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Oxford Cambridge and RSA

A LEVEL

Examiners' report

GEOLOGY

H414

For first teaching in 2017

H414/03 Summer 2023 series

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. A selection of candidate answers is also provided. 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 and the mark scheme can be downloaded from OCR.

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Paper 3 series overview

Paper 3; Practical Skills in Geology was introduced with the current specification in 2019 as a replacement for the centre-assessed and externally moderated coursework, which consisted of fieldwork or centre-based laboratory tasks and evaluative tasks. As such, the focus of this paper is on applied practical skills in relation to provided stimulus materials. Candidates are expected to understand a range of field techniques which include:

- interpretation of rock/sediment/mineral/fossil descriptions
- ability to use fieldwork equipment such as compass clinometers
- photo interpretation including sketching to mimic
    - field sketching and labelling
    - manipulation of data such as measuring and converting scales
- construction and interpretation of graphic logs
- plotting and interpreting a range of different types of graphs
- drawing and interpretating rose diagrams
- planning and evaluating results of laboratory experiments
- field observations
- map work to include;
    - drawing of cross sections
    - calculation of true thickness
    - interpretation of features shown on maps
    - labelling features onto maps
    - drawing conclusions from maps both coloured geological and outline problem maps
- constructing geological histories from cross sections, photographs, and maps.

There is an emphasis on candidates being able to identify named minerals, rocks, sediment, and fossils and being aware of their diagnostic features. Theoretical knowledge is also tested but usually with the context of a specimen, diagram, or photograph.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• carefully read the stem and any other information provided as part of the question and used stimulus material, where appropriate, in answers • were accurate with their labelling, plotting and drawing • used terminology effectively, giving examples where appropriate • in the extended prose questions gave clear explanations of problems arising from the geology on the map and gave comparisons between required factors. • used terminology and examples of rocks/sea level change processes and tectonic activity • showed working in the maths questions which can gain marks even if the final answer is incorrect • used rock and mineral names appropriately • described practical steps to be taken in the correct order.	• misinterpreted the topic of the question • did not structure the extended questions as the stem outlined • did not compare required factors and did not refer to the stimulus material in the stem • wrote about ways to solve problems rather than the causes of them • did not use a range of appropriate terminology • did not use appropriate axis scales for graphs and constructed incorrect types of graph • were not specific in locating appropriate features on diagrams • did not understand the term evaluate • described practical procedures without clarity and in an inappropriate order • did not show working for the maths questions • did not write about the required number of issues.

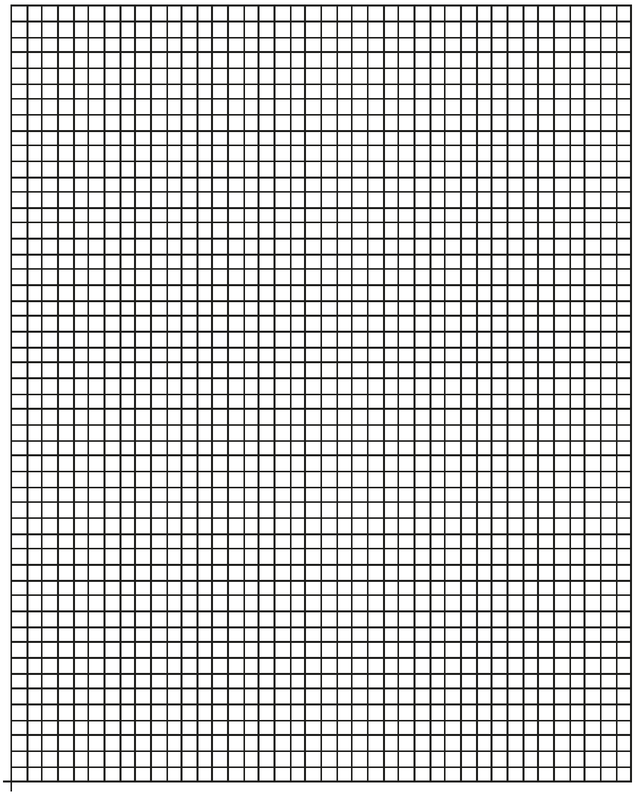
Question 1 (a)

1 A student has collected a sediment sample for analysis in the laboratory using a sieve stack. This is a stack of sieves arranged with the biggest mesh at the top (4 mm or –2Φ) and the smallest at the bottom (0.0625 mm or 4Φ).

The student's results are shown in the table.

Phi Φ	**% of Sample**
–2	0
–1	3
0	23
1	64
2	8
3	2
4	0

(a) Plot the results from the table as a cumulative frequency curve on the grid.



[3]

Most candidates produced appropriate cumulative frequency curves using all of the provided graph area for their axes. This provided candidates with a straightforward scale for their plot. As a result, most candidates achieved maximum marks. A minority did make errors, due to either misreading the question stem and not recognising the need to calculate cumulative frequency from the stimulus data or a misconception about what a cumulative frequency curve was.

Misconception

Candidates need to be familiar with the various ways that geologists present data such as cumulative frequency curves, histograms, rose diagrams, graphic logs, and so on. They should be confident in how these can be constructed from raw data as well as being able to use the presentation technique to answer follow-on questions which may then require the use of statistical techniques. The more exposure that candidates have to these practical applications of geological information the more confident they should be in their use and interpretation of the information they provide.

Question 1 (b)

(b) The coefficient of skewness can be calculated using the equation:

$$\text{Coefficient of skewness} = \frac{(\Phi_{84} + \Phi_{16}) - 2\Phi_{50}}{2}$$

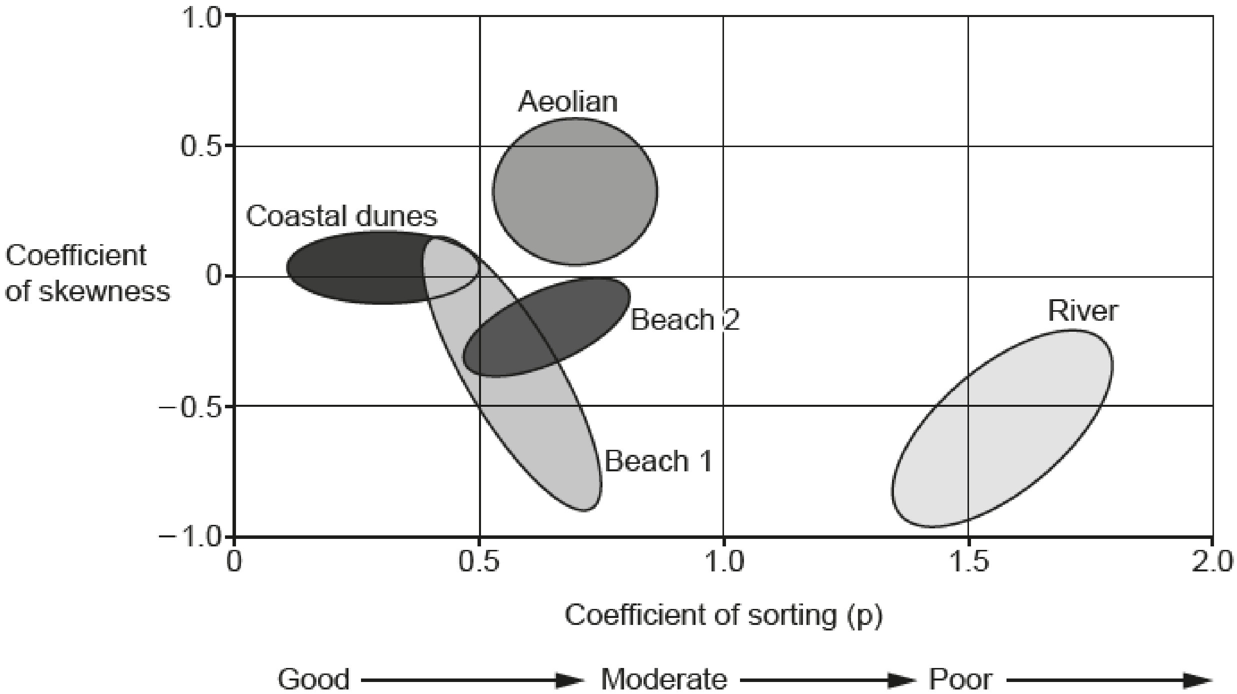
Calculate the coefficient of skewness for this sample.

Coefficient of skewness = ... **[2]**

Most candidates proved they knew how to apply the equation to their graph from Question 1 (a) and either provided the correct answer or produced phi values for the three required percentages accurately from their drawn graph. The calculation was usually carried out correctly. Candidates who had not drawn a cumulative frequency were not able to accurately attempt this question.

Question 1 (c)

(c) The bivariate plot shows the likely origin of sediment based on the coefficient of skewness against the coefficient of sorting (p).



The coefficient of sorting for the sediment was calculated as 0.65.

Use the value you have calculated for the coefficient of skewness in **part (b)** to suggest a likely origin for this sediment sample.

.... **[1]**

A minority of candidates misread the information provided and instead of using a vertical line from the x axis at 0.65 to plot the location of the sediment, used a horizontal line from the y axis. Candidates should read all of the provided information carefully.

Question 1 (d)

(d) Other than skewness and sorting, suggest **three** characteristics of sediment found in this environment of deposition.

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.... **[3]**

Most candidates gained some credit in this response. High-scoring candidates referred to grain shape, mineral composition, and gave an accurate grain size. Candidates could be more successful by being less generalised with their answers, as often too wide a range of possible shapes/sizes was provided. Some candidates did not note the use of the word sediment in the question and instead answered as if describing a rock. Cement, matrix and fossil content were used instead of the more appropriate clasts/grains and shells.

Question 1 (e)

(e) Evaluate the method used by the student to interpret the environment of deposition for this sediment sample.

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.... **[2]**

This question caused candidates some difficulty with few achieving maximum marks. Most creditworthy answers referred to the requirement to use more than one sample. 'Evaluate' is a higher level command word and candidates struggled to respond to this. In general, candidates either wrote about this being a good/easy experiment or about errors with the sieving without linking their answer to interpretation of their results and use when identifying an environment. A significant minority of candidates criticised the bivariate plot instead of referring to the actual method.

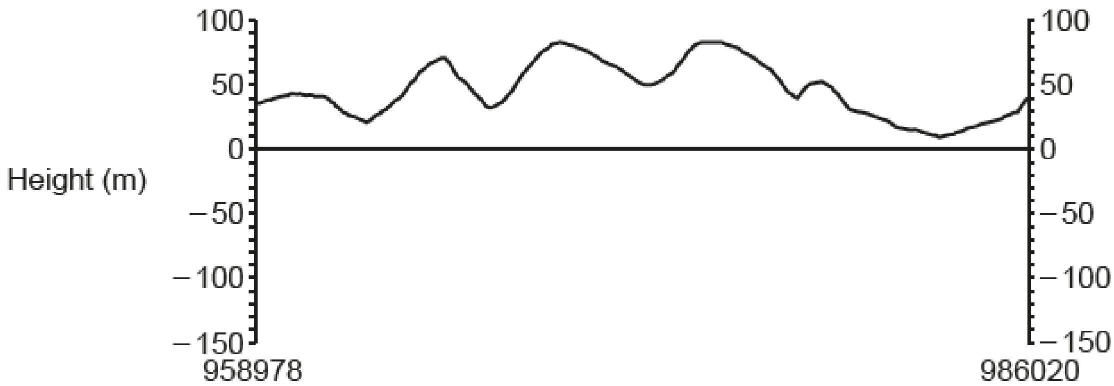
Misconception

Candidates can struggle to identify what a command word requires them to write about. Simpler command words such as 'list' and 'name' require only short, to the point answers. Those with a higher level of demand, such as 'evaluate' and 'justify', will require a more detailed response.

Question 2 (a) (i)

2 The 1:50 000 geological map excerpt (Pembroke and Linney Head), **in the Insert**, should be used for this question.

(a) **(i)** On the topographic sketch profile below draw and label a cross section of the solid geology from grid reference 958978 in the South West to 986020 in the North East.



[5]

There were very few omitted responses for the cross section. Candidates did still find this a difficult skill to master and therefore as much practice as possible is to be encouraged as there is usually a cross section in the examination. In this question the baseline at sea level has been added which helps candidates be more accurate with plotting their dip values. This did cause confusion for some candidates with some only plotting below the line and others only above it instead of extending down from the drawn landscape. Candidates should be encouraged to complete the sub surface geology and to include beds above ground as dotted lines when eroded fold structures are present.

Assessment for learning

Use of past exam material here can give candidates valuable practice in map skills. There are many old past papers which can be accessed as well as previous exam formats where cross sections and other map skills as examined in Question 2 can be found. Cross sections often carry many marks. The more practice candidates can have with the reading of dip angles, identification of structures, and use of the stratigraphic column to identify unconformities and names of rocks, the more their skills will develop.

Question 2 (a) (ii)

(ii) On your cross section, sketch the axial plane of the fold shown in the North East of the area. **[1]**

This question had the most omitted responses, probably due to candidates not reading all the information under the section. There are no dotted response lines leading to some candidates moving straight to Question 2 (a) (iii). In preparing candidates for examinations, the importance of reading everything should be emphasised in order to be prepared for questions in this style.

Question 2 (a) (iii)

(iii) Identify and fully describe **two** geological structures shown in your cross section.

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.... **[2]**

About a quarter of candidates gained marks on this question; the majority identified two structures, however, most then did not fully describe them. Therefore many answers gained only 1 mark for the identification of two structures. As there were two synclines in the area it was also necessary, if they chose both, to distinguish between them, the ideal way being to describe their location as being in the north-east or the south-west. Few candidates used the terms open or closed, and even fewer quoted the dips they had previously measured for the cross section. The most common way that candidates gained 2 marks was by use of the term asymmetrical as all three folds fell into this classification. A minority identified the unconformity from the stratigraphic column. No candidates described the unconformity having rocks of different dip amounts above and below, instead they defined what an unconformity was.

Question 2 (b) (i)

(b) (i) **Fig. 2, in the Insert**, is a photograph of a locality close to the area shown on the geological map.

Draw a sketch of this geological outcrop and label **two** geological features.

[2]

Candidates struggled to gain marks here primarily as most did not add a scale even through it was prominently shown on the photograph. Labelling was often vague and generalised with bed or bedding plane being the most used. Candidates were expected to identify the features of interest which were the nappe, recumbent fold, fault or fold axial planes.

Assessment for learning

This is a skill which needs practice to build up confidence. Past exam papers include a range of geological photographs suitable for practice. This is a skill worth developing first in the classroom before going on fieldwork. This allows candidates to learn an acceptable range of expected terminology for a variety of structures such as folds, faults, intrusions, and shows the importance of including a scale.

Question 2 (b) (ii)

(ii) The angle and direction of dip is often measured at geological localities.

Describe how to find and measure the strike of a bedding plane using a compass clinometer.

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.... **[3]**

This was another question which caused considerable difficulty. A significant number of candidates answered as if they were measuring the bed's dip and not the strike as asked for in the question. This answer required the stages to be in a logical order. Most candidates who gained marks began by referring to setting the compass clinometer to clinometer mode, and very few acknowledged that the clinometer had to be held vertically and rotated to find zero dip. A number of candidates had an awareness about turning dials and matching arrows or reading bearings, but answers were often vague and confused.

Assessment for learning

Fieldwork is the ideal time to demonstrate and build skills using a compass clinometer. However, it can also be demonstrated first in the classroom to learn the procedure, increase confidence and enhance memory of the steps involved. Various items can be used, such as piles of texts, large rock specimens, or anything which can provide a sloping surface. Then a clipboard or piece of thick card can be laid across the sloping surface. Dip and strike measurement can then be carried out on this artificial dipping surface. The more practice candidates gain before going into the field, the easier they will find it once outside on real geology.

Exemplar 1

Set the compass clinometer to W-E. Hold it vertically so the needle can move in the vertical plane along the protractor like scale. Hold the clinometer upright against the bed and rotate until the dip is equal to 0° from horizontal. Draw a line along this plane. Set it back to compass and hold it along the strike. Put the red needle in the red arrow by rotating the dial. The direction is pointed by the yellow arrow) [3]

This exemplar shows a high-level response to the question, demonstrating a clear explanation of how to take a strike reading. It is ordered and logical and it is possible to imagine this candidate doing exactly this on fieldwork.

Question 2 (c)*

(c)* Evaluate the potential geological problems that could be encountered by a company aiming to quarry the Carboniferous Limestone d^1 and d^2 shown on the geological map.

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.... **[6]**

Most candidates wrote close to a full page for this answer in continuous prose which is very encouraging. There were many potential problems for candidates to identify and there were some good Level 3 responses. The main aim for these extended questions is that a breadth of knowledge needs to be demonstrated rather than masses of information on just one or two potential problems. The candidates scoring Level 3 wrote about 4 or 5 different problems focused on geology, for example: steeply dipping strata; numerous fault issues; jointing and the issues they can cause; porosity and permeability; susceptibly to chemical weathering; and removal of drift overburden. A minority of candidates were distracted discussing roads, towns and people's opinions, which was not required. Careful reading of the question will lead to a more relevant answer.

Question 3 (a)

3 **(a)** Describe the difference between porosity and permeability in a hydrocarbon reservoir rock.

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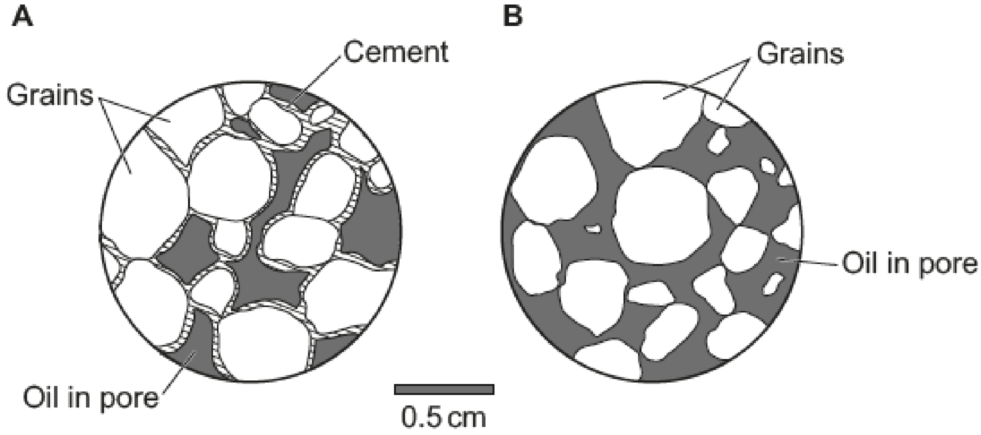
.... **[2]**

Most candidates gained marks on this question. Permeability tended to be better known while porosity was often not explained thoroughly enough as the concept of an amount of pore space was required.

Question 3 (b) (i)

(b) **(i)** Diagrams **A** and **B** show two sandstone samples, collected from two boreholes in a hydrocarbon field.



Explain which sample would yield a greater value of hydrocarbons.

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.... **[4]**

A good knowledge of the impact of cement on porosity and permeability was required. High scoring candidates recognised this and made detailed reference to either B being better with reasons or explaining why A was worse. A significant number of candidates wrote about both comparing them. To gain maximum marks candidates needed to refer to both properties explaining how cement or the absence of it impacted the rocks porosity or permeability. A sizeable minority incorrectly named A as the better reservoir rock thinking low permeability was a good factor and helped to store oil.

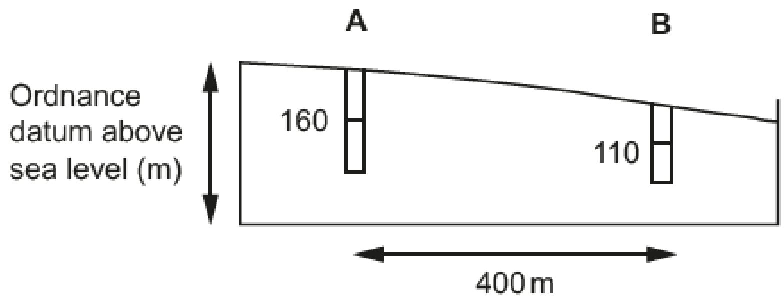
Exemplar 2

B does not have cement so has a higher porosity This allows more oil to be stored. The grains are poorly sorted in B which does decrease porosity compared to a well sorted ~~SS~~ rock how-ever the presence of cement in rock A is more significant as it reduces permeability (so less oil can migrate into the rock) and porosity (so less oil can be stored in the rock) **[4]**

This exemplar shows a concise way to get all 4 marks; this candidate writes partly about rock B but also rock A. In their response the marking points are met; Rock B, compared to rock A, has got higher porosity and permeability. In both cases the reason is the presence of the cement filling the pores which reduces the space for oil to be stored and limits the rate of flow of oil into or out of the rock

Question 3 (b) (ii)

(ii) The diagram shows the location of the two boreholes, **A** and **B**.



The two boreholes can be used to calculate the permeability of the sandstones using Darcy's Law.

The hydraulic conductivity (k) of the sandstones was found to be 1×10^{-3} cm sec^{-1} and the area of the hydrocarbon field was 1500 m^2.

Calculate the permeability (Q) of the sandstones.

Use the formula: $Q = -kA\left(\frac{h_2 - h_1}{L}\right)$

Permeability (Q) = ... Units = ... **[3]**

Most candidates attempted this question and there were very few omitted responses. Most candidates were successfully able to manipulate some if not all the equation. Deciding which borehole represented h_2 and h_1 caused the most difficulty. A significant number of candidates had this the wrong way round. Many candidates did get the correct value, the hardest part of the question was choosing the correct units which were m^3 s^{-1}

Question 4 (a) (i)

4 **Fig. 4, in the Insert**, is a photograph of a specimen taken from a hydrothermal vein.

Mineral specimens are often identified with the help of diagnostic properties such as colour, density and arrangement of cleavages.

(a) **(i)** Describe the shape and arrangement of cleavage in the mineral shown in **Fig. 4**.

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.... **[2]**

Most candidates struggled with this question, with only a small number gaining both marks. Candidates frequently did not direct their answer to the question and many either just described the mineral's appearance or wrote at length about cleavage. Few did not recognise three cleavages, with two being the most common response, and most opted for it being cubic. Many candidates used inappropriate terminology, for example describing the mineral as euhedral or saying it showed a chain silicate structure.

Question 4 (a) (ii)

(ii) Describe **one** additional test, apart from those listed above, that could be carried out on the mineral shown in **Fig. 4** that would help to identify it.

....

.... **[1]**

Most candidates attempted this question and most successfully described a test which would identify calcite. Those who did not gain any marks either did not provide enough information, omitting the name of a suitable acid or just writing "scratch it" which could refer to streak testing as well as hardness testing.

Question 4 (a) (iii)

(iii) Describe how a student would measure the **density** of the unknown mineral in **Fig. 4**.

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.... **[2]**

Candidates scored highly suggesting that most had carried out this experiment in class. Most candidates were aware that the mass must be measured before submersion in water. Candidates also correctly gave a detailed description of the use of a Eureka can. The equation was well understood and accurately described.

Question 4 (b)

(b) Some minerals are found to have relatively high densities.

Describe how this property can lead to accumulations of ore that are economic to extract.

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.... **[2]**

This question caused some difficulties. Most candidates attempted it but it was clear that a significant number had completely misunderstood the question as they wrote about the properties which can make a mineral valuable, cut-off grades and market prices. Those who did understand the focus primarily opted to write about placer deposits. The locations along rivers where these deposits can be found were particularly well known. A minority of candidates opted for magmatic segregation and most gained a mark for discussing gravity settling and/or cumulate layers.

Question 5 (a)

5 Information recorded by students from a cliff section during a field excursion is shown in the table below.

Bed 1 is 3.8 m from the base of the cliff, whilst the base of **bed 5** is 7.8 m from the base of the cliff.

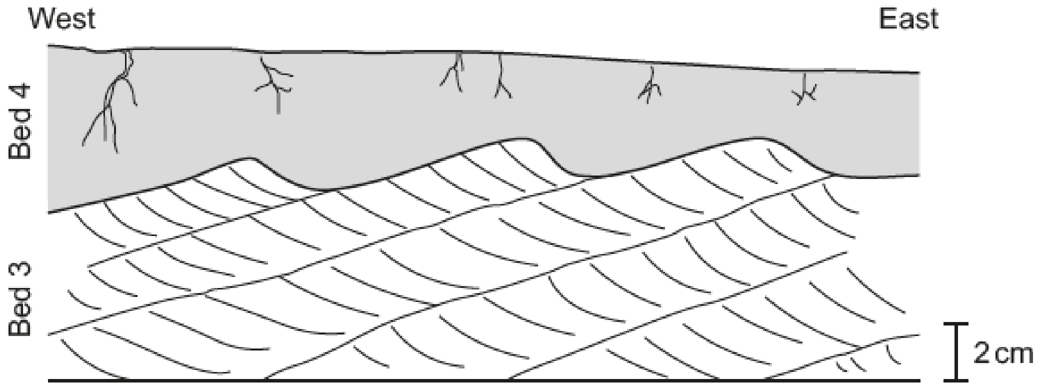
Bed	**Thickness (m)**	**Rock description**	**Features visible**	**Energy level** (Low, med, high)	**Sea level** (Low, med, high)
1	1.00	Well-bedded shale Pale grey	Marine brachiopods and bivalves	Low	High
2	1.20	Siltstone Laminated Coarsening upwards from clay to silt	Contains bivalve shells Some bioturbation visible		
3	1.70	Uneven base Coarsening upwards from fine to medium sandstone	Small scale Cross-bedding visible throughout bed Some scattered plant material		
4	0.20	Silty mudstone Reddish-brown colour	Contains plant roots towards the top of the bed		
5	0.10	Black, shiny	None		
6	0.75	Well bedded shale	Marine brachiopods, well preserved and intact		
7	1.00	Laminated siltstones	Bioturbation and trace fossils (burrows)		

(a) Complete the table to identify the energy level and sea level for each bed as either low, medium or high. The first bed has been completed. **[3]**

This question produced a variety of responses and few candidates achieved full marks. Energy levels tended to be better understood than sea levels. Clues had been given in the table for the first row and this should be used as a guide to help compare and complete the required answers.

Question 5 (b)

(b) One of the students produced a field sketch showing the top surface of Bed 3.



Outline how the palaeocurrent direction can be determined.

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.... **[2]**

Candidates knew how to tell the ancient current direction as was evident from their attempts in answering this question. Many struggled to explain it accurately enough for 2 marks and so it was more common to see candidates gaining 1 mark, usually for the stated current direction.

Assessment for learning

Candidates need to be clearer when stating current directions and need to provide the direction the current came from as well as the direction it is moving to. Practical experiments, fieldwork examples, plotting rose diagrams and photo interpretation could be used to give candidates a variety of experiences to accurately describe a palaeo-current

Question 5 (c)

(c) Using the lithological evidence of Bed 5, interpret the palaeoenvironment and climate that must have been present at this time.

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.... **[3]**

Many candidates incorrectly identified Bed 5 as obsidian and so then went off on a tangent to describe deep submarine conditions. A clue in the stem is the reference to describe the palaeo-climate as this is a hint the environment was terrestrial. This should then direct candidates to either aeolian, glacial, fluvial or deltaic. The presence of plant roots as well as marine fossils was a strong clue to deltaic environments.

Question 5 (d)*

(d)* Depositional cycles such as those recorded in the table can be caused by basin-wide sea-level changes or local tectonic variations.

Describe and compare the processes involved in both sea-level changes and local tectonic variations.

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.... **[6]**

This question provided candidates with a wide range of processes they could write about. The stem directed candidates to use/refer to the table in the stem of Question 5. Candidates were also required to compare processes involved in sea level change and tectonic variations. Nearly all candidates did not include reference to the deltaic environments as shown in the table and thus limited their response to a Level 2 as a maximum. Many candidates also focused their answers on only sea level changes again limiting the number of marks available to them. Strong answers included reference to eustatic and isostatic impacts on sea level and compared the speed and/or size of the area affected to the impacts caused by a variety of tectonic processes, while incorporating reference to delta environments and how sediment deposition changes with sea level changes.

Exemplar 3

Sea levels may change due to a period of glaciation where water is frozen as ice, so sea level falls. When climate warms and glacial ice melts, there is a ~~to~~ global rise in sea level which may cause widespread flooding and loss of habitats. This will cause deposition cycles to vary e.g. deltas. Sea level also changes due to isostatic rebound, where the overburden of a section of land is removed (e.g. a glacier retreats) and the compressed land expands upwards. This may cause a local fall in sea level and the change in rate of sedimentation as environments previously covered by water become exposed as land.

Local tectonic variations include diverging plate margins creating excess (lava) material which increases sea level. The movement of tectonic plates may also cause a specific environment to change e.g. deltic environments become above sea level and **[6]**

form wadi's and alluvial fans. If tectonic plates slowly move and come together, there is a loss of continental shelf and a sea level rise. Turbidity flows may stop overall due to a lack or shallower continental shelf.

The response above is a Level 3 response. The candidate explains the difference in eustatic sea level change compared to isostatic rebound. They cover di-vergent margins and the subsequent increase in lava eruption and continental drift changing continent size. Linked to this is a refence to deltas and how they can build out and become land.

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