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Examiners' report

GEOLOGY

H414

For first teaching in 2017

H414/01 Summer 2024 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. 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.

Paper 1 series overview

Paper H414/01 (Fundamentals of geology) assesses subject content from across modules 1 to 7. It contains two sections. Section A consists of 25 multiple choice questions and section B which includes short answer and two 6 mark extended response questions. It covers A01, A02 and A03.

This paper is one of three examination components for A level geology. This component focuses on:

- The development of practical skills
- Minerals, rocks and fossils
- Global tectonics
- Sedimentary environments and geochronology
- Petrology and economic geology
- Geohazards
- Basin analysis

The paper appeared to be accessible with most candidates attempting all the questions.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• carried out familiar and unfamiliar calculations • could rearrange an unfamiliar equation • could convert units and use the correct units • were familiar with and used scientific geological terminology • were able to identify and interpret thin section diagrams of igneous, sedimentary and metamorphic rocks • were able to structure both extended answers so that balanced comparisons could be made, and products (igneous or sedimentary) could be clearly linked to processes • could describe an appropriate experiment for an unfamiliar scenario • understand the link between changing lateral environments (meandering rivers) and the vertical sequence that evolves (Walther's Law) and then construct an appropriate sedimentary log • knew the processes and variables involved in various placer deposit scenarios • understood the processes operating within oceanic core complexes.	• struggled with calculations • could not rearrange equations • were unable to convert units • we're not always secure in use and understanding of geological scientific terminology • were unable to confidently interpret thin section diagrams • struggled to organise extended answers which are balanced or to provide significant detail • could not describe an appropriate experiment for an unfamiliar scenario • did not understand Walther's Law when linked to meandering rivers and how this would look on a sedimentary log • did not understand placer deposit scenarios and controls • did not understand the processes operating within oceanic core complexes.

Section A overview

This section provided candidates with a broad range of topics to be assessed. Many candidates did show a full range of geological knowledge, and candidates are becoming familiar with the demands of this style of question. This style of question clearly suits some candidates who find the questions requiring longer answers more challenging.

Question 1

The diagram shows a thin section of a rock made of one mineral.

×10

Use the thin section diagram to answer questions **1** and **2**.

1 The mineral in the rock has rhombohedral cleavage and is scratched by a copper coin but not by a fingernail.

Which mineral is the rock composed of?

A Calcite

B Orthoclase feldspar

C Plagioclase feldspar

D Quartz

Your answer [ ] **[1]**

Many candidates recognised the mineral as being A Calcite. Calcite can often be mistaken for the other 3 distractor minerals.

Assessment for learning

It is important that candidates can identify the main rock forming minerals in the field, laboratory, thin section or from descriptions. In this case calcite can be mistaken for any of the 3 distractor minerals and so candidates need to practice identifying and describing the properties of minerals by looking at hand specimens in the field or lab. Successful identification of the minerals then allows a candidate to identify the rock that the mineral is in.

Question 2

2 What is the rock type?

A Marble

B Metaquartzite

C Orthoquartzite

D Phyllite

Your answer [ ] **[1]**

Those candidates that correctly identified that the mineral in Question 1 was calcite were then able to correctly identify the rock as A Marble. If candidates thought the mineral was quartz then they were likely to name the rock Metaquartzite.

Question 3

3 The table shows the bulk composition of a sample from a chondritic meteorite that fell to Earth in 1934.

Oxide	Weight (%)
SiO_2	39.1
Al_2O_3	1.9
FeO	31.5
MgO	20.7
CaO	1.5
Others	5.3

Which layer of the Earth has a composition most similar to this meteorite?

A Continental crust

B Mantle

C Oceanic crust

D Outer core

Your answer [ ] **[1]**

Candidates do need to know the approximate composition of the various layers of the Earth. In this case the inner or outer core can be ruled out as there is not enough iron. Candidates then needed to work out if the composition was intermediate/silicic (continental crust), mafic (oceanic crust) or as in this case ultramafic B mantle with 39.1% SiO_2.

Question 4

4 The nebular hypothesis explains the formation of the Solar System.

What is the correct order of the formation of the Solar System according to this hypothesis?

	Earliest event	→	Latest event
A	Giant nebula collapses	Rotation **decreases** and protoplanetary disc forms	Formation of planetesimals
B	Giant nebula collapses	Rotation **increases** and protoplanetary disc forms	Formation of planetesimals
C	Rotation **decreases** and protoplanetary disc forms	Formation of planetesimals	Giant nebula collapses
D	Rotation **increases** and protoplanetary disc forms	Formation of planetesimals	Giant nebula collapses

Your answer [ ] **[1]**

Candidates needed to recognise that the earliest event in the formation of the Solar System was the giant nebula collapse and the latest event being the formation of planetesimals. Candidates then needed to know that the rotation of the protoplanetary disc increases and not decreases (as it collapses) leading to B being the correct answer.

Question 5

5 The mineral composition of the layers of the Earth have been inferred using both direct and indirect evidence.

Pyroxene (augite) and plagioclase feldspar are the main minerals in which layer of the Earth?

A Continental crust

B Lower mantle

C Oceanic crust

D Upper mantle

Your answer [ ] **[1]**

In a similar way to needing to know the broad chemistry of each layer of the Earth it is also necessary to know the mineral composition especially of the crust and mantle. Candidates should know that augite and plagioclase are the key minerals in mafic igneous rocks and hence oceanic crust, answer C.

Question 6

6 Which graph, **A**, **B**, **C** or **D**, shows the correct shape for the formation of a daughter isotope during radioactive decay?

Your answer [ ] **[1]**

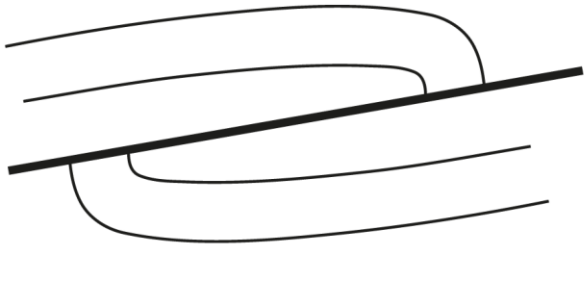
Many candidates recognised graph C as being the correct one. The clue is that there is 0% daughter isotope when the rock forms at time 0. This increases to 50% daughter after 1 half-life and then 75% after 2 half-lives (50% + 50%/2) etc.

Assessment for learning

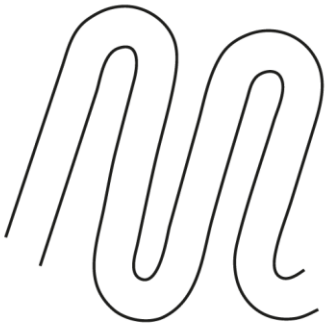
Candidates do need to practice using daughter isotope graphs (along with the appropriate half-life value) to work out the age of a rock. Familiarity with using these graphs would enable a candidate to recognise that graph C is correct having 0% daughter at formation then 50% after 1 half-life and 75% after 2 half-lives etc.

Question 7

7 The cross-section diagrams show fold structures formed at convergent plate margins.



Fold **1** 1 cm = 200 m



Fold **2** 1 cm = 100 m

Identify these fold structures.

	Fold 1	**Fold 2**
A	Isoclinal	Nappe
B	Isoclinal	Overfold
C	Nappe	Isoclinal
D	Overfold	Isoclinal

Your answer [ ] **[1]**

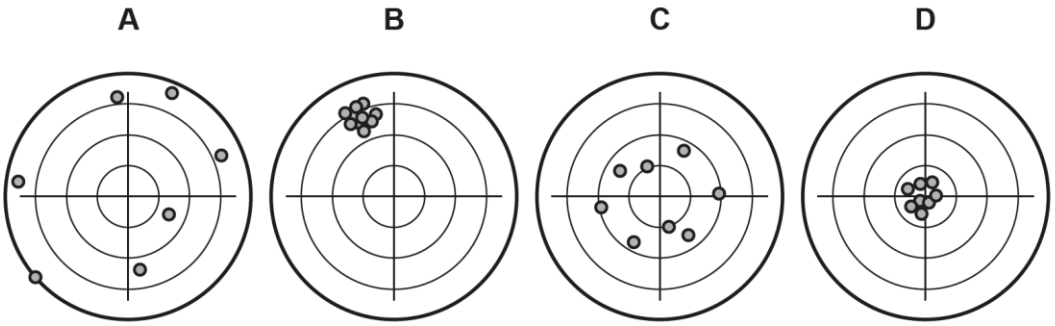
Candidates do need to be able to recognise simple fold structures in cross-section. C is the correct answer with the key being identifying the nappe structure which has a thrust fault along the fold axis and the isoclinal fold having two parallel limbs.

Question 8

8 Global positioning systems (GPS) allow accurate and precise measurement of the relative movement of lithospheric plates.

For the repeat GPS measurements in the diagrams below the true value is at the centre of each chart.

Which diagram, **A**, **B**, **C** or **D**, shows repeat measurements that are accurate but imprecise?

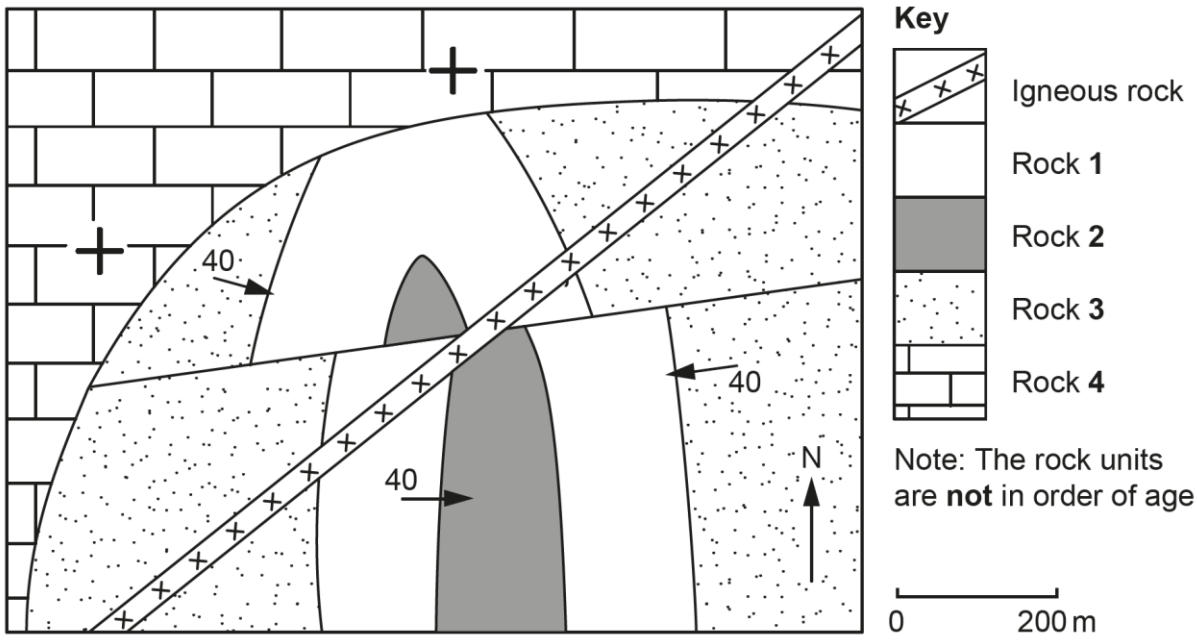


Your answer ☐ **[1]**

This style of question is new to candidates. Candidates are often unsure of the difference between accuracy and precision. C is the correct answer with results centred around the correct answer so are accurate but are slightly dispersed and so are imprecise.

Question 9

The geological map shows a flat area. The sedimentary rocks are the right way up.



Use the geological map to answer questions **9**, **10** and **11**.

9 Apply relative dating techniques to determine the youngest feature on the geological map.

A Dyke

B Fault

C Fold

D Unconformity

Your answer [ ] **[1]**

Most candidates recognised that the igneous feature A dyke cross-cut everything on the map and so is the youngest feature.

Assessment for learning

Candidates need to be able to interpret simple geological maps both in terms of the geological history but also being able to recognise structural and igneous features. Practice on a regular basis will help in interpreting simple maps like this but also for the real geological maps in H414/03. Studying simple maps is the best way to build up these skills.

Question 10

10 Apply relative dating techniques to determine the oldest rock on the geological map.

A Rock **1**

B Rock **2**

C Rock **3**

D Rock **4**

Your answer [ ] **[1]**

Candidates find this is a relatively difficult task as the candidates first need to work out what kind of fold is present which can then lead to knowing the relative age of the rock in the fold core. The dip arrows show that it is a (plunging) synform which as the rocks are the right way up has the youngest rocks in the core and the oldest away from the core. Hence rock 3 C is the oldest.

Question 11

11 Identify the fold structure shown on the geological map.

A Antiform plunging north

B Antiform plunging south

C Synform plunging north

D Synform plunging south

Your answer [ ] **[1]**

There are several steps required to achieve the correct answer C, this makes this a challenging question. Firstly, candidates need to recognise that this is a synform (dip arrows pointing inwards) and then secondly that the bed outcrops curve round and join (indicating that the fold is plunging). Thirdly, the most difficult part is working out which way it is plunging, with a synform the plunge is in the direction the curved beds converge, to the north.

Assessment for learning

To help visualise plunging directions candidates could fold a sheet of A4 card into an antiform and then tilt it so that it is plunging and then cut horizontally across the card to mimic a horizontal land surface, this will show the card curving round but with an antiform the direction of plunge is where the beds/card diverges. The opposite is the case if the same is done to a plunging synform made of A4 card.

Question 12

12 The Al_2SiO_5 polymorphs are useful metamorphic index minerals.

What would be the correct order of formation of the Al_2SiO_5 polymorphs during retrograde metamorphism?

A Andalusite to garnet

B Andalusite to sillimanite

C Kyanite to sillimanite

D Sillimanite to andalusite

Your answer ☐ **[1]**

Candidates can find the idea of prograde and retrograde metamorphism difficult especially when linked to Al_2SiO_5 polymorphs. Candidates need to be able to visualise or draw the phase diagram. Garnet is not a polymorph and so can be discounted and D sillimanite to andalusite is the only retrograde pair, B and C show a prograde sequence.

Question 13

13 The transmission of seismic energy depends on the competence of the rock.

Through which rock type would the velocity of P waves be lowest?

A Gabbro

B Limestone

C Mudstone

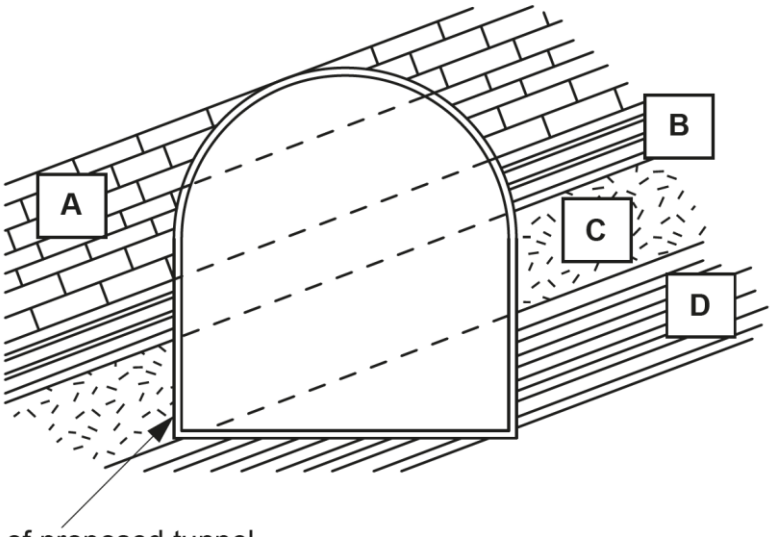
D Schist

Your answer ☐ **[1]**

C mudstone is the least competent of the rocks and so lowers the velocity of P waves.

Question 14

The geological cross-section shows an area where a tunnel is due to be constructed.



A Massive beds of well jointed, fissured limestone

B Thin beds of alternating mudstones and sandstones

C Dolerite sill

D Very thin beds of fissile, crumbly shale

Use the cross-section diagram to answer questions **14** and **15**.

14 The tunnel will be constructed using drilling and blasting techniques.

In which rock unit, **A**, **B**, **C** or **D**, is the engineering geology problem of underbreak, where not enough material is removed, most likely to occur?

Your answer ☐ **[1]**

Candidates are becoming more familiar with overbreak and underbreak when drilling and blasting and the geological conditions that make them more likely. In this case the harder and stronger igneous rock C the dolerite sill is likely to have broken and fallen less leading to underbreak.

Question 15

15 There are concerns that the proposed tunnel may flood.

Through which rock unit, **A**, **B**, **C** or **D**, is high water flow most likely?

Your answer ☐ **[1]**

Candidates are confident in identifying permeable rocks that could lead to flooding. In this tunnel A the jointed and fissured limestone will be very permeable.

Question 16

16 A dam and reservoir are planned for water supply. The dam is to be constructed in a broad, shallow valley on clay bedrock.

Which type of dam would be most suitable for this purpose?

A Arch dam

B Buttress dam

C Earth dam

D Gravity dam

Your answer ☐ **[1]**

Candidates are not confident in identifying which type of dam suites the ground conditions. C an earth dam will work as it is on clay bedrock which is impermeable, and the earth dam is not too heavy. The dam does not need to be very high as the valley is shallow, the earth dam is relatively cheap and effective under these circumstances. The other three would probably be too heavy and subside on clay bedrock.

Question 17

17 In groundwater supplies, which term would describe a rock unit with a coefficient of permeability of $10^{-6}\,ms^{-1}$ (very low)?

A Aquiclude

B Aquitard

C Confined aquifer

D Unconfined aquifer

Your answer ☐ **[1]**

Candidates are generally confident in understanding these groundwater related terms. Candidates do need to be able to both define the terms and understand the geological requirements for each. A very low permeability is perfect for B the aquitard. Aquitard and aquiclude can be confused an aquitard will have a very low permeability (as in this case) so will allow a little water through whilst an aquiclude will have zero permeability and allow no water through.

Question 18

18 The minerals in rocks that groundwater has flowed through can affect drinking water quality.

The presence of which mineral is most likely to affect the quality of drinking water to toxic levels?

A Calcite

B Galena

C Pyrite

D Quartz

Your answer [ ] **[1]**

Most candidates knew the composition of the four minerals and recognised that B galena being a lead mineral can be toxic in drinking water.

Question 19

19 During which geological time period since the start of the Permian was global sea level at its highest?

A Cretaceous

B Jurassic

C Permian

D Triassic

Your answer [ ] **[1]**

Remembering when sea levels were high and low is quite difficult with candidates needing to be familiar with the sea level graph. However, many candidates did know that sea level was very high in the Cretaceous A.

Question 20

20 The study of the ecology of modern reef-building corals and their comparison with fossil corals allow fossil corals to be used as palaeoenvironmental indicators.

Which combination in the table are the best conditions for good coral growth?

	Water temperature (°C)	Water depth (m)	Salinity (‰)
A	21	60	65
B	23	45	55
C	25	30	45
D	27	15	35

Your answer ☐ **[1]**

Candidates do generally know the specific conditions that modern corals require to thrive and so many candidates recognised D as having the correct set of conditions. The salinity is the condition candidates will be less confident with, but many knew that 27°C and 15 metres depth are ideal.

Question 21

21 Which combination of sedimentary conditions led to the exceptional preservation of a range of organisms, including *Archaeopteryx*, in the Jurassic Solnhofen Limestone?

A High salinity and anoxic conditions

B High salinity and oxic conditions

C Low salinity and anoxic conditions

D Low salinity and oxic conditions

Your answer ☐ **[1]**

Most candidates knew the special conditions required to preserve Archaeopteryx which are A high salinity and anoxic conditions both of which slow down degradation of the organism.

Question 22

22 Carboniferous rocks are the main source rocks for natural gas in the Southern Basin of the North Sea.

In which palaeoenvironment were these source rocks deposited?

A Deltaic bottomset beds

B Deltaic foreset beds

C Deltaic topset beds

D Shallow marine platform carbonates

Your answer [ ] **[1]**

Many candidates knew that not only were the coal measures the source of the natural gas in the Southern Basin but also that they formed on the deltaic topset beds C in swamp conditions.

Question 23

23 Which of these is unlikely to result in the loss of oil or natural gas from a trap structure?

A Erosion

B Faulting

C Lateral spill point

D Subsidence

Your answer [ ] **[1]**

Candidates needed to work through the three distractor answers and realised that erosion, faulting and lateral spill points all provide avenues for the escape of oil or gas. D subsidence will lead to the burial of the source rock and the potential trapping of the oil and gas.

Question 24

24 Cephalopod fossils can be used to zone and correlate rocks in sedimentary basin analysis.

Which cephalopods are used to zone the Jurassic Period?

A Ammonites and belemnites

B Ammonites and ceratites

C Belemnites and nautiloids

D Ceratites and goniatites

Your answer [ ] **[1]**

Many candidates knew that ammonites and belemnites A are used as zone fossils in the Jurassic. Candidates needed to know the stratigraphic distribution of the various cephalopods some of which did not exist in the Jurassic.

Question 25

25 What is the geological time range for trilobites?

A Cambrian to Carboniferous

B Cambrian to Permian

C Ordovician to Permian

D Ordovician to Triassic

Your answer [ ] **[1]**

Candidates were confident in knowing the stratigraphic range of trilobites being A from the Cambrian to the Permian. Candidates do need to know the stratigraphic range of several key fossil groups.

Section B overview

Candidates appeared to have sufficient time to complete this section which indicates that candidates are familiar with the demands of the paper.

Question 26 is focussed on igneous processes and products linked to volcanic activity often contrasting mafic effusive eruptions with explosive intermediate/silicic eruptions. Candidates are generally confident with this topic and showed a good understanding of magma formation and intrusion. A potential experiment was described to illustrate viscosity of magmas. Candidates calculated the discharge rate of an eruption based on a given formula and a worked example; many candidates carried this out successfully. A 6-mark Level of response question compared eruption styles of two volcanoes asking for an explanation for the style and the hazards associated with each. Candidates are clearly confident with this style of question.

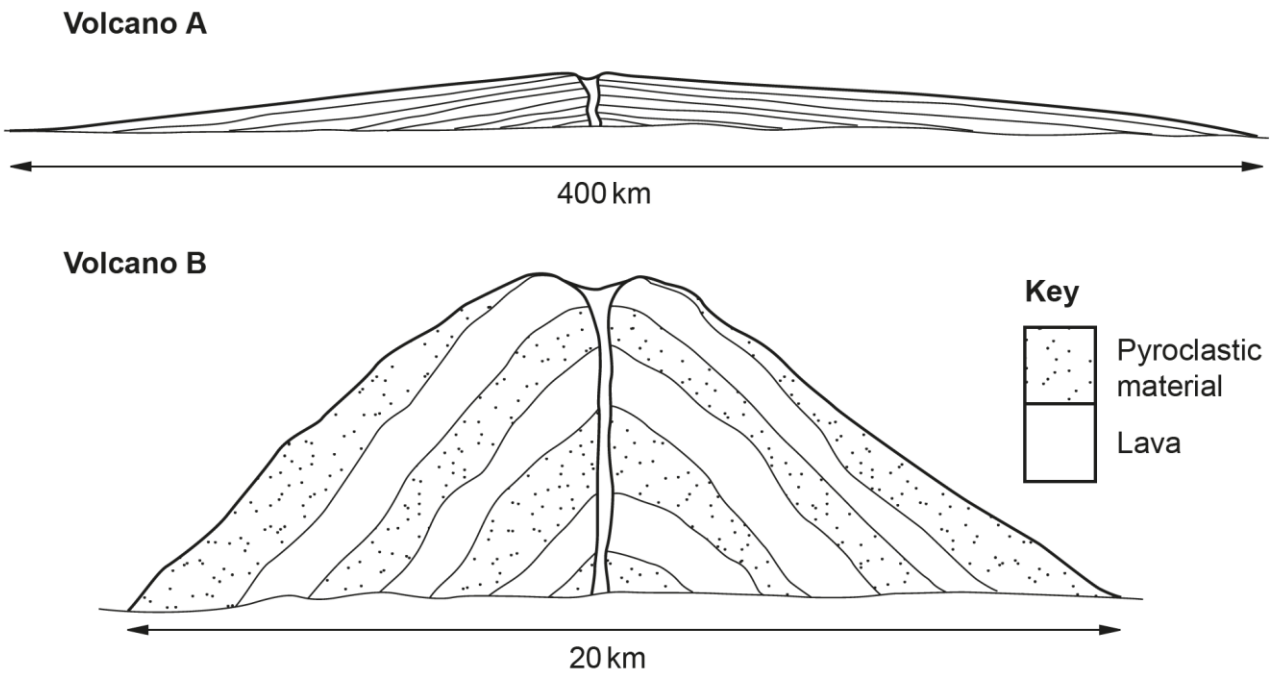
Question 27 focussed on sedimentary processes including the formation of imbricate structures and an understanding of the application of Walther's Law in a meandering river environment. Evaporite mineral formation and sequences was tested. Carbonate deposits were explored including the formation of chalk and the role of the Carbonate Compensation Depth. The 6-mark Level of response question focussed on a comparison of the texture and mineralogy of desert and deep sea turbidite sandstones.

Question 28 looked at placer deposit minerals and environments, secondary enrichment and ore exploration. A calculation was required involving working out the volume and mass of an ore deposit.

Question 29 tested candidates understanding of processes at mid ocean ridges including oceanic core complexes including hydrothermal vents and ophiolites.

Question 26 (a) (i)

26 The diagrams show cross-section forms of **two** volcanoes, **A** and **B**.



(a)
(i) Identify the type of volcano shown in each cross-section diagram.

Volcano **A** .....

Volcano **B** .....

[2]

Candidates confidently recognised volcano A as a shield volcano and B as a strato or composite cone volcano.

Question 26 (a) (ii)

(ii) State the most likely plate tectonic settings for the locations of volcanoes **A** and **B**.

Plate tectonic setting for volcano **A** .....

Plate tectonic setting for volcano **B** .....

[2]

Having confidently identified the two volcanoes most candidates were also able to identify the tectonic settings. Candidates should be encouraged to use the terms divergent rather than constructive and convergent rather than destructive.

Question 26 (b)

(b) Explain how magma forms at convergent plate margins.

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..... **[3]**

Most candidates discussed partial melting however the strongest answers also discussed water being brought down during subduction and leading to flux melting.

Question 26 (c) (i)

(c) Buoyancy and viscosity are two factors that affect the behaviour of magma.

(i) Explain the difference between buoyancy and viscosity.

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.....

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..... **[2]**

Many candidates had a general understanding of buoyancy and viscosity. Candidates who did particularly well gave a more refined definition such as buoyancy being the upwards force and viscosity the resistance to flow.

Question 26 (c) (ii)

(ii) Outline a simple experiment that could be carried out in a school science laboratory to model the viscosity of magma using a liquid such as golden syrup.

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..... **[2]**

Most candidates were able to outline a simple experiment either using a sloped surface for the syrup to run down and working out the rate of flow or dropping a heavy weight/ball bearing into the syrup and seeing how far it travelled. Less successful answers did not discuss the timing over a set distance, or the distance travelled.

Question 26 (d)

(d) Describe the process of intrusion by which magma ascends through the crust.

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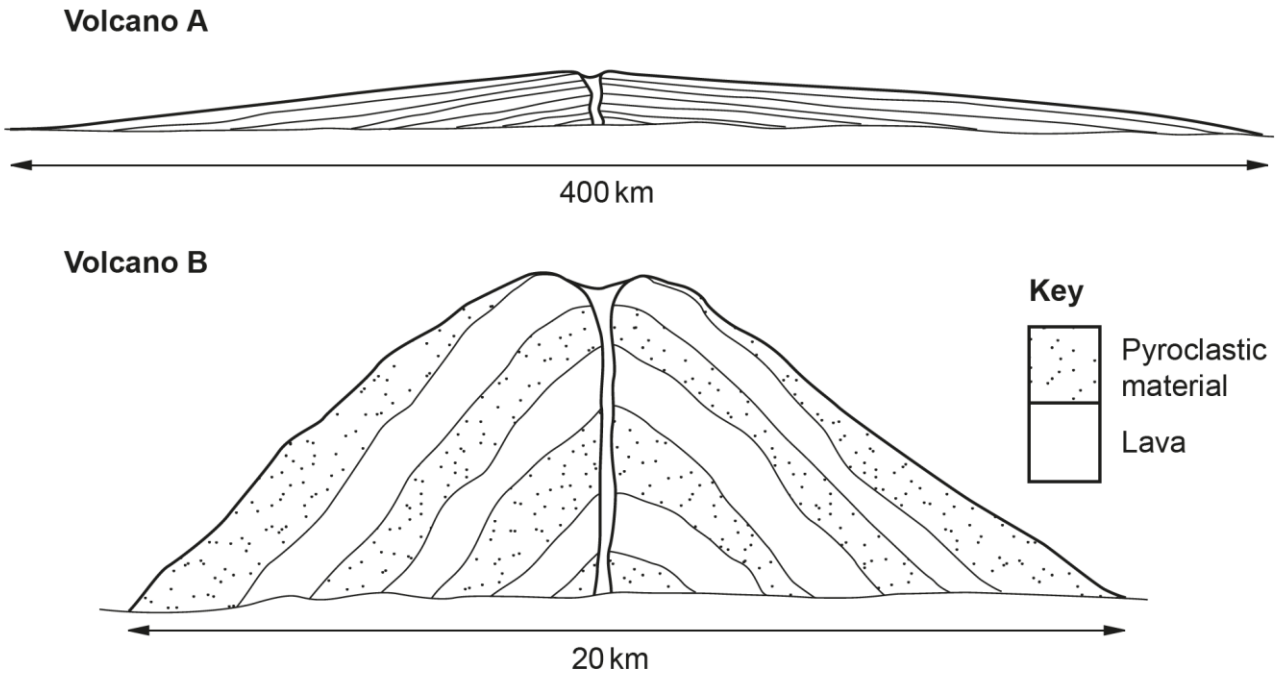
..... **[3]**

Less successful answers only mentioned magma moving through lines of weakness. Stronger answers discussed stoping in detail and the assimilation of the country rock. Strong answers also indicated that xenoliths represent country rock that had not been fully assimilated.

Question 26 (e)

Cross-sections of volcanoes **A** and **B** are shown again for reference.



(e) The volume of material erupted from a volcanic vent each second is known as the discharge rate (Q). The discharge rate depends on:

- the depth of the magma chamber (d)
- the pressure within the magma chamber (P)
- the radius of the volcanic conduit (r)
- the viscosity of the magma (μ).

The table shows data for the start of an eruption from volcanoes **A** and **B**.

Volcano	d (m)	P (Pa)	r (m)	μ (Pa s)
A	5000	5.0×10^6	1.0	100
B	7000	3.0×10^7	50.0	450

The discharge rate for volcano **B** is $2.34 \times 10^7\ m^3\ s^{-1}$.

The formula for calculating the discharge rate is: $Q = \frac{\pi r^4 P}{8 \mu d}$

Use the formula and the data in the table to calculate the discharge rate for volcano **A**.

Give your answer to **3** significant figures.

Discharge rate for volcano **A** = ... $m^3 s^{-1}$ **[3]**

Most candidates were able to use the formula given and work out the discharge rate. Some candidates lost marks as they did not give the answer to 3 significant figures. It is important that all candidates understand the correct use of significant figures.

Question 26 (f)*

(f)* Compare the nature of the eruption styles and volcanic hazards that would be associated with volcanoes **A** and **B**.

Use your knowledge of different magma compositions and characteristics to explain your answer.

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..... **[6]**

Candidates were generally confident in comparing the eruption styles and volcanic hazards. Good answers were clearly organised and answered the question fully including eruption styles, volcanic hazards, magma composition and magma characteristics.

Exemplar 1

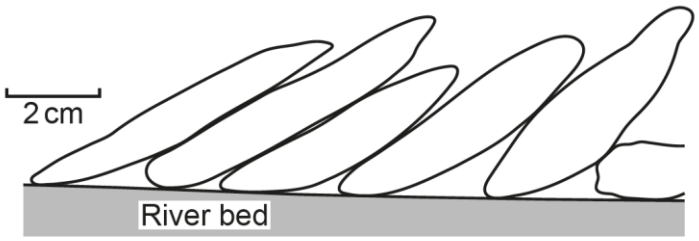
- volcano A would erupt low viscosity basaltic magma that is low in silica (56-65%) whereas volcano B would erupt high viscosity silicic magma that is rich in silica ~~(75%)~~ (over 75%)
- gas can escape the low viscosity basaltic magma much more easily than viscous silicic magma, therefore volcano A will have effusive eruptions and volcano B will have explosive eruptions
- basaltic ~~magma~~ lava from volcano A can travel long distances before solidifying meaning a major hazard is lava flows
- silicic magma from volcano B will explode into lots of tephra, therefore a major risk is ash falls or pyroclastic flows
- both volcanoes will give off toxic volcanic gases such as carbon dioxide which escapes from the magma at low pressure

In Exemplar 1, this candidate covered all four aspects of the required response: eruption styles, volcanic hazards, magma composition and magma characteristics. This example shows that a full mark answer can be concise.

Question 27 (a) (i)

27

(a) The cross-section diagram shows an imbricate structure formed in river sediments.



(i) Draw an arrow above the diagram to show the current direction at the time of formation. **[1]**

Most candidates correctly drew an arrow going from left to right.

Question 27 (a) (ii)

(ii) Explain how an imbricate structure forms.

.....

.....

.....

..... **[2]**

Most candidates knew that the pebbles are aligned by the current but only the strongest answers referred to traction and the pebbles dipping upstream.

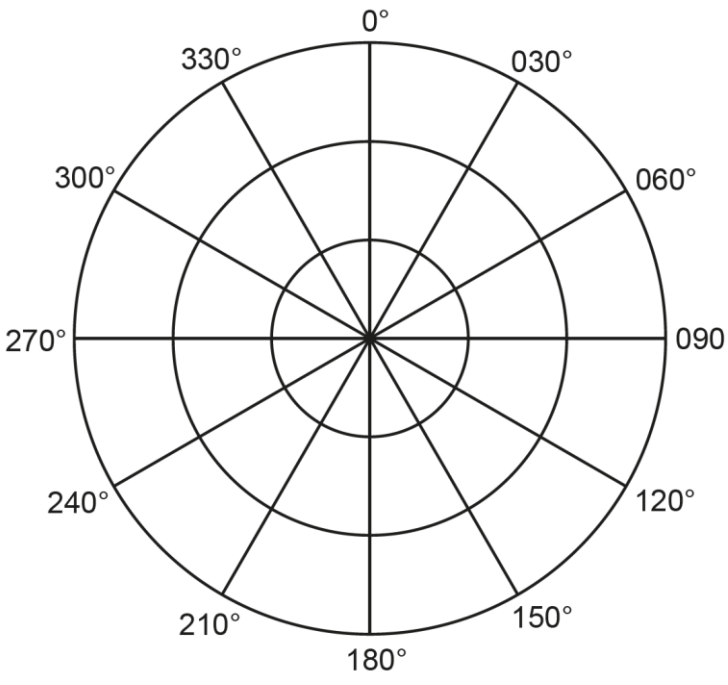
Question 27 (b) (i)

(b)

(i) The table shows measurements of dip direction of clasts in an ancient fluvial deposit showing imbrication.

Plot the data from the table on the rose diagram.

Dip direction (°)	Number of clasts measured
001–030	10
031–060	15
061–090	8
091–120	2
121–150	1
151–180	0
181–210	0
211–240	0
241–270	0
271–300	0
301–330	2
331–360	4



[2]

Most candidates successfully plotted the rose diagram. It is important that candidates treat rose diagrams like any other graph and make sure that both the axes are completed with the number of clasts shown as 0. 5, 10 and 15 along any of the spokes.

Question 27 (b) (ii)

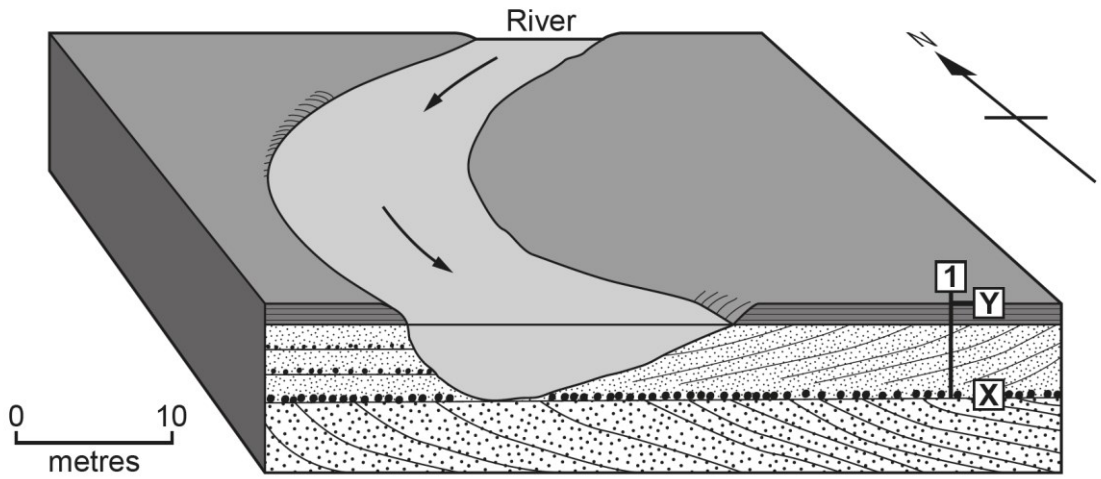
(ii) Interpret the palaeocurrent direction shown by the imbrication.

..... **[1]**

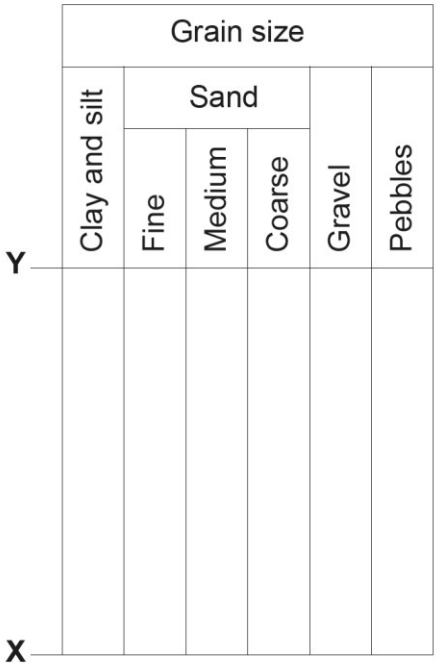
Most candidates recognised that NE was a main dip direction shown on the rose diagram but did not realise that the dip direction is opposite to the current direction. Hence the answer should be SW and not NE.

Question 27 (c) (i)

(c) The block diagram shows sediments deposited by a meandering river.



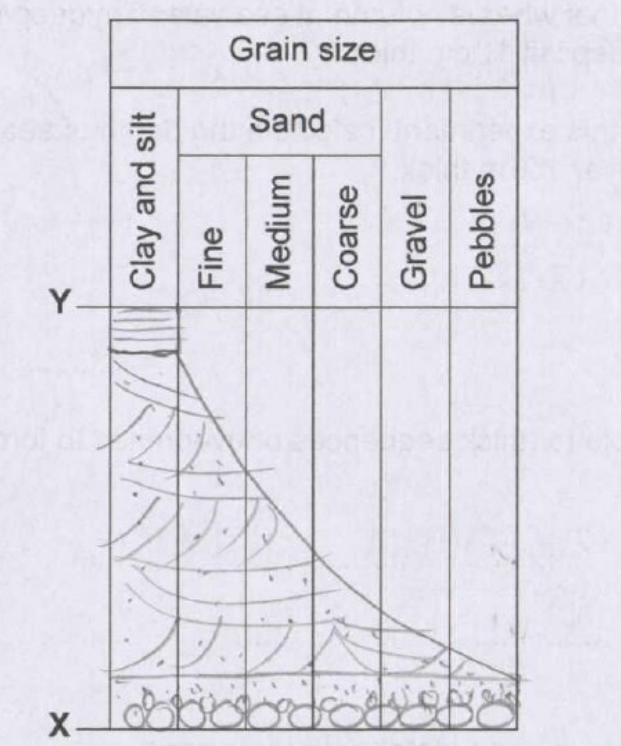
(i) Draw a sketch graphic log on the chart below to show the change in grain size from **X** to **Y** in the vertical sequence at location **1**.



[2]

Most candidates were able to construct an appropriate sedimentary log showing a fining upwards sequence. Some candidates, however, did not have coarse enough clasts at the base with coarse sand rather than gravel or pebbles.

Exemplar 2



Exemplar 2 gives a strong answer showing a coarsening upwards sequence from pebbles at the base to clay at the top. Ideally, as in this case, the beds have an appropriate ornamentation to match the grain size.

Question 27 (c) (ii)

(ii) Use Walther's Law to help explain how this vertical sequence of fluvial sediments formed.

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.....

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.....

..... **[4]**

Walther's Law always proves a challenge to candidates. The strongest answers were able to link the lateral facies/environment changes with the vertical sequence. Stronger answers then discussed the various sub environments of a meandering river and the relevant sediments: pebbles in the channel lag, sand at the point bar and clay on the flood plain.

Question 27 (d) (i)

(d) Evaporites can form in playa lakes and shallow marine environments.

(i) State the order of the **four** evaporite minerals that form when a playa lake dries up.

Last to form .....

.....

.....

First to form .....

[2]

It was clear that some candidates knew the complete sequence perhaps helped by using a mnemonic aid, less successful answers did list calcite and gypsum but not necessarily in the correct order.

Question 27 (d) (ii)

(ii) Explain why the minerals form in this order.

.....

..... **[1]**

Many candidates knew that the order of formation of the evaporite minerals linked to solubility of the minerals. Stronger answers then described that it was the least soluble that precipitated first or vice versa.

Question 27 (d) (iii)

(iii) An experiment showed that when a column of seawater 6 m deep was evaporated to dryness it produced an evaporite deposit 10 cm thick.

Based on the results of this experiment, calculate the depth of seawater needed to evaporate to produce an evaporite layer 150 m thick.

= ..... m **[2]**

Most candidates completed this calculation successfully. The main error was giving the answer as 90 m having not converted cm to m.

Question 27 (d) (iv)

(iv) Suggest how it is possible for thick sequences of evaporites to form in shallow marine environments.

.....

..... **[1]**

Very few candidates knew about repeated influxes of seawater could lead to thick sequences of evaporites.

Question 27 (e) (i)

(e)

(i) Describe how chalk forms in deep-water carbonate seas.

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.....

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..... **[2]**

Many candidates knew that chalk is formed from the remains of microscopic organisms. The strongest answers knew that these were coccoliths/coccolithophores and that diagenesis converted the fine sediment into chalk.

Question 27 (e) (ii)

(ii) Chalk often contains nodules of flint.

Explain the most likely origin of flint nodules in chalk.

.....

..... **[1]**

Very few candidates knew how flint formed. This is the first time that this has been asked and candidates need to know that flint nodules form from the precipitation of Si/SiO_2/quartz and that the Si is derived from sponge spicules.

Question 27 (e) (iii)

(iii) Explain why carbonate sediments do not form at depths greater than 5 km in modern marine environments.

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.....

..... **[2]**

Many candidates knew of the Carbonate Compensation Depth which was often simplified to the CCD. Stronger answers explained that high pressure or lower temperature caused the calcium carbonate to dissolve.

Question 27 (f)*

(f)* Describe and explain the differences in texture and mineralogy of sandstones deposited in desert and deep sea turbidite sedimentary environments.

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..... **[6]**

Candidates tended to be more confident when describing the desert sandstones compared to the deep sea turbidite sandstones. Equally candidates tended to be more confident in describing the texture and mineralogy compared to explaining why the textures or mineralogy were present. The strongest answers were balanced between the two sandstones and provided descriptions and explanations for the textures and mineralogy.

Exemplar 3

- desert sandstone is very well sorted and rounded while turbidite sandstones are poorly sorted and poorly rounded, because in a desert the main transport mechanism is wind blowing fine sand grains that collide with each other over long distances whereas turbidites are high energy currents that transport over a relatively short distance and deposit quickly
- desert sandstones are mostly quartz since in the desert other minerals like feldspar have weathered away, turbidite sandstones can have other mineral grains and rock fragments because they haven't weathered away that much before deposition
- desert sandstones have a haematite cement because water precipitates it between the grains as the sand underground undergoes diagenesis, turbidite sandstones have a clay matrix made of some clay minerals because the clay is often deposited with the clasts and takes up the space between them.

In Exemplar 3, this candidate had a well-structured answer that compared the two sandstones throughout rather than describing them separately. This allowed the differences to be directly described and then explained. The answers were concise and made appropriate use of the correct terminology throughout.

Question 28 (a) (i)

28 Surface processes can be important in concentrating metal ore minerals to form economic deposits.

(a) The table shows properties of some common ore minerals.

Ore mineral	Chemical formula	Cleavage	Density ($g\,cm^{-3}$)	Hardness
Cassiterite	SnO_2	Poor	7.0	6–7
Chalcopyrite	$CuFeS_2$	None	4.2	3.5–4
Galena	PbS	3 at 90°	7.5	2.5
Gold	Au	None	19.3	3

(i) Use the data in the table to evaluate whether each ore mineral is likely to be found concentrated in placer deposits.

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..... **[4]**

It was important that candidates were clear in their evaluation as to whether the minerals were or were not likely to form placer deposits. The best answers took each mineral in turn and looked at the key properties of density, hardness and cleavage and explained how they would impact on the chances of the mineral forming a placer deposit. Some excellent answers also noted the chemical composition and indicated whether they were likely to be oxidised and so become soluble.

Question 28 (a) (ii)

(ii) Draw **and** label a cross-section diagram to explain how placer deposits can form on beaches.

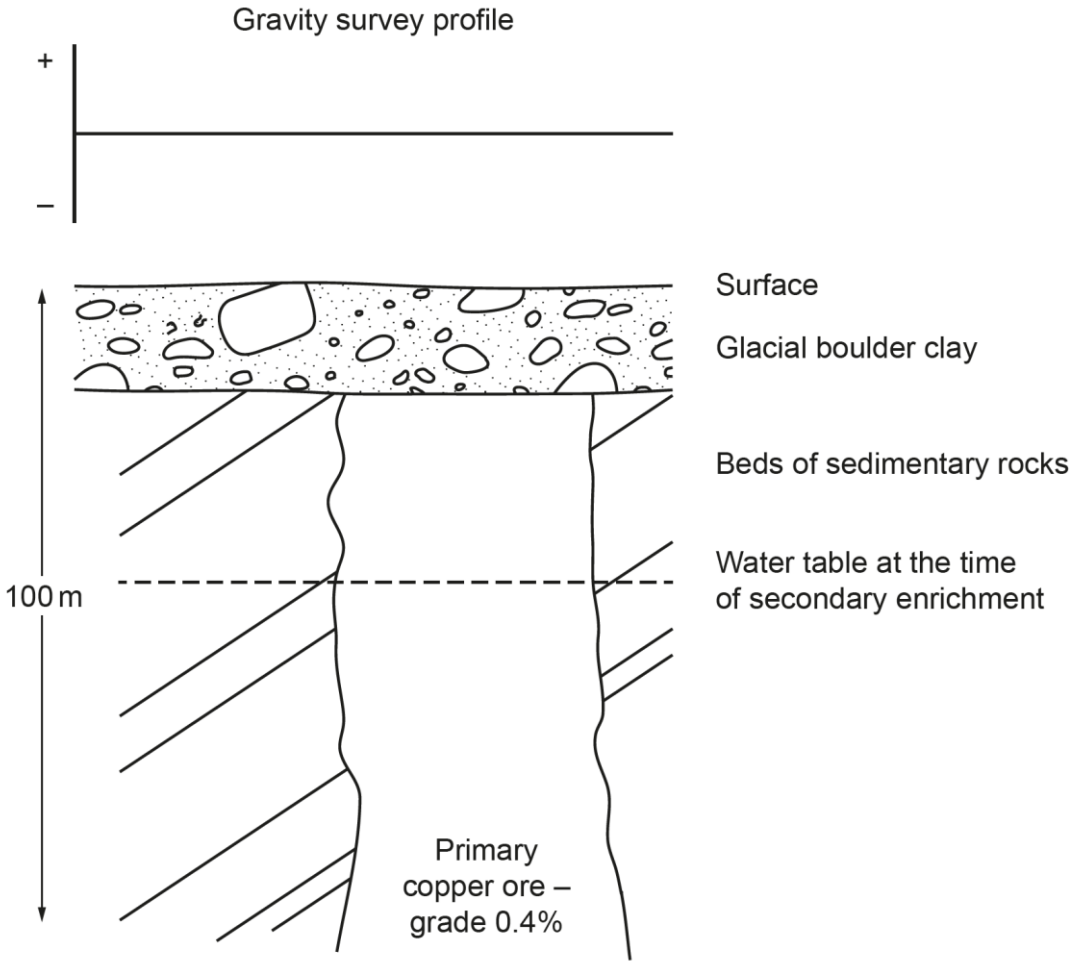
[2]

Many candidates did draw a correct cross section although some drew a plan view which was not asked for. Many candidates did not have enough appropriate labels to gain full marks. Candidates need to practice fully labelling all the possible placer environments including the location of mineral deposition, high and low energy locations and transportation.

Question 28 (b) (i)

(b) The cross-section diagram shows the geometry of a vein of copper ore discovered using geophysical exploration techniques.

The copper ore has been concentrated by secondary enrichment.



(i) Shade on the cross-section an area where the percentage of copper will be >0.4%. **[1]**

Many candidates correctly shaded just above or below the water table. It is good practice not to shade too far above and below the water table.

Question 28 (b) (ii)

(ii) Draw a sketch graph on the axes above the cross-section diagram to show the shape of the profile that would be produced by a transect gravity survey. **[1]**

Most candidates drew a positive anomaly in the correct location directly above the primary ore deposit. Because the copper ore mineral is relatively dense compared to normal country rock it will produce a positive gravity anomaly.

Question 28 (b) (iii)

(iii) Explain why geochemical exploration techniques may be unsuccessful in locating this vein of copper ore.

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..... **[2]**

Most candidates realised that the glacial boulder clay is above the ore deposit which could block the transfer of copper rich groundwater and so would not be picked up by geochemical exploration methods. The strongest answers noted that boulder clay is impermeable and that the groundwater above the water table will be depleted in copper.

Question 28 (c)

(c) Prior to mining an ore deposit the reserves must be determined.

Describe the follow-up stages of mineral exploration and site investigation that allow reserves to be calculated.

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.....

.....

..... **[3]**

Many candidates knew that exploration drilling was important, fewer candidates took the next step by describing chemical analysis of core samples to work out the metal content of the ore. Many candidates also mentioned using geophysical techniques to work out the extent of the deposit although often detail was lacking. Very few candidates described the use of a regular drill grid pattern or geostatistical modelling.

Question 28 (d) (i)

(d) A porphyry copper ore deposit has a circular cross-section area with a diameter of 800 m and is 500 m thick.

The average density of the ore is 3.2×10^3 kg m^{-3}.

(i) Calculate the mass of this copper ore deposit in tonnes.

Note: 1 tonne = 1000 kg

Mass = ... tonnes **[3]**

Many candidates were able to work out the volume of the ore body and then able to use the ore density and volume to work out the overall mass. Some candidates worked out the first step (volume) but then made an error in the second step.

Question 28 (d) (ii)

(ii) The average grade is 0.6% copper.

Calculate the reserves of copper in this copper ore deposit.

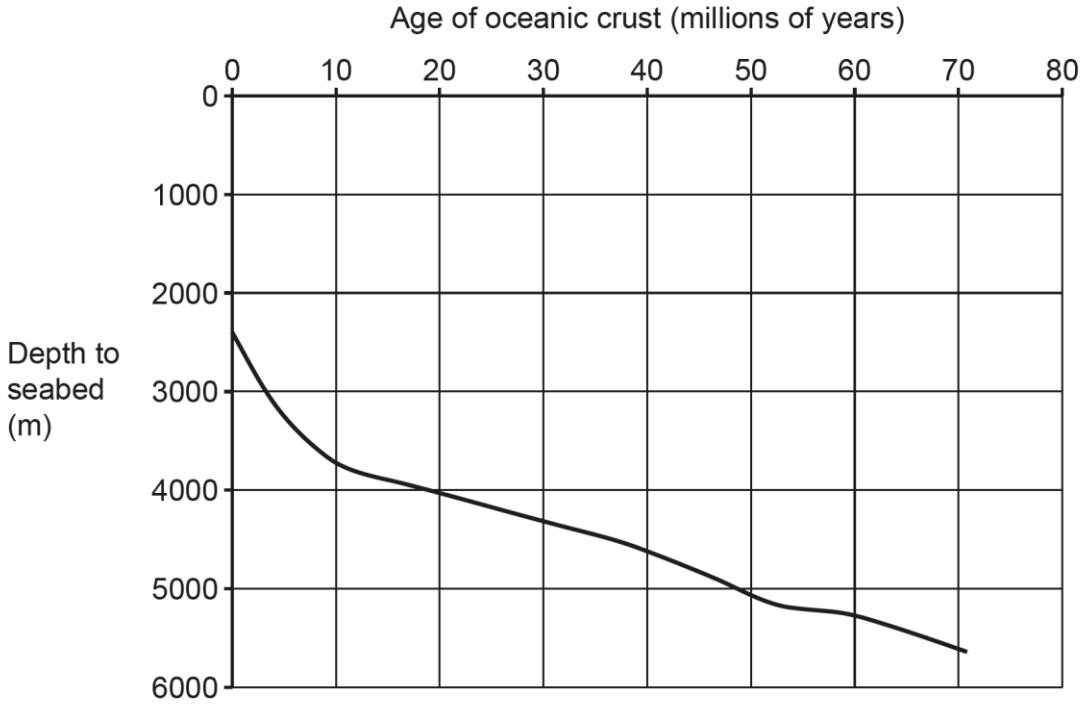
= ..... tonnes **[1]**

Most candidates were able to work out 0.6% of their answer for Question 28 (d) (i). Ecf was allowed so that the correct calculation based on an incorrect answer in Question 28 (d) (i) still gained credit.

Question 29 (a) (i)

29

(a) The graph shows the relationship between the depth to the seabed and the age of the oceanic crust in the eastern part of the Atlantic Ocean.



(i) Draw an arrow to show the position of the Mid-Atlantic Ridge on the graph. **[1]**

Most candidates correctly drew an arrow pointing at 0 (millions of years) and the shallowest depth.

Question 29 (a) (ii)

(ii) Explain the change in depth to the seabed shown on the graph.

.....

.....

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..... **[2]**

Candidates in general were not clear about why depth increases with distance from the MOR. Some tried to link it to deposition or reaching a subduction zone. The strongest answers discussed the elevated ridge being due to the buoyancy imposed by the rising magma and described how as the crust moved away from the ridge it became older, colder and so denser leading to sinking of the crust.

Question 29 (b)

(b) A basalt sample obtained from the seabed by dredging was radiometrically dated using the potassium–argon (^{40}K–^{40}Ar) method.

95% of the parent ^{40}K isotope remained in the basalt sample.

The decay rate equation is: $N = N_0e^{-\lambda t}$

Where:

N = % of ^{40}K in the sample

N_0 = initial % of ^{40}K in the sample at the start of decay

λ = the decay constant = 0.693 / 1250 for the ^{40}K–^{40}Ar system

t = the age of the sample in millions of years

Rearrange the decay rate equation to make t the subject.

Calculate the age of the basalt sample (t) in millions of years (Ma).

Age of basalt sample (t) = ... Ma **[2]**

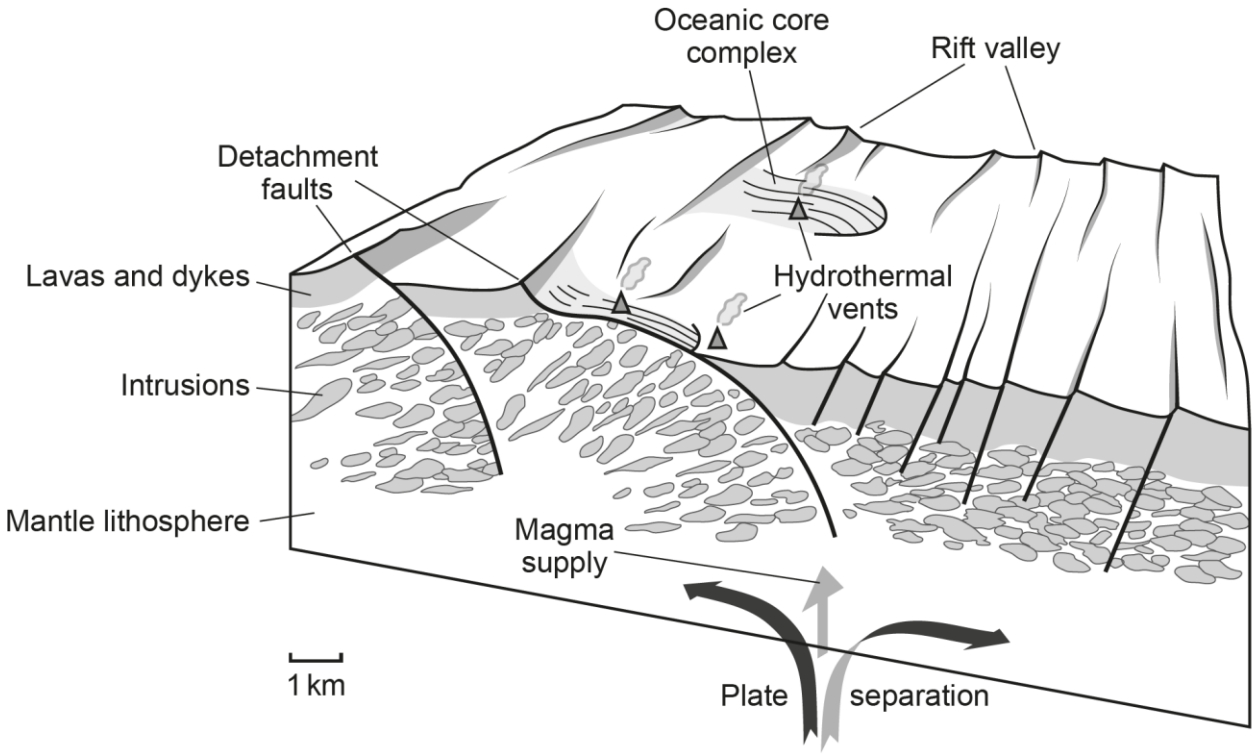
Candidates do need to be able to rearrange different equations to carry out calculations. In this case one key step that many candidates missed was converting e to ln.

Question 29 (c) (i)

(c) The Mid-Atlantic Ridge is a slow-spreading ridge.

Recent research has shown that slow-spreading ridges have unusual features.

The simplified block diagram shows some of these features.



(i) Use information shown on the diagram to describe **one** characteristic of a detachment fault.

.....

..... **[1]**

Candidates were required to study the detachment faults illustrated on the diagram. The most common correct observations were that the faults are curved and that they are normal faults

Question 29 (c) (ii)

(ii) Gabbro and peridotite have been found at the surface of oceanic core complexes.

Explain the origin of the gabbro and peridotite and why they are now exposed at the surface.

.....

.....

.....

..... **[2]**

Candidates are not confident when discussing aspects of oceanic core complexes. In this case the best answers indicated that gabbro forms at mid ocean ridges and peridotite forms in the mantle. Very few candidates knew that faults brought these plutonic rocks up to the surface.

Question 29 (d) (i)

(d) Hydrothermal vents are common along mid-ocean ridges.

(i) Explain how these hydrothermal vents form.

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.....

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.....

..... **[3]**

Very few candidates could give detailed responses to this question. Common misconceptions were that the vents were created by escaping gas from magma that was close to the surface. Strong answers discussed seawater seeping into the crust, being heated up, removing/scavenging metals from the oceanic crust before escaping up fractures to the surface where on contact with cold seawater metal sulphides were precipitated to form chimneys/mounds. Candidates do need to fully understand these processes operating near mid ocean ridges.

Question 29 (d) (ii)

(ii) Describe **one** feature and **one** product of hydrothermal vents at mid-ocean ridges.

Feature .....

.....

Product .....

..... **[2]**

Strong answers described metal sulphides and unusual ecosystems existing at these vents. Many candidates mentioned black (or white) smokers with many just mentioning black smoke.

Question 29 (e) (i)

(e) Ore deposits that originated from hydrothermal processes at mid-ocean ridges occur in sequences of oceanic lithosphere found in continental areas.

(i) What name is given to sequences of oceanic lithosphere found in continental areas?

..... **[1]**

Many candidates recognised that ophiolites are being described in the question.

Question 29 (e) (ii)

(ii) Explain how these sequences become incorporated into continental crust.

.....

.....

.....

..... **[2]**

Most candidates knew that ophiolites form at convergent plate margins. The strongest answers also used the correct term "obduction" to describe the way the ophiolite is incorporated into the continental crust.

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