

GCE

Geology

H414/02: Scientific literacy in geology

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS**PREPARATION FOR MARKING
RM ASSESSOR**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.

5. Crossed Out Responses

Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add a tick to confirm that the work has been seen.

7. There is a NR (**No Response**) option. Award NR (No Response):
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
 - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.
10. For answers marked by levels of response:

Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Levels of response questions on this paper are **2(b)** and **6(a)(i)**.

11. Annotations

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given

Annotation	Meaning
	Ignore
	Blank page

12. Subject Specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

13. Subject-specific Marking Instructions

INTRODUCTION

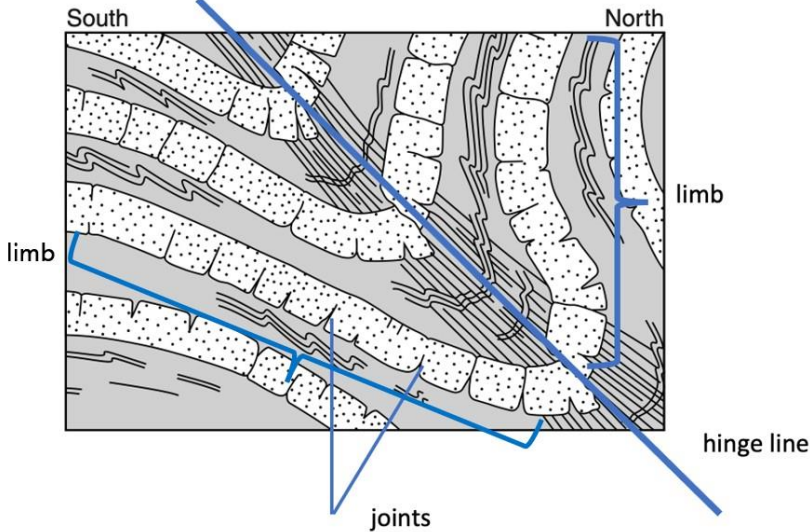
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

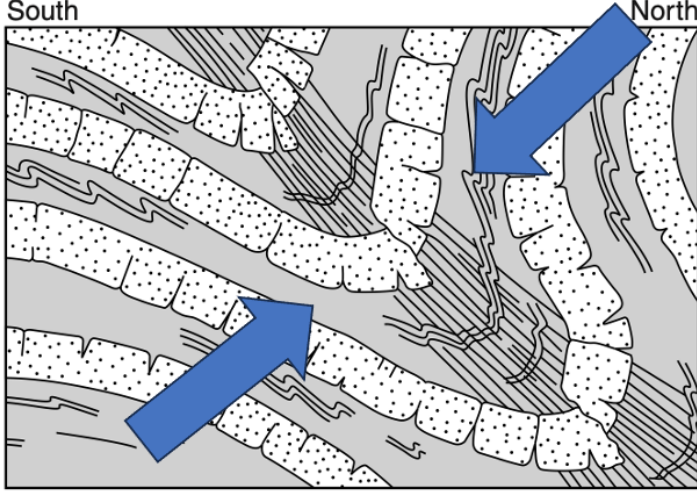
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

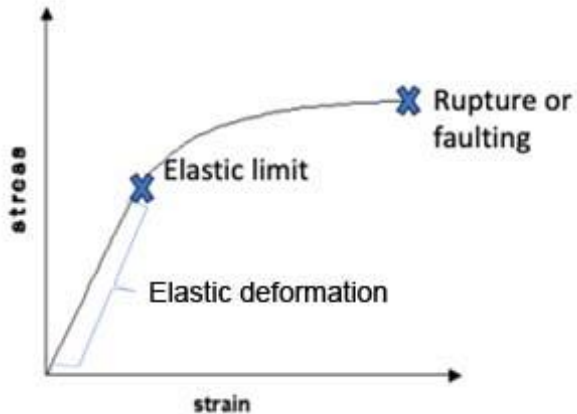
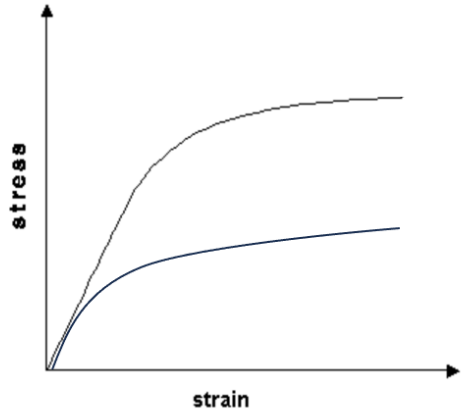
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	AO Element	Guidance
1	(a)	(i)	 Hinge line – drawn through points of greatest curvature in the sandstone beds / parallel to slaty cleavage ✓ Limb – correctly indicated to south or north of hinge line – anywhere along either limb ✓ Joints – at least one fracture within a sandstone bed indicated ✓	3	AO2.1a	1 mark for each correct label Hinge line – MUST pass through at least two sandstone beds
1	(a)	(ii)	Compression / compressive ✓	1	AO2.1a	ALLOW crustal shortening

Question			Answer	Marks	AO Element	Guidance
1	(a)	(iii)	 Arrows drawn at right angles to the hinge line, pointing inwards towards the hinge line ✓	1	AO2.1b	No requirement to label arrows
1	(a)	(iv)	<u>Description of distribution:</u> Parallel to hinge line / axial plane OR only found in shale / incompetent rock OR only found in the fold core ✓ <u>Explanation:</u> (Platy minerals) align / rotate / recrystallise / new minerals grow AND at right angles / perpendicular to directed stress / force / pressure ✓ OR Aligned minerals form lines of weaknesses where fractures occur so cleavage forms ✓	1 MAX 1	AO2.1a AO2.1b	ALLOW around / along the hinge line / axial plane DO NOT ALLOW near the hinge line IGNORE reference to metamorphism / slate

Question			Answer	Marks	AO Element	Guidance										
1	(a)	(v)	Shale is incompetent / weak OR sandstone is competent / strong ✓ Shale is ductile / plastic / deforms easily OR sandstone is brittle ✓ (Additional) folding occurs (in incompetent layers) when the stress is high / under compression ✓	MAX 2	AO3.1a	DO NOT ALLOW shale has weaknesses ALLOW flow folding of incompetent rock										
1	(b)		<table><thead><tr><th>Term</th><th>Description</th></tr></thead><tbody><tr><td>Boudinage</td><td>Ductile flow when subjected to stress and strain</td></tr><tr><td>Buckling</td><td>Striations resulting from friction</td></tr><tr><td>Plunge</td><td>Cylinder or lens-like structures forming layers</td></tr><tr><td>Slickensides</td><td>A fold that has an axis tilted from the horizontal</td></tr></tbody></table> ✓✓✓✓	Term	Description	Boudinage	Ductile flow when subjected to stress and strain	Buckling	Striations resulting from friction	Plunge	Cylinder or lens-like structures forming layers	Slickensides	A fold that has an axis tilted from the horizontal	4	2 x AO2.1a 2 x AO3.1a	1 mark for each correctly drawn line
Term	Description															
Boudinage	Ductile flow when subjected to stress and strain															
Buckling	Striations resulting from friction															
Plunge	Cylinder or lens-like structures forming layers															
Slickensides	A fold that has an axis tilted from the horizontal															
1	(c)	(i)	Change in the shape / volume / size / length OR the resultant deformation OR the response of a rock to <u>stress / force / pressure</u> ✓	1	AO1.1a	ALLOW AW DO NOT ALLOW result of stress unqualified										

Question			Answer	Marks	AO Element	Guidance
1	(c)	(ii)	- Elastic deformation – anywhere along straight part of graph ✓ - Elastic limit – point at which behaviour changes from elastic to plastic ✓ - Rupture or faulting – point at which failure occurs ✓ 	3	AO2.1b	1 mark for each correct label
1	(c)	(iii)	A line drawn below the line on the graph ✓ 	1	AO3.1b	DO NOT ALLOW straight line Line MUST start at origin

Question			Answer	Marks	AO Element	Guidance
1	(c)	(iv)	Rocks under high confining pressure are less likely to fracture / fractures close-up ✓ Rocks under high confining pressure are stronger / less ductile ✓ Rocks under high confining pressure take longer to deform / become strained ✓ Rocks under high confining pressures are more likely to be at high temperatures ✓ Confining pressure is experienced from all sides / uniformly ✓	MAX 2	AO2.1a AO3.1d	ALLOW rocks undergo pressure solution / stylolites form ORA rocks at low confining pressures are likely to be at lower temperatures

Question			Answer	Mark	AO Element	Guidance
2	(a)	(i)	<u>Any one</u> description from: Shows cyclical changes OR 7 or 8 cycles ✓ Atmospheric CO₂ varied / fluctuated AND stayed at low levels ✓ <u>Any one</u> explanation from: Reflects glacial and interglacial periods OR periods of ice melting and reforming ✓ Reflects fluctuations in global temperatures ✓ More CO₂ dissolved in the cold water at this time ✓ (Iron coming from continents) boosted phytoplankton OR more (marine) plants which absorbed more atmospheric CO₂ ✓	MAX 1 MAX 1	AO3.1a	ALLOW numbers to describe shape of cycles ALLOW atmospheric CO₂ was low if quantified with values ALLOW reference to Milankovitch Cycles IGNORE discussion of CO₂ trapped in / released from ice
2	(a)	(ii)	Chemical composition of shells is CaCO₃ / calcite / carbonate ✓ OR Shells are a <u>store / sink</u> for CO₂ ✓ OR CO₂ is extracted from water to make shells ✓ OR Can be used for <u>oxygen / carbon</u> isotope analysis ✓	MAX 1	AO2.1b	IGNORE isotope mass numbers
2	(a)	(iii)	Foraminifera OR Coccoliths ✓	1	AO1.1d	ALLOW any calcareous microfossil from the last 60 million years, e.g. ostracods, (some) dinoflagellates, pteropods DO NOT ALLOW plankton / algae unqualified

Question			Answer	Mark	AO Element	Guidance
2	(a)	(iv)	Ocean crust is (mostly) younger than 60 million years ✓ Sediments older than this have been destroyed / subducted ✓ Recycled by plate tectonic movements / correct reference to Wilson cycle ✓	MAX 2	AO3.1e	ALLOW explanation that sediments will have undergone lithification / diagenesis to become rocks ALLOW discussion of CCD

Question			Answer	Mark	AO Element	Guidance
2	(b)	*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) The impact on the environment is discussed AND detailed reference is made to the scale of change AND the change is compared to the geological record. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) The impact on the environment is discussed AND some reference is made to the scale of change OR the change is compared to the geological record. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) An impact on the environment is suggested OR some reference is made to the scale of change OR the change is compared to a change in the geological record. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks - No response or no response worthy of credit.	6	2x AO3.1c 2x AO3.1d 2x AO3.1e	Indicative content may include: <u>Impact on environment:</u> • Climate change / global warming / enhanced greenhouse effect / global atmospheric / ocean temperature increase • Ice caps melt / ocean thermal expansion • Sea level rise / ocean circulation changes / AMOC slowdown / ocean anoxia • More extreme weather events / drought / desertification / wildfires • Extinction of wildlife / loss or changes to habitats / loss of coastal habitats / loss or replacement of shallow marine biota • Release of methane hydrates <u>Scale of change</u> • (Release of methane hydrates) further increases of temperature / positive feedback loop / runaway greenhouse effect • Current average global temperatures 15°C – could increase by 2-3°C (by 2100) • Global weather patterns altered / rainfall patterns change on continental scale • Eustatic sea level changes / sea levels could rise by 7m (Greenland ice melt) / up to 75m (Antarctica ice melt) • Could trigger a mass extinction / higher than normal rate of extinction

						• Creation of new epoch / Anthropocene / golden spike in geological record <u>Comparison with geological history</u> • Last time CO₂ levels were this high was over a million years ago • Currently in ice age • Earth has been warmer in geological past – Greenhouse Earth events: Cretaceous / Jurassic / Triassic / Devonian / Ordovician / Cambrian • CO₂ levels / global temperatures / sea levels much higher in named past periods, E.g. • Palaeocene-Eocene Thermal Maximum (PETM), 55.8 Ma, temperatures >25°C, 1600 ppm CO₂ • Cretaceous CO₂ 1000 ppm / temperatures 4-8°C higher / sea level up to 200m higher • Ordovician CO₂ 3000-9000 ppm • Comparison with past mass extinction events, e.g. Ordovician-Silurian, Permo-Triassic, Cretaceous-Tertiary
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Question			Answer	Mark	AO Element	Guidance
2	(c)	(i)	Formed by continental <u>collision</u>(s) OR land masses came together to form a <u>supercontinent</u> ✓ As a result of orogenesis / mountain building events ✓ Wilson Cycle stage of ocean closure OR subduction zones dominated ✓	MAX 2	AO1.1c AO2.1a	ALLOW collision of correct named continents, e.g. Gondwanaland / Laurasia / Laurentia / Euramerica / Avalonia / Baltica for MP1 ALLOW during the Variscan / Hercynian Orogeny for MP2 MUST indicate which part of the Wilson cycle was dominant ALLOW closure of Iapetus / Rheic Ocean for MP3 ALLOW Pangaea had formed by the Permian Period
2	(c)	(ii)	Oceanic currents / circulation reduced ✓ Atmospheric circulation reduced OR less redistribution of heat from Equator to Poles ✓ (If supercontinent was at the Equator) desertification was likely to occur OR <u>interior</u> of supercontinent became very hot / dry OR suffered an extreme continental climate ✓ (If supercontinent was at the poles) would accumulate lots of ice and reflect heat energy from the sun / have increased albedo OR (If supercontinent was at the Equator) land mass would have reduced albedo ✓	MAX 2	AO1.1c AO2.1a	ALLOW AW for interior

Question			Answer	Mark	AO Element	Guidance
3	(a)	(i)	$\frac{0.107 + 0.103 + 0.108}{3}$ $= 0.106 \text{ (g)} \checkmark$	1	AO2.1b	ALLOW if answer written in space in table rather than on answer line
3	(a)	(ii)	FIRST CHECK ANSWER ON THE ANSWER LINE. If answer is -2.34 (%) award 2 marks Change in mass / initial mass $\frac{0.117}{5.000}$ $= 0.0234 \checkmark$ x 100 $= -2.34 \text{ (%) } \checkmark$	2	AO2.1b	ALLOW if answer written in space in table rather than on answer line % Change in mass = $\frac{\text{Change in mass}}{\text{Initial mass}} \times 100$ MAX 1 if no negative sign given in the answer (as it is loss of mass the value should be negative) MAX 1 if correct to 1 decimal place (-2.3)
3	(a)	(iii)	• Increase sample size from 5g to reduce margin of error $\checkmark$ • Use a balance with a precision of more decimal places $\checkmark$ • Heat the samples until there is no more mass loss $\checkmark$ • Increase number of repeats $\checkmark$ • Better temperature control while heating, e.g. use of oven $\checkmark$	MAX 1	AO3.1f	Any one reasonable suggestion linked to the improvement of the experimental design ALLOW Place lid on crucible when heating ALLOW crucibles should be cooled for a set period of time after heating OR cooled to the same temperature

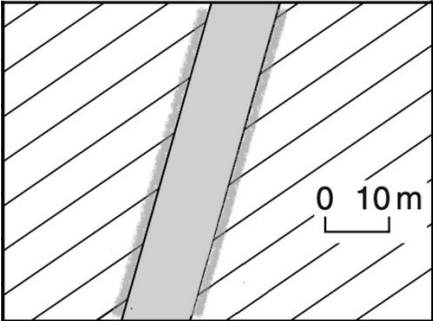
Question			Answer	Mark	AO Element	Guidance
3	(b)	(i)	Percentage acid soluble material (%) Mean percentage change in mass (%) • 2 OR 3 points plotted correctly ✓ • Straight line of best fit drawn through data points ✓	2	AO2.1b	ALLOW ECF from 3 (a)(ii)
3	(b)	(ii)	Linear ✓	1	AO3.1d	
3	(b)	(iii)	Spearman's rank OR Pearson / correlation coefficient ✓ Compares two different data sets / variables AND to determine if there is a correlation OR the strength of the correlation OR if there is a statistically significant correlation / relationship between them ✓	1 1	AO2.1b	

Question			Answer	Mark	AO Element	Guidance
3	(c)		B is purest ✓ <u>Any three evaluations from:</u> Loss on ignition means losing volatiles / gases / impurities on heating ✓ B had lowest loss of mass on heating / ignition (so contained less volatiles) ✓ Acid insoluble material is left following the reaction with acid ✓ Acid insoluble material means what is left when the water / liquid evaporates ✓ B has largest % of acid insoluble material ✓	1 MAX 3	AO3.1c	ALLOW Heating decomposes the ferric nitrate ($\text{Fe}(\text{NO}_3)_3$) further leaving only hematite
3	(d)	(i)	Gangue ✓	1	AO1.1a	
3	(d)	(ii)	<u>Stream sediment sampling/analysis</u> ✓ Sampling of sediment along a water course OR detects anomalous metal values in sediment downstream of ore deposit ✓ OR <u>Soil sampling/analysis</u> ✓ Augers or handheld tools used to sample soil in target area OR soil samples down slope will have anomalous values OR weathering / erosion disperses metals from ore deposits into the soil ✓ OR	MAX 2	AO1.1d	1 + 1 for any correct pair of named method and matching description ALLOW drilling AND analysis of recovered <u>drill core / chips</u> to detect anomalous concentrations of metals

Question			Answer	Mark	AO Element	Guidance
			<u>Biogeochemical / geobotanical / vegetation sampling/analysis</u> ✓ One plant type (twigs, leaves, stems) collected from sample area OR detects anomalous metal values taken up by plants / concentrated in plant tissue OR certain plants grow where there are high concentrations of a particular metal ✓ OR <u>Water sampling/analysis</u> ✓ Sampling of water along a water course OR detects anomalous metal values in water downstream of ore deposit ✓			
3	(d)	(iii)	Soluble iron / ferrous iron / Fe^{2+} OR iron from mid ocean ridges / hydrothermal vents ✓ Photoferrotrophs / (photosynthetic) bacteria oxidise the iron OR formed during the Great Oxidation Event ✓ Insoluble iron / ferric iron / Fe^{3+} precipitates out of the water ✓ Formation of cyclical layers / bands of <u>chert / silica</u> AND <u>iron / hematite / magnetite</u> ✓	MAX 2	AO1.1a	DO NOT ALLOW sediments
3	(e)	(i)	The (average) length of <u>time</u> / <u>time</u> interval for an earthquake (of a given magnitude or exceeded) to occur again ✓	1	AO1.1d	ALLOW $T = (n+1)/m$ OR $T = 1 / \text{probability}$
3	(e)	(ii)	<u>Method</u> – Seismic gap theory OR future earthquakes are expected to occur along sections of a fault that has not slipped for a long time / locked sections ✓ <u>Limitation</u> – Unable to predict exactly where along the fault the next earthquake will happen OR cannot predict when the next	2	AO2.1a	1 + 1 for any correct pair of method and matching limitation

Question			Answer	Mark	AO Element	Guidance
			earthquake will happen OR cannot predict magnitude of next earthquake ✓ OR <u>Method</u> – Measuring stress build up in rocks OR changes in ground levels OR use of tiltmeters / laser technology to measure ground deformation OR detecting changes in groundwater level / radon concentration in groundwater ✓ <u>Limitation</u> – Changes are very small / hard to measure / at the limit of technology OR to date have not successfully predicted an event OR complex / difficult to interpret ✓ OR <u>Method</u> – Use of microseismics / harmonic tremors / exsolution of volatiles as a volcanic eruption predictor ✓ <u>Limitation</u> – Changes are very small / hard to measure / at the limit of technology OR complex / difficult to interpret ✓ OR <u>Method</u> – Tsunami warning systems (allow prediction of when tsunami will arrive) ✓ <u>Limitation</u> – May not be enough time to evacuate coastal areas close to epicentre OR failure of warning chains / lack of evacuation plans / infrastructure OR LIC's cannot afford the technology ✓			ALLOW <u>Method</u> – (changes / unusual) animal behaviour, e.g. birds, snakes, rodents, dogs <u>Limitation</u> – disbelief by society or scientists / not taking warning seriously OR not reliable as animals don't always react to potential changes OR animals give the same reaction to something else
3	(e)	(iii)	<u>Any one from:</u> Allows <u>hazard (risk) maps</u> to be produced OR positions of faults / rock types / soil types / steep ground / areas at risk from liquefaction / landslides can be located ✓ OR Allows evacuation plans / evacuation routes / safe muster points / safe locations for emergency services / hospitals ✓	MAX 1	AO2.1a	

Question			Answer	Mark	AO Element	Guidance
4	(a)	(i)	(Maximum) <u>amplitude</u> of P-wave / S-wave / seismic wave / earthquake wave ✓	1	AO1.1b	ALLOW <u>amplitude</u> correctly labelled on a diagram of a seismogram
4	(a)	(ii)	Seismometers / seismograms recorded in a shadow zone will not show seismic waves / vibrations ✓ Seismometers / seismograms recorded between 103° to 142° from the epicentre are in the P-wave shadow zone / will not show any P-wave arrivals ✓ Seismometers / seismograms recorded beyond 103° from the epicentre are in the S-wave shadow zone / will not show any S-wave arrivals ✓ P-waves are refracted / slow down in the liquid outer core OR S-waves cannot travel through the liquid outer core ✓	MAX 2	AO2.1b	ALLOW AW
4	(b)	(i)	<u>Ridge push</u> AND rising magma pushes plates apart (at MOR) OR plates move away from ridge due to gravity / slide off the ridge ✓ <u>Slab pull</u> AND the slab sinks (at subduction zones) and pulls the rest of the plate with it (due to gravity) ✓ <u>Convection cells / currents</u> AND in the mantle move plates / lithosphere OR hot upwelling at MOR OR cooler denser rocks sink at subduction zone ✓	1 1 1	1x AO1.1a 2x AO1.1c	MUST describe mechanism for each mark MAX 1 for a list of two OR three names of mechanisms OR MAX 1 for correctly describing a mechanism without naming it

Question			Answer	Mark	AO Element	Guidance
4	(b)	(ii)	Slab pull ✓	1	AO2.1a	
4	(c)		Iron / magnetic minerals in magma align to Earth's magnetic field OR (angle of inclination) is locked in when magma cools below Curie temperature / rock crystallises ✓ (Sea floor spreading) creates symmetrical pattern on either side of ridge ✓ Reversing / switching / flipping of magnetic poles creates (normal and reverse) magnetic stripes ✓	MAX 2	AO2.1a	
4	(d)	(i)	D Transgressive sill ✓ E Sill ✓ F Dyke ✓	1 1 1	AO3.1b	
4	(d)	(ii)	F  0 10m Both sides shaded full length in country rock ✓	1	AO2.1a	DO NOT ALLOW shading within the dyke IGNORE any shading on diagrams D and E

Question			Answer	Mark	AO Element	Guidance
5	(a)	(iv)	Siberian Traps OR 252 Ma major volcanic activity OR continental flood basalts of this age ✓ OR Plate tectonic / stratigraphic reconstructions showing existence of supercontinent / Pangaea at this time ✓ OR Lithological evidence / desert sandstones / evaporites showing hot, arid conditions at this time OR the coal gap ✓ OR ¹²C isotope / CO₂ / SO₂ spike ✓ OR Evidence of sea level changes ✓	MAX 1	AO1.1a	ALLOW evidence of impact event at this time if qualified, e.g., crater in Antarctica OR impact evidence such as shocked quartz (in Antarctica / Australia) ALLOW Glacial deposits (indicating global cooling / volcanic winter)
5	(a)	(v)	Soft substrate ✓ Fine-grained substrate OR fine-grained deposition of infill ✓ Low energy / no current ✓ Oxygenated sea floor ✓	MAX 2	AO1.1a AO1.1c	DO NOT ALLOW shallow marine unqualified ALLOW rapid deposition / burial IGNORE reference to anoxic conditions

Question			Answer	Mark	AO Element	Guidance
5	(b)	(i)	Solnhofen Limestone – Any one description for 1 mark from: Geological setting: shallow / lagoon / inland sea / hypersaline / anoxic / tropical or warm setting Sedimentary conditions: carbonate deposition / carbonate mud ✓ Whereas Burgess Shale – Any one description for 1 mark from: Geological setting: shallow shelf with escarpment / base of submarine cliff / deeper water / tropical or warm setting Sedimentary conditions: clastic deposition / clay / black mud / underwater landslide / turbidity current / rapid deposition / rapid burial / seafloor was aerobic / sediments were anoxic ✓	MAX 2	AO1.1a AO2.1a	ALLOW implicit comparisons / differences ALLOW description of geological setting or sedimentary condition for each ALLOW slow or rapid deposition / burial for Solnhofen Limestone as contested
5	(b)	(ii)	Solnhofen Limestone – Any one description for 1 mark from: Explanation of (atom-by-atom) replacement with calcite / 3D preservation / pyritisation ✓ Whereas Burgess Shale – Any one description for 1 mark from: Explanation of (atom-by-atom) replacement with clay / usually 2D preservation / explanation of carbonisation / pyritisation / silicification ✓	MAX 2	AO1.1a AO2.1a	ALLOW implicit comparisons / differences ALLOW necrolytic features (due to hypersaline conditions) for Solnhofen Limestone ALLOW 1 mark for replacement unqualified for either or both

Question			Answer	Mark	AO Element	Guidance
5	(b)	(iii)	Shows virtually all present-day animal phyla appeared at this time OR rapid appearance of many new organism types (compared to older rocks) OR many different organisms preserved showing rapid <u>adaptive radiation</u> / <u>complex communities</u> had emerged at this time ✓ Lagerstätten allow us to see soft bodied organisms not usually preserved ✓ Soft bodied organisms out number hard bodied suggesting many soft bodied organisms were present ✓ Enigmatic / problematic / experimental body plans preserved OR organisms with no known affiliation ✓ Sudden appearance of mineralised skeletons / organisms with hard exoskeletons ✓ Preservation of fine detail / soft tissue provides (more) evidence ✓	MAX 2	AO1.1c AO2.1a	ALLOW many different organisms preserved over a short time frame show rapid evolution occurred for MP1
5	(c)	(i)	Assumes sedimentary processes / sedimentary rocks / facies formed in the past were formed in the same way / environment as today ✓	1	AO2.1a	AW IGNORE the present is the key to the past

Question			Answer	Mark	AO Element	Guidance
5	(c)	(ii)	A facies is all the characteristics of a rock that allow it to be distinguished from rocks formed in an adjacent environment OR a facies association is a group of facies that occur together in one depositional environment ✓ Glauconitic or feldspar-rich sandstones / conglomerates / quartzites show shallow water (start of Cambrian) OR detailed description of Cambrian deposits ✓ Turbidites / shale show deeper water / offshore (later in Cambrian / Ordovician) OR detailed description of Ordovician deposits ✓ Volcanic rocks / tuffs (Ordovician) show volcanic centres were nearby ✓ Limestones show shallow marine / shelf / reef (Silurian) OR detailed description of Silurian deposits ✓ Red sandstones show desert / land (end of Silurian) ✓ Welsh basin shows differing sea levels OR transition from offshore to onshore OR transition from deep marine to terrestrial / desert over time ✓ Lithostratigraphy allows correlation of sedimentary rocks ✓ Biostratigraphy / zone fossils allow correlation / dating (of sedimentary rocks) ✓	MAX 4	1 x AO1.1c 3 x AO2.1a	AW ALLOW any reasonable definition of a facies or facies association ALLOW discussion of Walther's Law

Question			Answer	Mark	AO Element	Guidance
6	(a)	(i)*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Hydrogeological impacts are described and explained AND engineering geology is used to explain in detail reasons for the failure. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Hydrogeological impacts are described and explained OR engineering geology is used to explain reasons for the failure. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Information is lifted from the text OR there is an attempt to describe a hydrogeological impact OR a reason for the failure is suggested. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks - No response or no response worthy of credit.	6	2x AO3.1a 2x AO3.1c 2x AO3.1e	Indicative points may include: <u>Hydrogeological impacts:</u> • Dam not heavy / strong enough to counteract weight of water (as height increased twice with no widening at base) • Filling reservoir led to greater hydrostatic head / raised water table / water adding weight increases the force trying to lift the dam (or force it laterally into valley sides) • Hydrostatic / pore fluid pressure forces apart grains / breaks cohesion • Water lubricates / forces apart discontinuities, e.g. fault / bedding planes / joints / fractures / foliation / cleavage planes • Permeable / weathered rocks are likely to allow water ingress <u>Engineering geology and reasons for catastrophic failure:</u> • <u>Hydrostatic uplift</u> due to water under the dam was the ultimate cause of failure • <u>Conglomerate</u> not strong enough to support the weight of the dam / resist lateral forces of arch / conglomerate was not homogeneous / gypsum veins are weak or dissolved • <u>Mica schist</u> – east side failed first: because weathering weakened mica schist / cross-faults allowed ingress of water / thinly

6	(b)	Collapse / subsidence of rocks above ✓ Concrete lining / steel ribs ✓ OR Loose rocks / dipping rocks ✓ Rock bolting / shotcrete ✓ OR Flooding / water ingress ✓ Rock drains / grouting / shotcrete ✓ OR Spoil management / disposal ✓ Use for aggregate / land reclamation ✓ OR Vibrations (from explosives) / underbreak / overbreak ✓ Use TBM ✓	2	AO1.1a AO1.1b	1 + 1 for any correct pair of geological impact and matching mitigation DO NOT ALLOW rocks become weakened unqualified ALLOW tunnel supports / reinforce tunnel for MP1 mitigation ALLOW idea of water leaking from aqueduct tunnels + impermeable barrier to prevent leakage for MP3 ALLOW drill the tunnel rather than use explosives for MP5 mitigation
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