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Examiners' report

GEOLOGY

H414
For first teaching in 2017

H414/02 Summer 2019 series

Version 1

Contents

Introduction

Our examiners’ reports are produced to offer constructive feedback on candidates’ performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates’ performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 2 series overview

This was the first year of examination of the new H414 OCR GCE Geology A Level. H414/02 is the second of the three examination components for this new qualification. The paper is synoptic in nature and assesses content from across all of the 1 to 7 teaching modules, with an emphasis on scientific literacy – the ability to comprehend a passage of text of A Level standard, to extract information from it and use this information to answer the question posed.

Key point

In consequence, to do well on this paper, candidates needed to be able to draw together their knowledge and understanding, including mathematical and practical skills, from all parts of the OCR A Level Geology course and successfully apply them to unfamiliar situations and contexts.

The H414/02 paper included two six mark extended Level of Response questions (LoR), indicated by an asterisk (*) in the question paper and the mark scheme. The list of indicative points given in the guidance column of the mark scheme for these questions are by no means an exhaustive list and candidates are not expected to include all the points in order to attain the highest level. In consequence, there were many possible and equally credit-worthy ways that well-prepared candidates successfully answered these questions.

Those candidates who had been given opportunities to practise the required mathematical skills (Appendix 5e of the specification) over the two years of the course were able to demonstrate their proficiency and performed well on the mathematical skills questions.

Candidate performance overview

Candidates who performed well on this paper generally did the following:

- Read the questions carefully, taking note of all the information supplied and the command words used.
- Produced clear and concise answers to the structured short answer questions using correct geological terminology, knowledge and understanding gained from their course of study.
- Gave appropriate length answers to the extended LoR questions using sustained and coherent lines of reasoning, including appropriate geological content.
- Put together their knowledge and understanding from different areas of the specification when answering individual questions.
- Performed mathematical calculations with confidence, following the required rubric, e.g. clear working, use of correct units and significant figures.
- Plotted graphs with precision, including fully labelled axes, suitable choice of scales, accurate point plotting and, where required, a sensible choice of line of best fit.
- Applied their experience gained from carrying out practical work both in the laboratory and the field to demonstrate competence in the required range of practical geological skills and techniques.
- Drew clear, well-labelled and accurate diagrams when required.

Candidates who performed less well on this paper generally did the following:

- Wrote under-developed answers which either repeated the information provided in the questions or did not clearly address the questions asked.
- Did not have a good command of correct scientific terminology and knowledge and, in some cases, had almost illegible handwriting which was extremely difficult and time-consuming to decipher.
- Did not have the depth and breadth of geological understanding required to answer the mainly synoptic questions on this paper.
- Found it difficult to apply what they had learnt to unfamiliar contexts.

Candidate performance overview

- Were unable to tackle the mathematical skills questions with any confidence – some gave 'No Response' to all the calculation questions or produced poorly set out, unstructured calculations, often without a clear final answer.
- Were inexact in plotting and reading information from graphs and tables.
- Produced poor, inaccurate and incorrect diagrams not worthy of credit.

Although the answer spaces provided in the paper are a guide to an appropriate length of answer, in some cases, candidates found it necessary to continue their answer beyond the space provided. The additional answer space at the end of the paper should be used for this purpose. It is very helpful if candidates' flag that they have used the additional answer space and it is essential that any answers written in the additional space are correctly numbered with the full question number to make sure they gain any credit deserved.

It is a requirement within A Level Geology that at least 10% of the marks available assess the use of mathematical skills in the context of geology at a level of demand which is not lower than that expected at higher tier GCSE (9–1) Mathematics. The mathematical skills required are clearly explained in Appendix 5e of the specification, and further support is provided by the OCR Geology mathematical skills handbook, available on the OCR website.

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/)

Question 1 (a)

1 The physical and chemical processes that act on sediments after they become buried are varied but can be grouped under the term diagenesis.

(a) Complete the table showing four diagenetic processes.

Name of diagenetic process	Explanation of process
Cementation	
	Sediment squeezed by weight of overlying sediment; porosity and permeability reduced.
	Crystals change in size and shape.
	Minerals dissolve where grains press into each other.

[4]

Most candidates attained some credit for their answers to this question, but few gained all 4 marks. Compaction was the most well-known diagenetic process, with recrystallisation and pressure dissolution less so. There were some precise explanations given for the process of cementation with correct use of technical terms such as precipitate / crystallise / pore space. Many did not explain the source of the cement.

?	**Misconception**	The most common misconception was that cementation is the process of infilling by finer grains or matrix, rather than by the precipitation/crystallisation of minerals from circulating pore fluids/connate water.

Question 1 (b) (i)

(b) Peat undergoes diagenesis that allows it to change into coal. Different types of coals are formed at different stages as shown in Fig. 1.1 below.

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Fig. 1.1

Fig. 1.2 shows the geothermal gradient for an area in South Wales at the time of coal formation.

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Fig. 1.2

(i) Using Fig. 1.2, calculate the average geothermal gradient in this area.

Give your answer to **2** significant figures.

geothermal gradient = ... °C km^{-1} **[2]**

Many candidates were able to calculate correctly the average geothermal gradient, but some lost the second mark as they did not write down their answer to the correct number of significant figures. Not all candidates remembered to subtract the surface temperature from the temperature at depth before dividing by the depth.

	AfL	In all A Level sciences candidates are expected to be able to interpret and abstract information from diagrams, graphs and tables to an appropriate resolution. For graphs this means to ±½ scale division. Several candidates did not draw their horizontal and vertical lines on the graph with care and so the values they abstracted were inexact.

Question 1 (b) (ii)

(ii) Using Fig. 1.2, state the depth range at which you might expect to find **anthracite** coal deposits.

depth range = ... km **[1]**

This question required candidates to apply the information from Fig 1.1 to make a prediction using Fig 1.2. If they used the graph carefully they would have found that the upper and lower ranges were both whole kilometre values. Many candidates only stated one number and did not give a range. Other candidates did not use the information given in Fig. 1.1 (temperature range of 170° to 200°C) for the formation of anthracite. The most common misconception was to give 7 km as the upper limit of the depth range. Given that this depth corresponds to a temperature of 220°C, it should have been clear to candidates that this was not the required value.

Question 1 (c)

(c)* Sedimentary rocks are classified using a variety of diagnostic properties.

Explain, with named examples, how appropriate diagnostic properties are used to classify the different **siliciclastic** rocks.

....

.... **[6]**

There were some excellent answers to this Level of Response question that attained the maximum Level 3 marks with ease. Candidates secure in their knowledge and understanding of how the key diagnostic properties of colour, composition, grain size, grain shape and sorting are used to classify siliciclastic rocks gave logically structured explanations of the classification system, often including a comprehensive range of correct named siliciclastic rocks to exemplify their answers.

Some candidates included irrelevant information about environment of deposition which is not used in classification and, in some cases, detracted from the overall quality of their answers as it distracted from a focus on the key properties used in classification. Weaker responses stated diagnostic properties but did not explain how they are used in classification or did not give correct named examples of rocks to back up their response.

A significant number of candidates could not be given any credit for their answers as they did not seem to understand the word siliciclastic or misinterpreted it and wrote about the silica content and classification of igneous rocks. Other incorrect responses described the Dunham classification of carbonate rocks or the diagnostic properties used to identify rock-forming minerals.

	AfL	Siliciclastic is the term used in the H414 Geology specification to describe clastic sedimentary rocks composed of silicate minerals, so it would help candidate understanding to use the full term when teaching this topic and make sure candidates comprehend its meaning.

Exemplar 1

One diagnostic property used is grain size. This measure the average grain size for a rock and puts it in the category of a siltstone or mudstone if < 0.0625 mm, a sandstone (0.0625 – 2mm) and then clastic rocks above 2mm. The composition of the rocks can also tell us a lot. Rocks with greater than 25% pottasium feldspar are likely to be Arkose, rocks with a quartz grain and quartz cement are orthoquartzite or if it has a haematite cement, red desert sandstone. The roundness and ~~The~~ sorting of the grains can also be very useful, well sorted and well rounded grains indicate ~~[illegible]~~ aeolian transport or beach deposits so usually sandstones whereas poor sorting and angular clasts would indicate rapid deposition and [6] not very much transport such as greywacke or a breccia. ~~[illegible]~~ If it is poorly sorted and has rounded grains then it would be a conglomerate.

An example of a Level 3 response worthy of 6 marks is given in Exemplar 1. This answer considers grain size, composition, sorting and roundness and gives a suitable number of correct named rock examples to illustrate how the classification system is applied.

Exemplar 2

Sedimentary rocks can be classified on how well sorted and well rounded the clasts are. A sedimentary rock such as desert sandstone shows well sorted and well rounded clasts. This is determined by simply looking at the rock, or, if the ~~rock~~ clasts are very fine, look at it under a microscope. An example of a poorly sorted ~~a~~ rock with angular clasts would be Breccia, as it is formed in glacial environments. Silicic rocks are also light in colour, so just by looking at it you can immediately tell the silica content based on if it's light (silicic) or dark (mafic).

Exemplar 2 is an example of a less successful response which achieved Level 1. The answer only gives two correct named rocks, but they are linked to properties used in classification.

Question 2 (a) (i)

2 Scientific knowledge of the physical structure of the Earth has advanced in the last 50 years.

The density of different parts of the Earth is one physical aspect that it has been possible to calculate. For example:

- density of surface rocks – 2.8 g cm^{-3}
- mean density of mantle – 4.5 g cm^{-3}
- mean density of the Earth – 5.5 g cm^{-3}

(a) (i) Describe and explain what can be inferred about the Earth's structure and processes of formation using the density evidence above.

....

....

....

....

.... **[2]**

Many candidates were able to attain one mark for describing and explaining that the Earth must contain a dense core to balance the lower density surface rocks and mantle. However fewer candidates went on to explain what could be inferred about the processes of formation of the Earth, to get both the marks.

Those who used technical terms such as differentiation or partitioning of the Goldschmidt elements on the basis of density were in the minority.

A significant number of candidates only discussed the relative densities of surface rocks and the mantle. But did not say anything about the denser material that must be present at depth to produce an overall density of 5.5 g cm^{-3}. As these candidates only considered two of the three data points they had not provided an answer to the question.

Question 2 (a) (ii)

(ii) The global distribution of seismic activity is shown in Fig. 2.1. Each black dot represents a recorded earthquake epicentre.

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Fig. 2.1

Describe and explain what can be inferred about the Earth's structure and internal processes using the seismic evidence from Fig. 2.1.

....

....

....

....

.... **[2]**

The division of the Earth's surface into lithospheric plates was well-known and most candidates attained some credit for their answers. Only the most successful answers went on to explain how the global distribution of seismic activity provides evidence for the movement of the lithosphere by internal processes such as ridge push or slab pull or that the lithosphere forms the thermal upper boundary of mantle convection cells.

?	**Misconception**	It has been highlighted in recent reports for the legacy specification that ideas about 'mantle convection moving' lithospheric plates are not valid. However, some candidates continue to use this discredited theory.

i	**OCR support**	The Module 3 Global Tectonics Delivery Guide contains several resources to help teachers understand and teach the up-to-date model of Plate Tectonics. These have been updated to include additional teacher guidance. • Learner resource 3 – Mantle convection • Learner resource 4 – Lithospheric plates, subduction zones and mantle plumes • Learner resource 5 – What makes the Earth's plates move? • Learner resource 6 – How geologists got moved • Learner resource 7 – Plate tectonic settings

Question 2 (b)

(b) A variety of volcanic landforms have formed across the Earth's surface. One factor controlling these landforms is the nature of surface igneous activity at plate boundaries.

Describe the landforms of The Andes and Indonesia by completing the table below.

Location	**Type of plate boundary**	**Type of volcanic activity**	**Composition of magma**	**Example of rock type**
The Andes in South America				
Indonesia				

[4]

Most candidates were awarded some marks for their answers to this question, but few gained all 4 marks. Some candidates seemed unsure of the meaning of the term volcanic landform and, in some cases, gave irrelevant as well as incorrect answers. Some candidates continue to use terms such as constructive / destructive margins which have not been used in OCR Geology specification for over 10 years. Candidates are best advised to use the technical terms given in the current specification.

Many candidates did not know the plate boundary beneath the Andes or Indonesia. Several of those who correctly stated convergent plate boundary for both did not differentiate between oceanic–continental and oceanic–oceanic settings. A common misconception was to give the Andes as an example of a continental-continental boundary.

There were also many contradictions given for the type of volcanic activity, composition of magma and rock type. Candidates who gave intrusive rather than volcanic rock names as their examples were not given credit as the question was about volcanic landforms and surface igneous activity. The most successful candidates confined themselves to giving one named rock example for each, as those who gave a list of rocks often contradicted themselves and lost marks.

i	**OCR support**	Learner resource 7 – Plate tectonic settings, in the Module 3 Global Tectonics Delivery Guide is an activity that can help candidates to bring together different aspects of volcanic processes and products and relate them to plate boundary settings in a visual and engaging way.

Question 2 (c) (i)

(c) There is evidence that a 'supercontinent' called Pangaea existed in the Permian which gradually broke up to give the present day distribution of the continents.

Palaeomagnetism in rocks can be used as evidence that the continents have moved apart.

(i) Describe how palaeomagnetism forms in rocks.

[3]

The basic processes for the formation of palaeomagnetism in rocks was well understood by most candidates but few provided the specific detail needed for all 3 marks. Many candidates did not appreciate the question was set in the context of reconstructing historical plate movement and gave answers explaining the formation of magnetic anomalies at mid–ocean ridges. These candidates could still get credit for explaining how basalt erupted at ocean ridges becomes magnetised, but rarely attained maximum marks.

A number of candidates knew the significance of the Curie point, but few of them could explain what remnant magnetism was.

Exemplar 3

When magma cools, magnetite (and iron) will align parallel to the earth's magnetic field at the time. Once the magma (and minerals) fall below the curie point and solidify, the alignment remains. The ~~rock~~ minerals may be found aligning differently to the present magnetic field, and therefore show palaeomagnetism. **[3]**

Exemplar 3 demonstrates the appropriate level of specific detail required, including a specific mineral (magnetite).

?	**Misconception**	Many candidates had a very superficial knowledge and understanding of palaeomagnetism and included a more simplistic explanation that iron minerals in magma align with respect to the Earth's magnetic field at the time. The orientation of the minerals in an igneous rock are not linked to the direction of the permanent remnant magnetism. Remnant magnetism is a property of the Fe ions (specifically the unpaired outer shell electrons) in the mineral lattice.

Question 2 (c) (ii)

(ii) Polar wandering curves use palaeomagnetism as evidence for the movement of continents.

Simplified polar wandering curves for two present day continents, **A** and **B**, are shown in Fig. 2.2. The ages of the rocks on each continent are given in millions of years (Ma), from the late Precambrian to the present day.

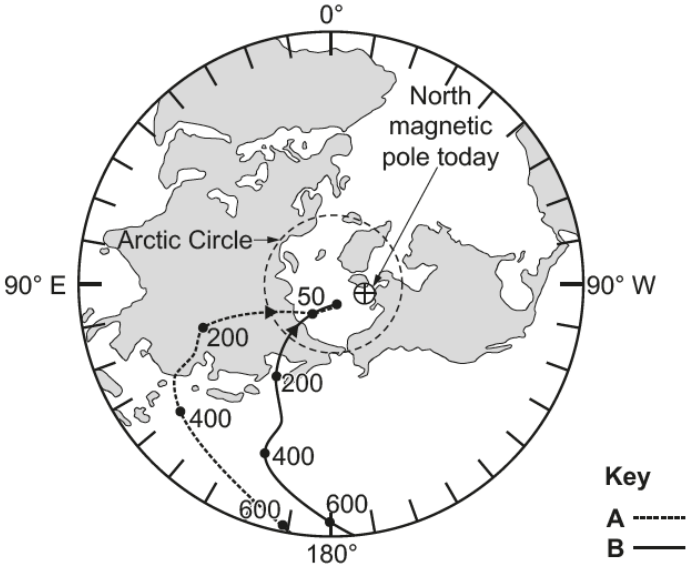

Fig. 2.2

Explain how the two polar wandering curves provide evidence for plate tectonic movement.

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....

.... **[3]**

A third of candidates gained some credit for this question but very few were credited with more than one mark. Candidates often discussed plate tectonic movements or continental drift in general but did not apply their discussion to the shapes of the polar wandering curves for continents A and B. Only a few candidates stated that the two continents had moved north from the late Precambrian to the present day, or that the matching curves show the two continents were joined at that time / diverging curves show the continents were moving independently.

Many answers would have been improved if they had referred to the specific ages shown on Fig. 2.2 when describing when the two continents were joined and when they were apart. Some candidates who had not answered part (c)(i) correctly, were able to explain how rocks became magnetised here.

?	**Misconception**	Candidates often referred to the movement of the North Pole rather than the movement of continents. Polar wandering curves show the movement of continents over time with respect to the position of the North Pole which is fixed. Polar wandering curves for different continents can be compared – matching curves show the continents were joined and moving together at that time and diverging curves show the continents were drifting apart.

Question 3 (a)

3 In the late 1800s the iron industry in the town of Merthyr Tydfil in South Wales was expanding rapidly. In order to supply the increasing demand for water, a new dam (the Pentwyn Dam) was developed at a site north of Merthyr Tydfil, in order to create a reservoir.

The maps in Fig. 3.1 show the area around the dam as well as the local geology.

(a) Large scale leakage occurred as soon as the Pentwyn Dam was completed.

Describe and explain **two** engineering strategies that could have been used to improve the site prior to the construction of the dam.

1 ....

....

....

2 ....

....

....

[2]

Engineering strategies to prevent leakage of dams and reservoirs were well-known and most answers to this question attained some credit. Around a third of candidates did not provide matching explanations to their chosen strategies and thus could not get the second mark. Common omissions were not to state what a reservoir lining would be made of and not to use the technical terms permeable or impermeable in explanations. Many candidates did not to use any appropriate technical terms in their explanations, for example permeable and impermeable.

A number of candidates described engineering strategies such as rock bolting and wire netting which were not relevant to the question and some suggested that the best strategy would be to move the dam. Other candidates did not comprehend the question and suggested geophysical surveys should be undertaken to investigate the site.

Question 3 (b) (i)

(b) Table 3.1 lists data relevant to the strength of various rock types.

Rock type	Uniaxial compressive strength (MPa)	Uniaxial tensile strength (MPa)	Shear strength (MPa)
Basalt	100–300	10–30	20–60
Granite	100–250	7–25	14–50
Limestone	30–250	5–25	10–50
Sandstone	20–170	4–25	8–40
Shale	5–100	2–10	3–30

Table 3.1

(i) Explain why basalt and granite have the highest values for the different types of strength.

....

....

....

....

.... **[2]**

Most candidates got one mark for explaining that basalt and granite are igneous rocks and therefore made of interlocking crystals. Candidates who went on to explain that igneous rocks are competent, lack pore space or do not contain bedding planes were awarded the second mark. Marks could not be awarded for stating that the rocks do not contain planes of weakness as competent rocks such as basalt and granite are often jointed.

Question 3 (b) (ii)

(ii) State the difference between the terms compressive strength and tensile strength.

....

.... **[1]**

The majority of candidates correctly stated the difference between compressive strength as resistance to stresses pushing towards each other and tensile strength as resistance to stresses pulling away from each other.

?	**Misconception**	Some candidates used terms from the stem of the question in their descriptions, which resulted in circular reasoning. These candidates used terms like compression / compressional forces or tension / tensional forces in describing differences and so could not gain any credit.

Question 3 (b) (iii)

(iii) Explain why the compressive strength of the underlying rock is important when considering the site for a new dam.

....

....

....

....

.... **[2]**

Many candidates showed awareness that compressive strength of underlying rocks was important because the additional weight of the dam and / or reservoir could potentially result in failure of the dam, reactivation of faults or subsidence of underlying rocks. However most of those candidates did not distinguish between the problems caused by the mass of the dam itself and the mass of the water in the reservoir behind it. Although subsidence was sometimes stated as an issue, few went on to develop their answer to explain the problem of differential subsidence due to variations in rock strength.

?	**Misconception**	A common misconception was using the terms dam and reservoir as synonyms. The term dam refers to the structure that holds back the water, whereas the term reservoir refers to the body of water stored behind the dam wall.

Exemplar 4

Very high load placed on rock through mass of dam and ~~xxxx~~ hydrostatic pressure of reservoir water. Failure in the rock could comprimise the structure and stability of the dam. Any break could cause catastrophic **[2]** floods of reservoir water down valley.

This candidate clearly differentiates between the mass of the dam and the hydrostatic pressure of the water in the reservoir and was credited with both marks.

Question 3 (b) (iv)

(iv) Using the data in Table 3.1, calculate the percentage difference between the compressive strength of the limestone and sandstone.

difference = ... % **[2]**

Half the candidates successfully applied their mathematical skills to answer this question and they took a variety of different approaches to calculating the difference. Some calculated the percentage difference between the means of the compressive strengths of the limestone and sandstone, some calculated the difference between the mid points of the ranges of strengths for limestone and sandstone and others calculated the difference between the upper and lower ranges of strength of the two rocks. The mark scheme allowed for credit to be given for any of these different approaches provided the candidate correctly calculated the percentage strength difference using a clear and valid comparison of the ranges of strength of the two rocks.

The most common error was calculating the strength of sandstone as a percentage of the strength of limestone rather than calculating the difference in strength as a percentage.

Question 3 (c)

(c)* The Pentwyn Dam was constructed from limestone blocks, broken limestone and sandstone over a waterproof core.

Evaluate the information and evidence given in Fig. 3.1 and Table 3.1 to determine whether the chosen site was appropriate for constructing a dam.

....

.... **[6]**

This Level of Response question asking candidates to evaluate whether the site of the Pentwyn Dam was appropriate for constructing a dam was a good discriminator and produced the whole range from 0 to 6 marks. Candidates who produced answers that satisfied the Level 3 requirements took careful note of the question and clearly evaluated the information and evidence given in both Fig. 3.1 and Table 3.1 to arrive at an explicit decision as to the suitability of the site. These candidates spotted most of the relevant geological and general factors and gave a logically structured discussion and evaluation of the evidence, with most concluding that the site was not appropriate for constructing a dam.

Some candidates did not distinguish the most relevant considerations for the site of the dam from those most relevant to the site of the reservoir. This limited the level that their answers could reach. The main issue for the foundations of the dam are the compressive strength of the underlying rocks and presence of faults. Had the question been about the floor of the reservoir, permeability would have been the key consideration. Lower attaining candidates did not differentiate between the factors of strength and permeability and made statements such as 'the rocks are weak so they will allow leakage'. Some candidates incorrectly stated that limestone is impermeable.

Many candidates had not studied Fig. 3.1 carefully and did not distinguish between the site of the dam on limestone and the site of the reservoir on both limestone and sandstone, some stated that the dam site was on sandstone. Others lost marks as they only evaluated the strength information given in Table 3.1, even though tensile and shear strength are not important factors for the siting of dams and reservoirs. To the detriment of their answers, some candidates focused entirely on the construction materials of broken limestone and sandstone over a waterproof core and ignored the prompt to evaluate information given in Fig. 3.1 and Table 3.1.

Some of the candidates who assessed the compressive strengths of the limestone and sandstone made the point that both are competent, strong rocks, while others compared their strengths to that of granite and basalt and concluded they were not as strong. Only the highest ability candidates recognised that the variability of the rocks compressive strengths was the key issue and could lead to differential subsidence, or that the minimum compressive strength values should be considered as the most important factor. Few candidates suggested reasons to account for the range of strengths.

Exemplar 5

The dam is located on 2 different rock types which have a huge difference in compressive strength, suggesting they will behave differently under stress, meaning it is unstable. The reservoir is located on sandstone ~~water~~ which is permeable, so leaking may occur and destabalise the dam. There are also 2 faults which could increase permeability or if they slipped then it could cause the dam to fail completly. The increased volume of water means that the reservoir ~~may~~ is close to the road, this may flood the road, or erode beneath it and cause it to fall into the reservoir. There are also a number of sinkholes surrounding the dam, **[6]** showing that the area is unstable. This means the dam foundations could be as well. To conclude, this site is too unstable and not appropriate for the construction of a dam.

This response is an example of a Level 3 answer that got full marks. This answer considers the strength and permeability of the underlying rocks, recognises the potential problems caused by the presence of faults and nearby sink holes, plus the proximity to the road and concludes with a clear statement that the site is unsuitable for a dam.

Exemplar 6

* From figure 3.1 it can be seen that roughly 0.5 km of the dam is covered by Carboniferous limestone in the southern area of the dam which spans over nearly two faults. This limestone is relatively strong of 30 – 250 MPa compressive force withstanding. As a result I deem the rock of this area to be appropriate, but the location not as two faults are present that may create structural issues and there is a change in composition of rock which can be difficult to deal with.

* The ~~north~~ north section of the dam above the fault is in Devonian Sandstone which can be relatively weak at on supporting 20 – 170 MPa of compressive strength. Sandstone is relatively porous as **[6]** ~~well~~ well and when introduced with water may become even weaker. For these reasons I deem the area not to be appropriate.

This exemplar meets the criteria for Level 2. The candidate has identified relevant factors including rock strength, presence of faults and porosity of the sandstone but they have not differentiated between the site of the dam and the site of the reservoir and they have not addressed the major issue of potential water leakage.

Question 4 (a) (i)

4 Bowen's Reaction Series, shown in Fig. 4.1, charts the formation of different minerals as a magma cools.

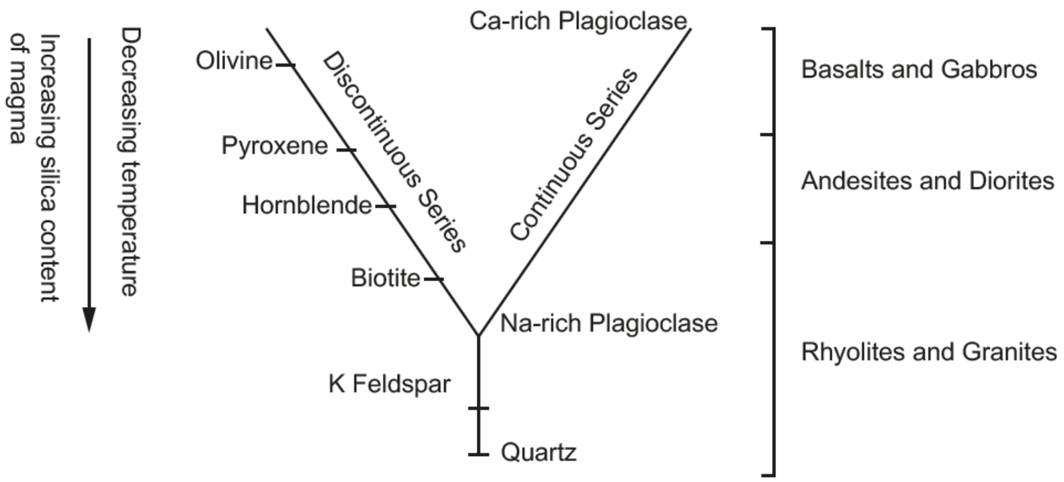

Fig. 4.1

(a) The reaction series indicates increasing silica content of magma as it cools.

(i) Explain why the silica content of magma increases as it cools.

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....

.... **[2]**

Just over a half of all candidates gained some credit for this question. A significant number of candidates did not make it clear whether the increasing silica content they described in their answer related to the remaining magma or to the crystallising minerals. Those who explained how magmatic differentiation occurs due to the removal of high temperature, dense mafic minerals by gravity settling were in the minority.

Common misconceptions included confusion about the terms rock, mineral and element (e.g. referring to iron and magnesium as minerals or olivine as a rock). Many candidates thought silica was a mineral (silica is silicon dioxide, SiO_2, quartz is a mineral composed of only SiO_2). Many candidates merely repeated the information given in the diagram or the question.

?	**Misconception**	A significant number of candidates were confused between the terms crystallise and cool. The molten minerals in magma all cool down together. At any particular point in time they will all be at the same temperature, but at the high temperature, mafic minerals with high melting points will crystallise first. They do not cool first.

Question 4 (a) (ii)

(ii) Changing silica content affects the properties of magma.

Explain how the differing silica content of extruded magma at divergent and convergent plate boundaries affects the properties of the magma and the resulting landforms.

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....

.... **[3]**

Although the majority of candidates gained some credit only a quarter of the candidates were given all 3 marks. Many candidates did not relate the volcanic landforms they described to a plate boundary type, while others described volcanic products rather than the volcanic landforms asked for in the question. Several candidates did not explicitly state the viscosity of the magma type they were describing, and so could not gain that mark. A common misconception was candidates who contradicted themselves and stated silicic magmas have a low viscosity making them thick or the reverse statements for mafic magmas.

Question 4 (b) (i)

(b) The viscosity of lava erupted by volcanos at convergent plate margins is dependent on both the composition of the lava and the temperature.

A group of students decided to investigate the effect of temperature on the viscosity of liquids. They dropped ball bearings through golden syrup, as shown in Fig. 4.2 below.

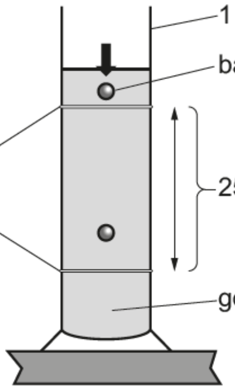


Fig. 4.2

The students recorded the time taken for the ball bearing to drop through the golden syrup from the top rubber band to the bottom rubber band. They repeated the experiment four times at two different temperatures. Their results are shown in Table 4.1.

	Time taken (s)	
Test	**20 °C**	**40 °C**
1	70	61
2	69	57
3	73	71
4	72	62

Table 4.1

(i) The students calculated a mean value of 60 seconds at 40 °C.

Explain how they arrived at this value.

....

....

....

.... **[2]**

Most candidates gave correct responses to this question and over half got 2 marks. The best responses recognised that the students should not have excluded the repeat test 3 result of 71 seconds as no reason was given to allow them to judge that it should be excluded. These candidates were clearly familiar with the statement about anomalous results given in the OCR Geology Practical Skills Handbook. The most common misconception was to suggest the students had rounded their calculated mean down to the nearest 10.

i	**OCR support**	The OCR Geology Practical Skills Handbook contains useful information about anomalous values: *'Anomalies (outliers) are values in a set of results that are judged not to be part of the inherent variation. If a piece of data was produced due to a failure in the experimental procedure, or by human error, it would be justifiable to remove it before analysing the data. For example, if a dip angle is clearly different to the other readings taken for that particular outcrop, it might be judged as being an outlier and could be ignored when the mean is calculated. However, data must never be discarded simply because it does not correspond with expectation.'*

Question 4 (b) (ii)

(ii) The students needed a modification of Stokes' Law in order to calculate the viscosity of the golden syrup.

Calculate the viscosity of the golden syrup at 40 °C.

Use the formula: $\text{Viscosity}(\eta) = \dfrac{2g \times (\rho_b - \rho_l) \times a^2}{9v}$

where: **g** is the acceleration due to gravity = $9.8\,\text{ms}^{-2}$
$\boldsymbol{\rho_b}$ is the density of the steel ball bearing = $8.0 \times 10^3\,\text{kg m}^{-3}$
$\boldsymbol{\rho_l}$ is the density of the liquid golden syrup = $1.4 \times 10^3\,\text{kg m}^{-3}$
a is the diameter of the ball bearing = $5.0 \times 10^{-3}\,\text{m}$
v is the velocity of the ball between the two rubber bands (ms^{-1})

Give your answer to an appropriate number of significant figures.

viscosity = ... Pa.s **[3]**

Around a quarter of all candidates performed all the steps in the calculation to arrive at the correct answer. The mark scheme allowed for the use of either 63 or 60 seconds as the time. The most common mistake was incorrect calculation of the velocity of the ball bearing as some candidates did not convert the distance of 25 cm into metres, before dividing distance by time. If candidates did make a mistake calculating the velocity, they could still attain 2 marks for error carried forward for the remaining calculation if their working was correct and clearly shown. A significant number gave 0.86 as their final answer showing they had made this error, but only those who showed their working could be given 2 marks for error carried forward. For this reason, it is advisable that candidates always show their working for any calculations.

Some candidates were careless in their substitution of numbers into the formula provided. The most common errors here were forgetting to include the velocity or forgetting to square the diameter of the ball bearing. Some candidates, having correctly done the hard part of the calculation, lost a mark as they did not give their final answer to an appropriate number of significant figures (in this case 2 or 3 s.f.).

Exemplar 7

$$\eta = \frac{(2 \times 9.81) \times (8 \times 10^{3} - 1.4 \times 10^{3}) \times (5 \times 10^{-3})^{2}}{9 \times (1/240)} = \frac{19.6 \times 6600 \times 2.5 \times 10^{-5}}{3/80} = 86.24$$

where $V = \frac{0.25\text{m}}{60\text{s}}$

$V = 4.17 \times 10^{-3} = \frac{1}{240}$

viscosity = ...86.................. Pa.s **[3]**

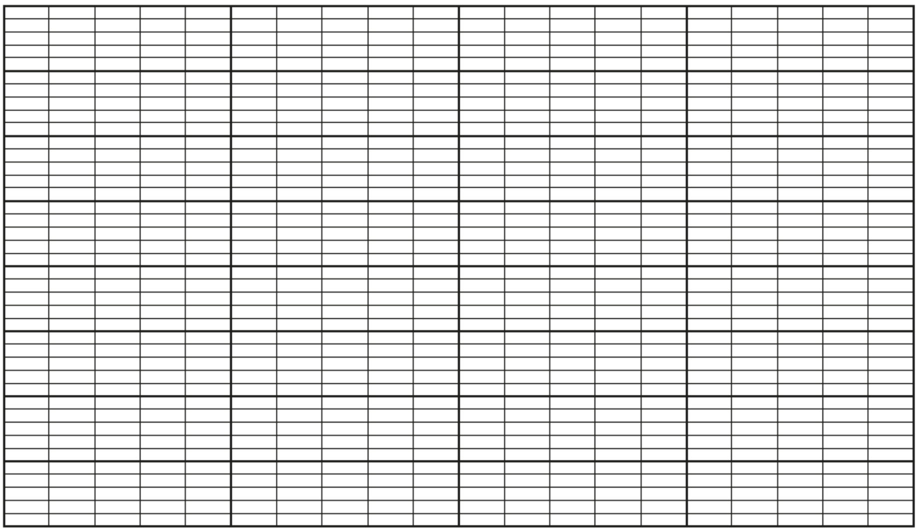
Exemplar 7 shows a very clear set of calculations. All steps are clearly laid out, including the velocity calculation, and the final answer is given to an appropriate number of significant figures. Candidates should be practising calculations with geological data at every opportunity and making themselves familiar with the use of significant figures. The extension activities in the exemplar PAG activities are one place where this can be done.

Question 4 (c) (i)

(c) Earthquake activity occurs at convergent plate boundaries.
The table below shows data for a series of earthquakes giving depth of focus and distance from the plate boundaries off the coast of Japan.

Distance from plate boundary (km)	1600	1100	900	390	180	100	420	1200	1000	260
Depth of focus (km)	350	310	200	30	35	20	100	300	230	45

(i) Plot a graph of the data and draw a line of best fit.



[3]

This graph plotting question was done well by almost every candidate. Almost all candidates correctly labelled distance (km) as the x-axis and the depth (km) as the y-axis, picked a suitable scale, plotted the points correctly and added a sensible straight line of best fit to attain the maximum 3 marks. However, those that used the standard geological convention of plotting depth downwards were in the minority. Only a handful of candidates did not add a sensible line of best fit (in this case a straight line).

	AfL	To aid accurate and speedy plotting of points, candidates should practice choosing appropriate scales that would make this task easier. There is advice on graph plotting in the Practical Skills Handbook, appendix 6. Using a pencil to draw graphs is standard practice and a good quality HB is recommended for this purpose. Many candidates used inappropriately hard (≥H) pencils that only made faint dots that are hard to see. It is advisable to have a specific sharp pencil for doing all geological drawings and to plot points as small precise crosses, as shown in Appendix 6. Further guidance is given in the Drawing Skills Handbook, page 4.

Question 4 (c) (ii)

(ii) Define the term focus.

....

.... **[1]**

Most candidates were familiar with the term focus but to be credited with the mark they did need to specify 'within the Earth' or words to that effect. A few candidates were confused between the terms focus and epicentre.

Question 4 (c) (iii)

(iii) Use a **labelled diagram** to explain the pattern shown by your graph.

....

....

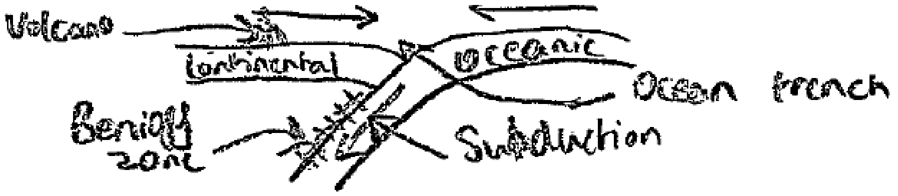
....

.... **[3]**

The majority of candidates gained some credit with most either getting one mark or full marks. Most candidates could describe the pattern shown on their graph, but fewer were able to explain this pattern. The statement given at the start of the question that 'earthquake activity occurs at convergent plate boundaries' should have helped to direct candidates to the correct explanation.

Although the question asked candidates to use a labelled diagram, few candidates drew a well-labelled cross-section diagram showing the Benioff Zone marking the top of the subducted plate at a convergent plate.

Exemplar 8



Friction occurs at the Benioff zone when the oceanic plate subducts under the continental. The depth of focus increases as the distance from convergent boundary increases because the oceanic plate **[3]** moves diagonally down so friction occurs at higher depths

Turn over

This candidate was credited with the maximum 3 marks. The response uses a suitable labelled diagram backed up with a sound description and explanation of how earthquakes occur along the Benioff Zone.

Question 5 (a) (i)

5 Analysis of sediments can give a valuable insight into the sedimentary processes and conditions operating at the time the sediment was deposited.

(a) The Welsh Basin, a sedimentary basin formed during the Lower Palaeozoic, is located across Central Wales and the Welsh borders.

Turbidite deposits are found within Ordovician rocks in the area. The diagram shown in Fig. 5.1 represents an idealised Bouma turbidite model of deposition.

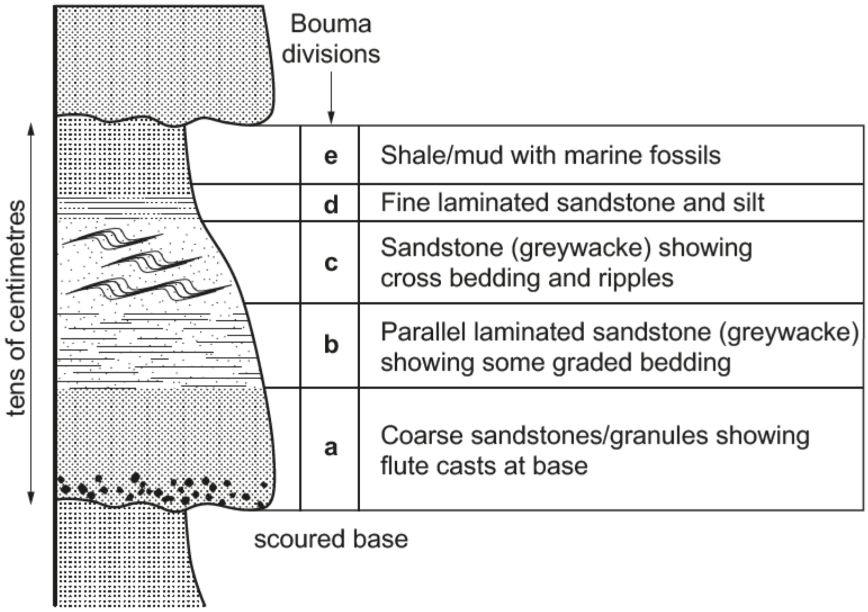


Fig. 5.1

(i) Explain how the idealised Bouma sequence shown in Fig. 5.1 was formed.

....

.... **[4]**

The quality of candidate responses to this question were variable and a quarter of candidates gave no creditable response. All candidates should be familiar with how the Bouma sequence shown in Fig. 5.1 was formed from 5.1.1b and 7.2.3a. High ability candidates produced excellent answers that considered each of the Bouma divisions in turn and clearly related units a to e and their features to decreasing current velocity as the turbidity current ran out of energy. Many of these high level responses also recognised the cyclical nature of the turbidite and interturbidite deposits shown in Fig. 5.1. Other candidates did not link the fining upwards sequence to a reduction in current velocity. The least successful candidate responses ignored the question and gave descriptions without any explanations for one mark.

A common misconception was to ignore the information in the stem of the question and interpret all or parts of the sequence as fluvial, deltaic or aeolian in origin. If these candidates gave correct explanations of individual features shown in the graphic log, they could attain up to a maximum of 2 marks.

Question 5 (a) (ii)

(ii) The orientation of flute casts at the base of a turbidite can be measured using a compass-clinometer.

A group of students took measurements from turbidite deposits found in the Welsh Basin. These are recorded in Table 5.1.

Orientation	Number of flute casts
0–180°	0
181–195°	0
196–210°	2
211–225°	3
226–240°	6
241–255°	14
256–270°	12
271–285°	8
286–300°	6
301–315°	2
316–330°	1
331–345°	2
346–360°	1

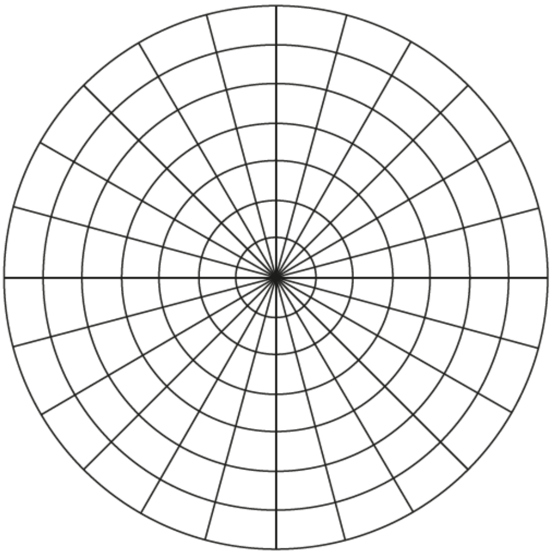


Table 5.1

Plot a rose diagram using the data in Table 5.1 and describe the pattern shown.

....

....

....

.... **[4]**

Most candidates were able to plot the rose diagram correctly and describe the pattern shown to get the full 4 marks.

Some candidates did not label north at the top of the rose diagram but could still gain marks if they plotted the diagram correctly according to their labelled compass bearings. Others appeared to have double plotted each segment which could not be given credit and some plotted odd and what appeared to be back to front diagrams.

Errors seen included: forgetting to label compass directions or bearings on the diagram; plotting the direction as a trend; incorrectly describing the direction of flow as east–west instead of east to west; or describing the pattern as south west west instead of west south west.

Question 5 (b)

(b) Two graphic logs were plotted of outcrops on the western and eastern sides of the Welsh Basin, shown in Fig. 5.2.

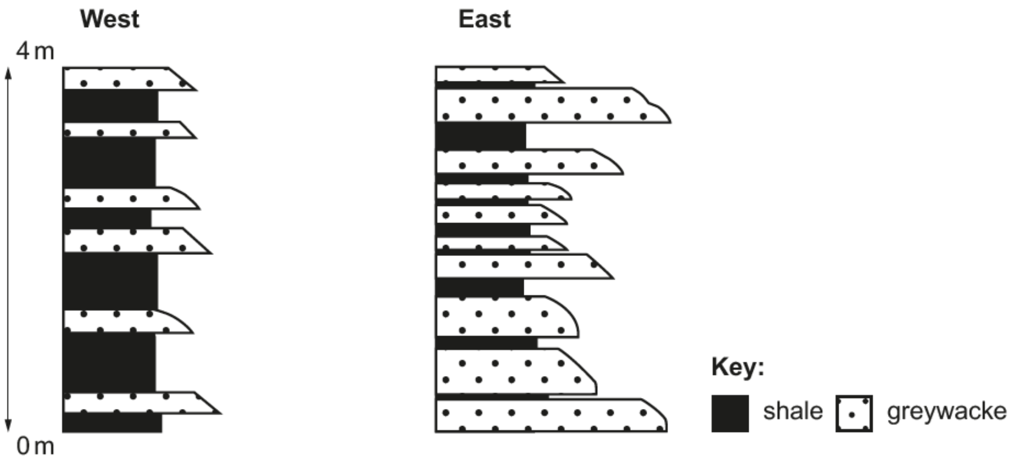


Fig. 5.2

Use the evidence provided by both the graphic logs and the rose diagram to describe and explain the geological setting and depositional environment of this area of the Welsh Basin.

....

....

....

....

....

.... **[4]**

Many candidates recognised that the greywacke was the result of deposition in higher energy conditions and the shale in lower energy conditions. Some candidates did not explicitly link their descriptions and explanations to the differing conditions on the eastern and western sides of the Welsh Basin.

The orientation of the flute casts on the rose diagram showed the palaeocurrent direction to be to the west south west, but some candidates incorrectly interpreted this to mean there were more flute casts in the west. As there are more greywacke units in the east, there would be more flute casts in the east, but they show flow in a westerly direction. Some candidates confused terminology – some thought the flute casts were the turbidite units themselves. A few candidates appeared unfamiliar with these sedimentary structures and referred to flute 'clasts' and, even 'flute clams' which were described as marine animals.

Question 5 (c)

(c) The two graphic logs have been interpreted as being of the same age.

Describe and explain how geologists may have used additional evidence to reach this conclusion.

....

.... **[5]**

The use of biostratigraphic correlation and zone fossils for dating Lower Palaeozoic rocks in the Welsh Basin was well-known and most candidates attained some credit for their answers to this question. However, many candidates did not develop their answers beyond stating the use of (zone) fossils for biostratigraphic correlation and explaining the same fossils equals the same age. Few candidates were able to give correct named examples of specific fossil types used, such as graptolites, trilobites or corals. A common misconception was to use ammonites as an example of a zone fossil in the Lower Palaeozoic.

The small number of candidates who referred to the possible use of ash / tuff bands or glauconite for chronostratigraphic correlation were given credit. However, those who wrote their whole answer about the use of radiometric dating lost marks as this technique is not generally used to correlate sedimentary sequences due to a lack of suitable minerals.

Very few candidates recognised and explained the limitations of lithostratigraphic correlation due to the problem of diachronous beds or the difficulties of attempting to match the different numbers of greywacke and shale units across the basin.

Exemplar 9

Geologists may have used relative dating techniques. For example they may have use
biostratigraphy. Although there wouldn't have been many macrofossils in
the abyssal plain there may have been microfossils. Zone fossils may have
been identified suggesting that the rocks formed at the same time if
they shared fossils. Additionally you ~~can~~ could have used lithostratigraphic
dating, to compare rock types and sequences to see if they shared a
sequence. ~~the~~ This method can be fairly effective in deep sea ~~environments~~
environments, where it is unusual to get lateral variation and diachronous
beds, which can cause problems. Finally you could use chronostratigraphic
methods. Ash from eruptions is commonly used in this method as it is deposited in
many areas geologically instantaneously. Additionally ash can
be dated radiometrically to give an exact date to a rock etc. **[5]**

This is an excellent response which addresses all aspects of stratigraphic correlation in relation to rocks in the Welsh Basin. The only improvement would have been if the candidate had given named examples of zone fossils used to date Lower Palaeozoic aged rocks.

Question 6 (a) (i)

6 Read the text below, then answer the questions that follow.

The Burgess Shale

This deposit is a Cambrian, Konservat-Lagerstätten, found at a locality in British Columbia, Canada.

Palaeoenvironmental Setting

Item removed due to third party copyright restrictions

Fig. 6.1

Environment

Most animals lived at the base of a large submarine cliff known as the Cathedral Escarpment. This formed at the outer edge of a wide, tropical platform of carbonate rock that may have extended as far as 400 kilometres from the shoreline.

The Escarpment itself was about 200 metres high before mud and other sediments began to fill in the basin.

Burgess Shale fossils

The Burgess Shale deposits exhibit a wide variety of organisms, including Cnidaria, annelid and priapulid worms, primitive molluscs and chordates, as well as the arthropods. More than 80% of these are soft bodied. It is exceptional to find complete animals preserved, especially ones that had only soft tissues and no mineralised structures.

Item removed due to third party copyright restrictions

Fig. 6.2

(a) (i) State the names of the fossil groups shown in the pie chart in Fig. 6.2 that could be found in sediments of a similar age that were **not** exceptionally preserved.

.... **[1]**

Question 6 is a scientific literacy question that required candidates to understand the extended passage above and also bring together knowledge and understanding from all parts of the specification. A third of all candidates answered this question correctly. Where candidates had reflected carefully about the hard-bodied fossils they had encountered over the course of their A Level Geology studies they were able to deduce a correct selection of at least two fossil groups from Arthropoda, Brachiopoda, Hemichordata and Mollusca. Some struggled with the unfamiliar fossil groups shown on the pie chart not realising they are unfamiliar because they are rarely preserved in the fossil record, and therefore only preserved in exceptional conditions. A common misconception was to name fossils not shown in the pie chart, such as corals.

Question 6 (a) (ii)

(ii) Soft tissue preservation is extremely rare, but the palaeoenvironmental setting and conditions where the Burgess Shale deposits were being formed were ideal for preservation.

Suggest and explain why both the setting and probable conditions allowed for preservation of soft bodied animals.

....

....

....

....

.... **[4]**

The conditions required for preservation of soft-bodied animals were well-known and there were many excellent responses to this question. The most successful candidates used all the information provided about the palaeoenvironmental setting for deposition of the Burgess Shale, picked out the conditions required for exceptional preservation and gave full, matching explanations. Those who gave descriptions without explanations were in the minority.

Question 6 (a) (iii)

(iii) The majority of soft bodied fossils in the Burgess Shale are preserved as carbon films.

Explain the mechanism of preservation resulting in carbon films.

....

....

....

....

....

....

....

.... **[3]**

Knowledge of the process of carbonisation as a preservation method was variable. The most common misconception was that carbon is introduced by replacement, rather than being present as organic carbon in the original soft body. Occasionally carbonation was given as an incorrect response.

Question 6 (b) (i)

(b) Trilobites are a relatively common arthropod fossil found in the Burgess Shale and include *Olenoides*, shown below.

Item removed due to third party copyright restrictions

Fig. 6.3

(i) The actual length of the *Olenoides* in Fig. 6.3 is 7.6 cm.

Calculate the magnification of the image.

magnification = ... × **[2]**

Most candidates correctly measured the length of the trilobite within allowable tolerance, but many then did their calculation the wrong way around with actual length at the top and image length at the bottom. Some were unsure what constituted the length of the trilobite in the image and measured the whole length of the photograph. It was possible to be awarded one mark for error carried forwards for a correct calculation based on an incorrect measurement if the candidate's working was clearly shown.

Question 6 (b) (ii)

(ii) Identify **one** piece of evidence from the photograph in Fig. 6.3 which suggests that *Olenoides* was both an epifaunal organism **and** that it remained roughly 'in-situ' after death.

....

....

....

....

.... **[2]**

A quarter of candidates got both marks for this question. Most correct answers to the first part cited the large number of limbs or thoracic segments would allow *Olenoides* to walk on the seafloor. Answers which referring to the eye position or the genal spines were also given credit. There was confusion between epifaunal and infaunal modes of life with some candidates giving the erroneous suggestion that 'the shovel shaped cephalon' would allow *Olenoides* to burrow.

Most candidates realised the specimen in the photograph was intact which indicated it had remained in-situ after death. Some lost the mark as they did not identify the most obvious piece of evidence that the antennae and limbs had not been broken off or they did not use technical terms such as not disarticulated.

Question 6 (b) (iii)

(iii) Explain how trilobites grew.

....

....

....

....

.... **[2]**

Many candidates knew trilobites grew by ecdysis and some used detailed technical terms such as facial suture, fixed and free cheeks in their answers. Weaker answers talked about trilobites 'shedding their exoskeleton'. While candidates are not required to learn specific lists of morphological terms they are expected to have knowledge of the growth process and lifestyle of trilobites (7.1.2a). Some candidates misinterpreted the question and wrote about trilobite evolution.

Question 6 (c) (i)

(c) Another Konservat-Lagerstätten deposit is the Chengjiang Formation in China. The chart in Fig. 6.4 shows the species diversity and evolution of various types of organisms, as well as an extinction event.

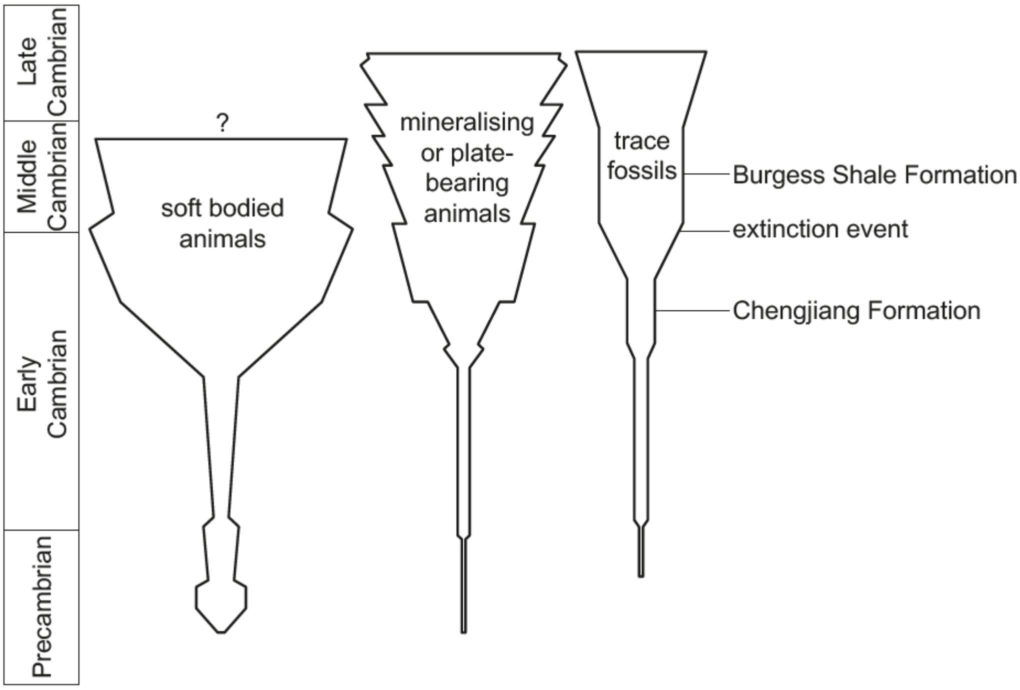


Fig. 6.4

(i) Explain how the information in Fig. 6.4 gives evidence for the 'Cambrian Explosion'.

....

.... **[1]**

Although many candidates recognised that the information on Fig. 6.4 showed there was a large increase in all types of organisms during the Early Cambrian, few answers conveyed an understanding that the increase was rapid or sudden, which was required to attain the mark.

?	**Misconception**	A significant minority of candidates read Fig. 6.4 downwards (backwards in time) and incorrectly stated that a mass extinction event occurred in the Late Precambrian.

Question 6 (c) (ii)

(ii) Fig. 6.5 shows the variation in number of types of organism across the whole of the Phanerozoic.

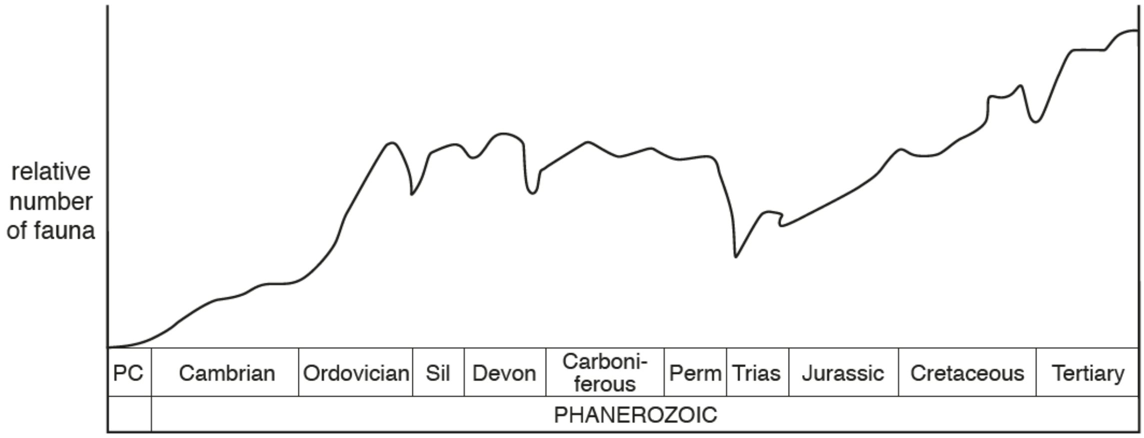


Fig. 6.5

Mark, **on Fig. 6.5**, with a vertical arrow (↓) the positions of **three** major extinction events. **[1]**

This question was answered well and virtually all candidates were awarded the mark. The small number of 'No Responses' may have been candidates who did not see the question, rather than candidates who did not know the answer.

Question 6 (c) (iii)

(iii) One of the extinction events occurred when the supercontinent Gondwanaland was situated over the South Pole.

Suggest why the formation of a supercontinent caused an extinction event.

....

....

....

....

....

....

....

.... **[3]**

The majority of candidates got some credit for their answers, with marks awarded spread across the full range. A great variety of correct reasons were given that covered the full range of options in the mark scheme. The most common correct reason cited was loss of continental shelf leading to increased competition. There were some excellent answers that conveyed sound understanding of positive feedback mechanisms caused by high albedo of ice caps. Less able candidates described loss of habitat but didn't specify where, while some answers were disorganised and contained little correct geological terminology.

Question 6 (d) (i)

(d) Radiometric methods of dating provide absolute ages for rocks. They rely on the constant rate of breakdown of radioactive isotopes of elements found in some minerals in rocks.

Some minerals in Lower Palaeozoic rocks contain the radioactive potassium isotope, ^{40}K, which breaks down to argon, ^{40}Ar. The half-life of this radioactive decay is approximately 1250 million years.

The radioactive decay curve for ^{40}K to ^{40}Ar is shown in Fig. 6.6.

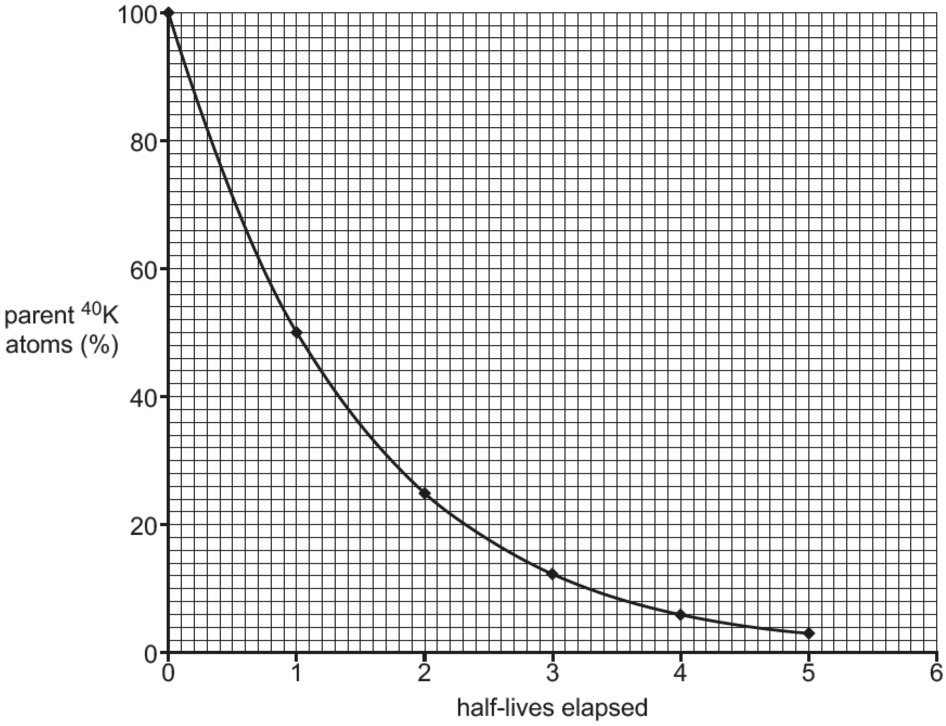


Fig. 6.6

(i) A sample of rock from the Lower Palaeozoic on analysis indicated that 76% of the original parent ^{40}K atoms were left.

Using Fig. 6.6, state the age of this rock.

age of rock sample = ... Ma **[2]**

The majority of candidates correctly read a value of 0.4 of a half-life from the graph. However some of them did not go on to correctly calculate the age of the rock sample.

Question 6 (d) (ii)

(ii) A second sample of rock indicated that only 70% of the original parent ^{40}K atoms were left. A more accurate way to date the rock is to calculate it using the formula for radioactive decay.

Calculate the age of this second sample of rock.

Use the formula: $N = N_0e^{-\lambda t}$

age of rock sample = ... Ma **[2]**

This question was at the upper end of stretch and challenge and targeted the most able candidates. It was encouraging to see that that one in ten candidates gained some credit. Candidates are expected to be able to calculate numerical ages using radioactive decay rates, including the use of the activity decay equation (5.3.2a).

	OCR support	The OCR Geology Mathematical Skills Handbook clarifies the nature of the mathematical skills required by the A Level Geology specification and indicates how each mathematical skill listed in Appendix 5e of the specification is relevant to the subject content of Geology. The content of the handbook follows the structure of the mathematical requirements table in Appendix 5e of the specification, with each skill (M1.1–M4.3) discussed in turn. For each skill it begins with a description and explanation of the mathematical concepts, followed by a demonstration of the key areas of the geological content in which the skill may be applied. Notes on common difficulties and misconceptions, as well as suggestions for teaching, are included in each section as appropriate.

Exemplar 10

radioactive decay.

Calculate the age of this second sample of rock. $N = N_0 e^{-\lambda t}$

Use the formula: $N = N_0e^{-\lambda t}$

$t = \frac{\ln N}{\ln N_0} \div -\lambda$ $\lambda = \frac{\ln(2)}{1250 \times 10^6} = 5.55 \times 10^{-10}$

age of rock sample = ...643......... Ma **[2]**

This response shows how one candidate worked through the problem to get full marks. Other candidates gained a compensatory mark for writing down relevant intermediate stage(s) in the calculation, such as $N/N_0 = 0.7 = e^{-\lambda t}$.

Question 6 (d) (iii)

(iii) The ratio of ^{40}K to ^{40}Ar atoms in the rock is used to determine the percentage of original parent ^{40}K atoms left in the rock.

Suggest why the final decay product of ^{40}Ar might cause a problem with the potassium dating method and explain how this problem would affect the calculated age of the rock.

....

....

.... **[1]**

Most candidates attempted an answer to this question. However, although the majority of candidates stated that argon is a gas and can be lost from a rock, they did not go on to explain this would lead to the calculated age being too young.

Exemplar 11

This is because ^{40}Ar is a gas this means that when produced it can easily escape, so if there are less daughter isotopes it will look younger than it should be. **[1]**

This response has identified the important point that because there is less daughter product the rock will appear younger.

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