian) concordant with Caledonian Orogeny (1)
structures (max 3)
cleavage formation records high directed compressional stress at a dpm (1)
general NE–SW trend of cleavage concordant with Caledonian Orogeny (1)
NE–SW trend of faults in NW of map concordant with Caledonian Orogeny (1)
Structures concordant with NW-SE compressive stress (1)
Folds evidenced by cleavage indicate compressive stress (1)

(d) Figure 1a (max 3)
truncation of metamorphic aureole/fault by ORSG (1)
lack of cleavage in ORSG (1)
missing mid-Devonian sequence/ ORSG directly overlies Ordovician/ period of erosion (1)
dip of beds in UORSG 10°NE or strike NW-SE; cf. dip of beds in Caledonian Basement to SE or strike of cleavage in Caledonian basement NE-SW/ idea of discordance between ORSG and L Palaeozoic sequence (1)

Figure 1b (max 2)
included fragments of Shap Granite in ORSG (1)
feldspar in arkose matrix of ORSG derived from Shap Granite (1)

(e) reasons (max 3)
red staining = terrestrial/tropical/oxidising (1)
Subangular-subrounded clasts = limited-moderate transport/erosion etc (1)
lithic fragments = limited transport (1)
Arkose matrix = immature – limited transport (1)
poor sorting = rapid deposition/ flash flood (1)
graded bedding = progressive loss in energy (1)
large fragments = high energy (1)
reference to uniformitarianism (1)
environment = fluvial/alluvial fan/wadi (1R)

SECTION B

Question 2

(a) *Describe the sedimentary and fossil evidence for Britain undergoing major environmental change during the Upper Palaeozoic.*

(b) *Evaluate the assumptions made in interpreting this evidence.*

[25]

Description

Carboniferous
Early – equatorial carbonate platform
Bioclastic and oolitic limestones, corals / reefs / brachiopods etc
Middle & Late – tropical forest / swamp/ deltaic
Cross-bedded deltaic sandstones, cyclothems, coal / seatearth / abundant vegetation/plant fossils - ferns, tree ferns, insects / amphibians

Devonian and Permian desert
Red sandstones / haematite / iron oxide staining / well sorted, rounded / aeolian dune bedding / evaporites (Zechstein sea) / breccias (screes, alluvial fans)/ desiccation cracks (lakes)/ fining upward meandering river cycles.
Coastal and marine deposits in Devonian SW England inc coral reefs limestones and tropical seas
Rare fossils / tracks / trails / footprints in non-marine sequences

Evaluation

Reliance on Principle of Uniformitarianism e.g. colonial corals only in tropical seas; Support of palaeomagnetism; Hadley Cell and horse latitudes operated in a similar way as today

Question 3

(a) Explain how palaeomagnetic data including:

- *magnetic inclination*
- *apparent polar wandering curves*

can be used to determine palaeolatitude changes through time.

(b) Evaluate the assumptions made in using these methods.

[25]

Description

Magnetic inclination explained; 3D dipole magnetic field, vertical at poles and horizontal at equator
Orientation of magnetic minerals in rocks aligned parallel to magnetic field at time of cooling - Curie point
Gives position of pole and angle of inclination which indicates latitude
Diagram of changes in magnetic inclination with latitude as UK drifts through latitude
Angle of inclination changes in rocks of different ages and analysis of rocks of different ages shows changes of latitude with time
Can be preserved in sediments aligned during deposition
Apparent polar wandering
Determination of position of magnetic pole at time of cooling (remnant magnetism)
Determined in rocks of different ages
Plotting positions of poles of different ages on a map and joining up points to produce an apparent polar wandering curve for a continent
Apparent as continent moves not pole (different continents have different polar wandering curves and there cannot have been several poles at same time)
Positions of pole relative to continent gives latitude of continent at a particular time and shows changes over time
Also shows time of continent collision and separation (diagram)

Evaluation

Useful technique if backed up by study of sediments
Assumes magnetic field has always been dipolar and close to geographic north (even during reversals)
Inaccuracies caused by problems with radiometric dating of rocks
Assumes rocks not overturned or magnetically disturbed since formation

Question 4

'During the Tertiary, Britain was subject to two contrasting plate tectonic regimes'. Describe and evaluate the geological evidence for this statement.

[25]

Description

Regime 1: Tertiary Igneous Province of NW Britain = Constructive Plate Margin. Abundant mafic igneous activity; Basalts; Dolerite Dyke Swarms; Gabbro Plutons; Seafloor spreading; Mantle Plumes; Evidence for tension e.g. Dyke swarms. Opening of Atlantic ocean.

Regime 2: Alpine orogenic influences = 'Edge' of Destructive Plate margin. Abundant structural evidence; Folding in southern England e.g. Dorset (Lulworth Crumple), London Basin; Reactivation of normal faults (Purbeck Disturbance); Uplift (inversion) of North Sea basins; all provide evidence for compression. Outer fringes of collision between Africa and Europe forming Alps

Evaluation

Large volume of flood basalts result from mantle plume; Hot spot trail to Iceland; Mid Ocean ridge still active. Abundant petrological and structural evidence.
Limited petrological evidence (rare intermediateash deposits) but widespread structural evidence; distinct E-W trend; reactivation of Mesozoic tensional features.

Thematic Unit 4 – Geology of the Lithosphere

SECTION A

Question 1

(a) uncommon to the west of the Sunda trench (1)
uncommon beneath Sumatra island (1)
concentrated in zone between Siberut Island and Sumatran fault (1)
virtually all above 100 km/shallow focus (1)
evidence of inclined plane (Wadati-Benioff zone) (1)
dipping to NE/towards Y (beneath Siberut island) (1)
associated with subducting slab (1)

(b) (i) intersection with trench (1) inclined line passing through or at top of Wadati-Benioff zone (1)

(ii) any of the four foci to the SW of the Sunda Trench; but check answers to part (i) and ecf with respect to intercept of line with ground surface (1)

(iii) any of the seven foci 'above' the main Wadati-Benioff zone towards and below the island of Sumatra (1)

(c) located between the trench and volcanic arc/island of Sumatra; fore-arc (1)
same (NW–SE) trend as/parallel to subduction zone/trench/island of Sumatra (1)
elevated topography due to folding/thrust faulting/compression/subduction (1)
presence of recent/Tertiary sediments (1)

(d)

Pre-Tertiary Rock Unit	Explanation of evidence
1. Altered peridotites, gabbros, dolerites and basalts (often pillowed)	represents ophiolite sequence (1) pillow lavas extruded on sea floor (1) oceanic crust/lithosphere assemblage of rock types (1) relevant additional detail on peridotite, gabbros, dolerite formation (1)
2. Greywacke (turbidites) and fine-grained marine sediments	Turbidites are deep marine sediments (1) deposited on abyssal plain/continental rise/trench (1) fine-grained sediment explanation/ example (1) fine-grained sediment low energy deep marine environment (1)
3. Andesite and basalt volcanics closely associated with reef limestones	Andesites/basalts = island arc/subduction zone (1) Basalts = seamount/guyot/volcanic islands (1) Reef limestones = shallow sea/marine (1) Atoll reefs flanking above islands (1)

Award one mark for recognition that rock unit was emplaced from ocean onto land i.e. obduction/thrusting/folding/uplift.
Mark holistically with maximum of three marks per rock unit

SECTION B

Question 2

(a) *Describe how the rate **and** direction of seafloor spreading might be calculated from*

- *patterns of ocean magnetic anomalies*
- *mantle plume (hotspot) data.*

(b) *Evaluate the effectiveness of these two methods in determining the rate **and** direction of seafloor spreading.*

[25]

Rate = distance / time (gradient of graphs = half-rate)
Distance = distance from ridge axis or hotspot
Direction = track of seamounts/ guyots; orthogonal to magnetic stripes/ ridge
Time = age of sea-floor basalts or age of reversals (magnetostratigraphy) or island lavas
Distance measured on maps produced by surveying / ships / satellites (GPS?)
Time measured using radiometric dating (combination of relative and absolute e.g. microfossils)
Highly effective techniques used to define the absolute velocity of plates and the hotspot reference frame but limited by accuracy

Accuracy: precise location of ridge axis / not to metres but to within 1km
distance / location to where specimen was collected accurate / GPS
absolute age of specimen accurate to ± 2% (? depending on method)
time of reversal not instantaneous
magnetostratigraphy - relies on above
graphical method allows line of best fit to be employed giving average rate

Spreading rates more accurate close to ridge. Edges of strips = reversals and accurate ages obtained from lavas on continents and islands. Plate boundaries may not be static.
Evidence suggests hotspots may also not be fixed.

Question 3

(a) *Describe the differences between oceanic and continental lithosphere in terms of*

- *composition*
- *thickness*
- *age.*

(b) *'Our knowledge of the composition of the continental lithosphere is limited'. Evaluate this statement.*

[25]

Definitions : Base of lithosphere = 1300°C isotherm
Lithosphere = zone above asthenosphere
Lithosphere = crust and upper mantle; solid; rigid

Continental	Oceanic
range in thickness from about 40km to perhaps 200km	typically 50-100 km (but at ridge is no thicker than crust)
Andesitic-Granitic / int-silicic	Basaltic / mafic
Sedimentary, igneous and metamorphic rocks	Layered / 1, 2 and 3 (sediments, pillows, dykes and gabbros)
Older < 4.2Ga Tends to be older in "middle" with vertical stratigraphy / Law of Superposition	Younger < 200Ma Older away from ridge / horizontal stratigraphy

Knowledge biased to surface outcrops and hence sedimentary rocks. Lower crust poorly constrained. Need to rely on few deep boreholes (e.g. Kola superdeep borehole), geochemical experiments, geophysics e.g. gravity surveys.

Question 4

'The strength of rocks and how they deform in the lithosphere is controlled solely by temperature'.

Evaluate the validity of this statement.

[25]

Strength
Discussion of rock strength in terms of yield point (stress) and fracture point (stress)
Temperature increases with depth (except in subduction zones)
Geothermal gradient sketch graphs
Lithosphere 1300°C isotherm and definition
Increase in temperature lowers yield stress of rocks and rocks may not fracture
Sketch stress-strain plots to illustrate this
Definition of ductile/brittle/elastic/plastic
Increased temperature raises brittle-ductile transition zone
Rocks therefore weaker at depth if solely temperature plays a role

Evaluation
Role of increased (confining) pressure with depth increases rock strength
Role of strain rate - slow strain rates make rock stronger
Role of fluids - reduce rock strength (role of pressure solution and pore pressure counteracting confining pressure)
Role of mineralogy/rock type quartz-feldspar-olivine increased strength through lithosphere
Role of type of stress (rocks stronger in compression than tension)

MARK BAND CRITERIA FOR A2 ESSAYS

Summary Description	Marks out of 25	Criteria
Outstanding	25-23	Not the perfect answer, but a candidate could not be expected to produce better work at this level in the time allowed.
Very good	22-20	Arguments are purposeful, well supported & show both balance and style. Irrefutable evidence of a thorough grasp of concepts & principles. A hint of flair apparent in work.
Good	19-17	The answer is direct & explicit; shows the ability to use knowledge & understanding & to discuss. May be limited in terms of supporting material & breadth of coverage.
Quite good	16-14	Shows a reasonably secure grasp of the basics, but answer may show some slight deficiencies in terms of either knowledge & understanding or directness & organisation.
Modest	13-11	Material is mainly relevant & sound, but points need more development (& support). Could be much more direct & explicit in approach.
Minimal	10-8	Work impoverished by limited knowledge & understanding; tendency to rehash prepared material & to answer by inference. Answer rather hit & miss.
Weak	7-5	Little evidence of knowledge or understanding; unable or unwilling to address the question; essentially random in approach.
Very weak	4-1	Largely irrelevant; too brief; abundant erroneous material.
Unacceptable	0	Wholly irrelevant or nothing written.

Incorporated into this mark scheme is the assessment of candidates on their ability to organise & present information, ideas, descriptions & argument clearly & logically, taking into account their use of spelling, punctuation & grammar.

QUICK GUIDE

Description		K / U	Discussion	Terminology
Outstanding	23-25	Not perfect BUT		Thorough
Very good	20-22	Thorough grasp	Well supported Hint of flair + EVALUATION	Sound
Good	17-19	Direct/explicit	Limited support - breadth Lacks detail - depth	Significant
Quite good	14-16	Basics	Slight deficiencies. Limited scope relevance	Basic
Modest	11-13	Mainly relevant	Needs much more development	
Minimal	8-10	Limited/rehash	Hit and miss	Little
Weak	5-7	Little evidence	Question not addressed	
Very weak	1-4	Irrelevant/erroneous	Too brief	
Unacceptable	0			

Thus key dividing lines are:

Outstanding - Across the board – no significant weaknesses

Very good - EVALUATION

Good - Good read - some omissions in content/detail/discussion

Quite good - Essay title has been addressed but not a convincing argument

Modest - Bit difficult to follow. Do they really know?
Addressed the question but need much more discussion = mark scheme

Minimal/Weak/Very weak - Rehash at best - irrelevant material/no essay to mark/mark per point?

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