



Oxford Cambridge and RSA

Tuesday 3 June 2025 – Morning

A Level Geology

H414/01 Fundamentals of geology

Time allowed: 2 hours 15 minutes



You must have:

- an HB pencil
- a protractor
- a ruler (cm/mm)
- a scientific or graphical calculator



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s)

Last name

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is **110**.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE

- Read each question carefully before you start your answer.

Section A

You should spend a **maximum** of **35 minutes** on this section.

For each question write the letter in the box.

1 What is the correct chemical formula for pyrite?

- A FeS
- B Fe₂S
- C FeS₂
- D FeSO₄

Your answer

[1]

2 Using Mohs hardness test, which of the following conclusions is correct for the hardness of calcite?

- A > copper coin and < steel nail
- B < fingernail
- C > fingernail and < copper coin
- D > steel nail

Your answer

[1]

3 This is a description of an igneous rock:

- Light grey in colour
- Flow-banded
- Fine crystal size

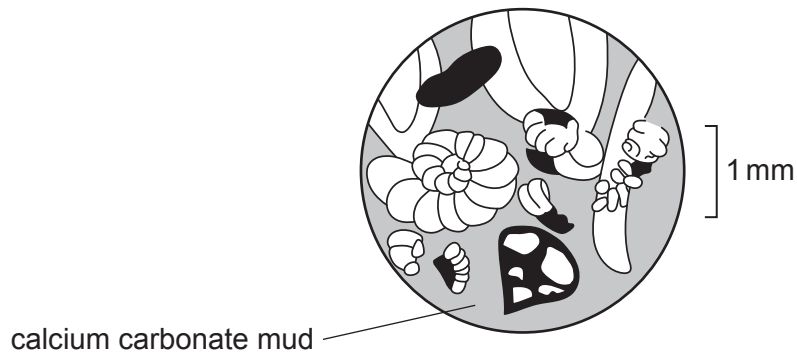
What is the rock type?

- A Basalt
- B Microdiorite
- C Obsidian
- D Rhyolite

Your answer

[1]

- 4 The thin section diagram shows a carbonate rock.



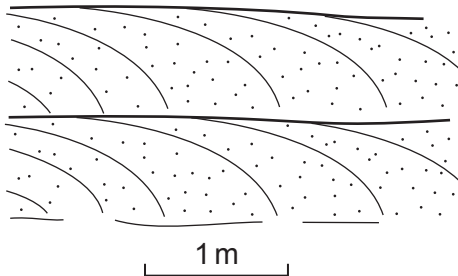
Use the Dunham classification scheme to identify the rock type shown in the thin section.

- A Grainstone
- B Mudstone
- C Packstone
- D Wackestone

Your answer

[1]

- 5 The diagram shows a cross-section through a sedimentary structure.



Identify the sedimentary structure and the correct way-up.

- A Inverted asymmetrical ripple marks
- B Inverted cross-bedding
- C Right way-up asymmetrical ripple marks
- D Right way-up cross-bedding

Your answer

[1]

- 6 The table shows the grain sizes of 16 pebbles collected from a riverbed.

Pebble number	Grain size (mm)
1	24
2	13
3	16
4	12
5	25
6	22
7	9
8	15
9	13
10	18
11	24
12	10
13	13
14	23
15	15
16	16

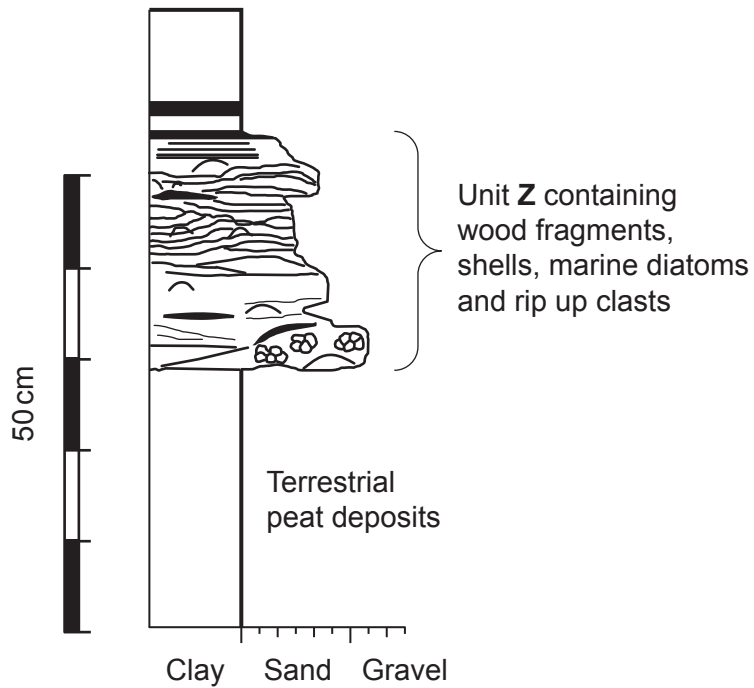
What is the median of these pebble grain sizes?

- A** 13 mm
B 14 mm
C 15.5 mm
D 16.75 mm

Your answer

[1]

- 7 The graphic log shows a sequence of recent sedimentary deposits in Scotland.



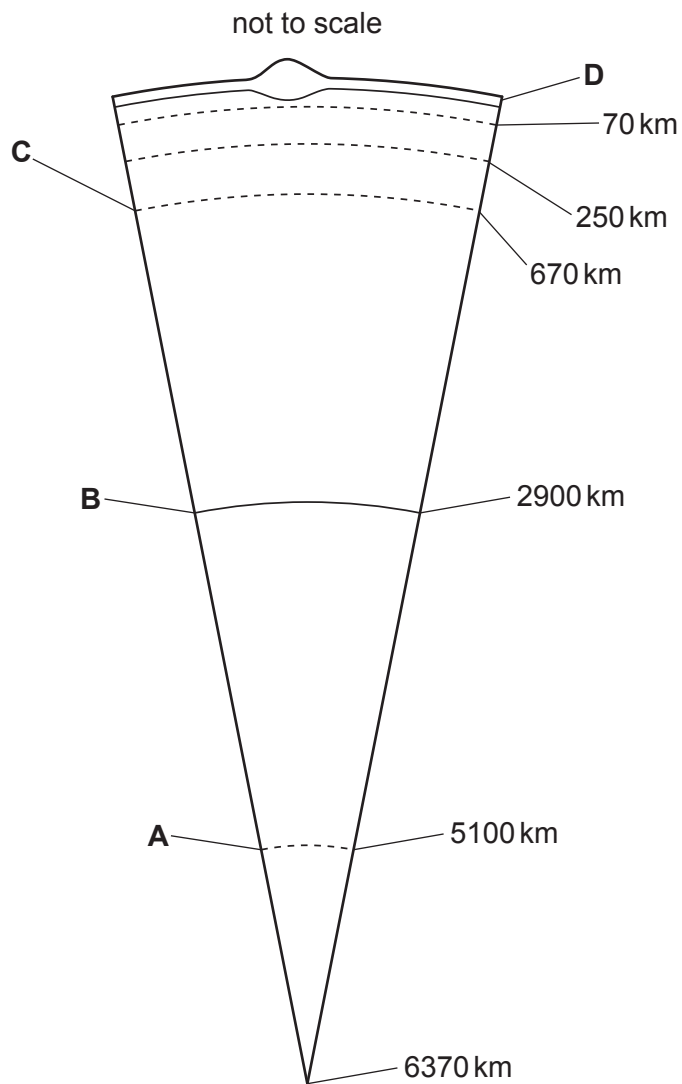
What type of deposit is unit **Z**?

- A** Deltaic deposit
- B** Fluvial deposit
- C** Tsunami deposit
- D** Turbidite deposit

Your answer

[1]

- 8 The diagram shows a simplified cross-section through the Earth.



Which letter on the cross-section, **A**, **B**, **C** or **D**, marks the position of the Lehmann discontinuity?

Your answer

[1]

- 9 The layers of the Earth are defined by their rheological properties.

What comprises the lithosphere?

- A** Ductile crust and ductile upper mantle
- B** Ductile crust and rigid upper mantle
- C** Rigid crust and ductile upper mantle
- D** Rigid crust and rigid upper mantle

Your answer

[1]

10 Which value is the inferred average density of the Earth's outer core?

- A** 7.5g cm^{-3}
- B** 11.5g cm^{-3}
- C** 15.5g cm^{-3}
- D** 17.5g cm^{-3}

Your answer

[1]

11 What are the correct Goldschmidt classifications for the elements lead and oxygen?

	Lead	Oxygen
A	Chalcophile	Atmophile
B	Chalcophile	Lithophile
C	Siderophile	Atmophile
D	Siderophile	Lithophile

Your answer

[1]

12 What are the orientations of the maximum and minimum principal stresses at transform (conservative) plate boundaries?

- A** Maximum and minimum principal stresses are both horizontal
- B** Maximum and minimum principal stresses are both vertical
- C** Maximum principal stress is horizontal and minimum principal stress is vertical
- D** Maximum principal stress is vertical and minimum principal stress is horizontal

Your answer

[1]

13 Which geophysical survey method would **not** provide evidence for the internal structure and processes occurring at mid-ocean ridges?

- A** Electromagnetic survey
- B** Resistivity survey
- C** Seismic reflection survey
- D** Seismic tomography survey

Your answer

[1]

14 Acid mine drainage can be mitigated using reed bed wetlands. These are an example of which type of remediation?

- A** Active treatment
- B** Barrier method
- C** Passive treatment
- D** Stabilisation / solidification

Your answer

[1]

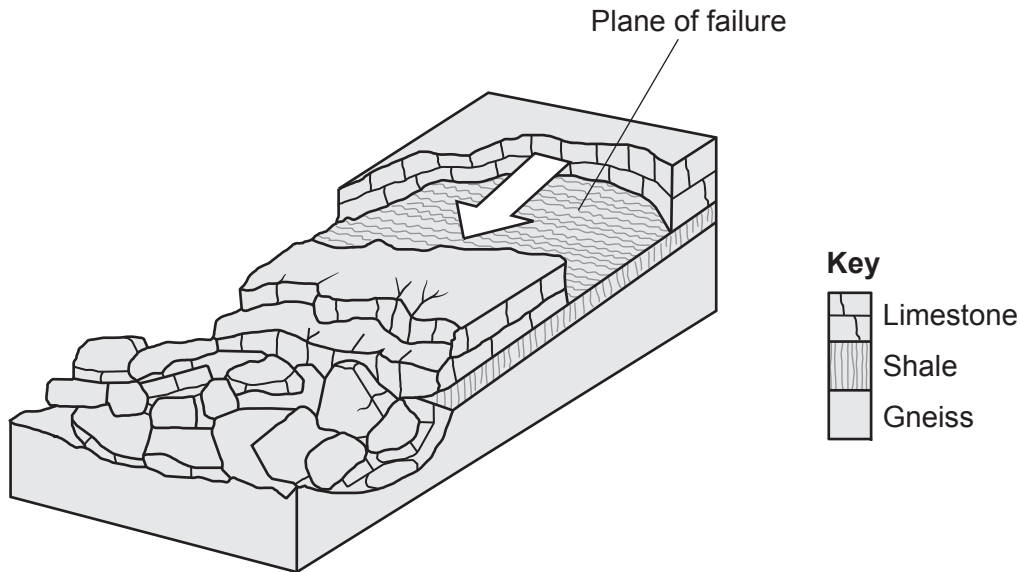
15 Which combination is most likely to result in liquefaction of sediments during an earthquake?

- A** High pore fluid pressure and increased friction
- B** High pore fluid pressure and reduced friction
- C** Low pore fluid pressure and increased friction
- D** Low pore fluid pressure and reduced friction

Your answer

[1]

16 The block diagram shows a recent landslide.



The landslide is the result of a slip plane developing along the bedding plane between two rock types.

Which statement is true regarding the competence of the two rock types?

- A** Competent rocks above and below
- B** Competent rock above and incompetent rock below
- C** Incompetent rock above and competent rock below
- D** Incompetent rocks above and below

Your answer

[1]

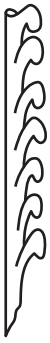
17 Which slope stabilisation method would be most suitable to support the sides of a road cutting through clay?

- A** Rock bolts
- B** Shotcrete
- C** Vegetation
- D** Wire netting

Your answer

[1]

The diagram shows a graptolite fossil collected from the Welsh Basin.



×4

Use the graptolite fossil diagram to answer questions **18** and **19**.

18 What is the actual length of this graptolite fossil?

- A** 1.1 mm
- B** 11 mm
- C** 44 mm
- D** 176 mm

Your answer

[1]

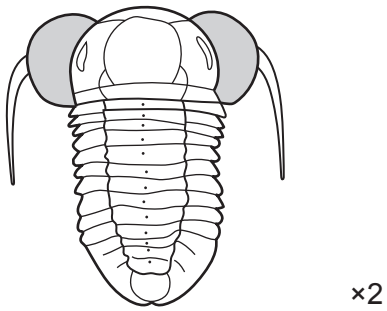
19 This type of graptolite fossil is used to date and correlate rocks of which age?

- A** Cambrian
- B** Carboniferous
- C** Devonian
- D** Silurian

Your answer

[1]

20 The diagram shows a fossil trilobite.



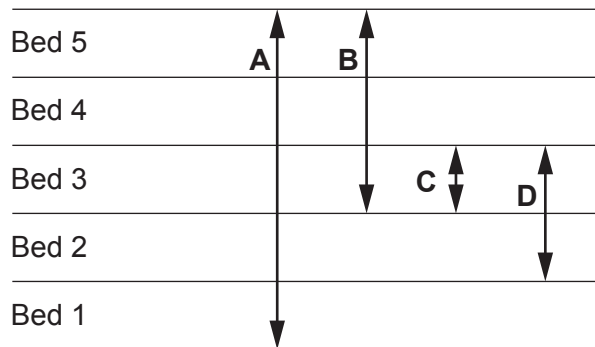
What was the most likely mode of life of this trilobite?

- A Epifaunal
- B Infaunal
- C Nektonic
- D Planktonic

Your answer

[1]

21 A sequence of Jurassic strata in Yorkshire has been logged and the ammonite fauna recorded as species **A** to **D**.



Which of the ammonite species **A**, **B**, **C** or **D** is the best zone fossil?

Your answer

[1]

22 The following statements about belemnites may be true or false.

- 1 Belemnites are cephalopods
- 2 Belemnites have an internal guard made of calcite
- 3 Belemnites became extinct at the start of the Cretaceous period

Which combination of statements is true?

- A** 1, 2 and 3
- B** Only 1 and 2
- C** Only 2 and 3
- D** Only 1

Your answer

☐

[1]

23 Which isotopic change recorded in marine microfossils would indicate the onset of an icehouse Earth event?

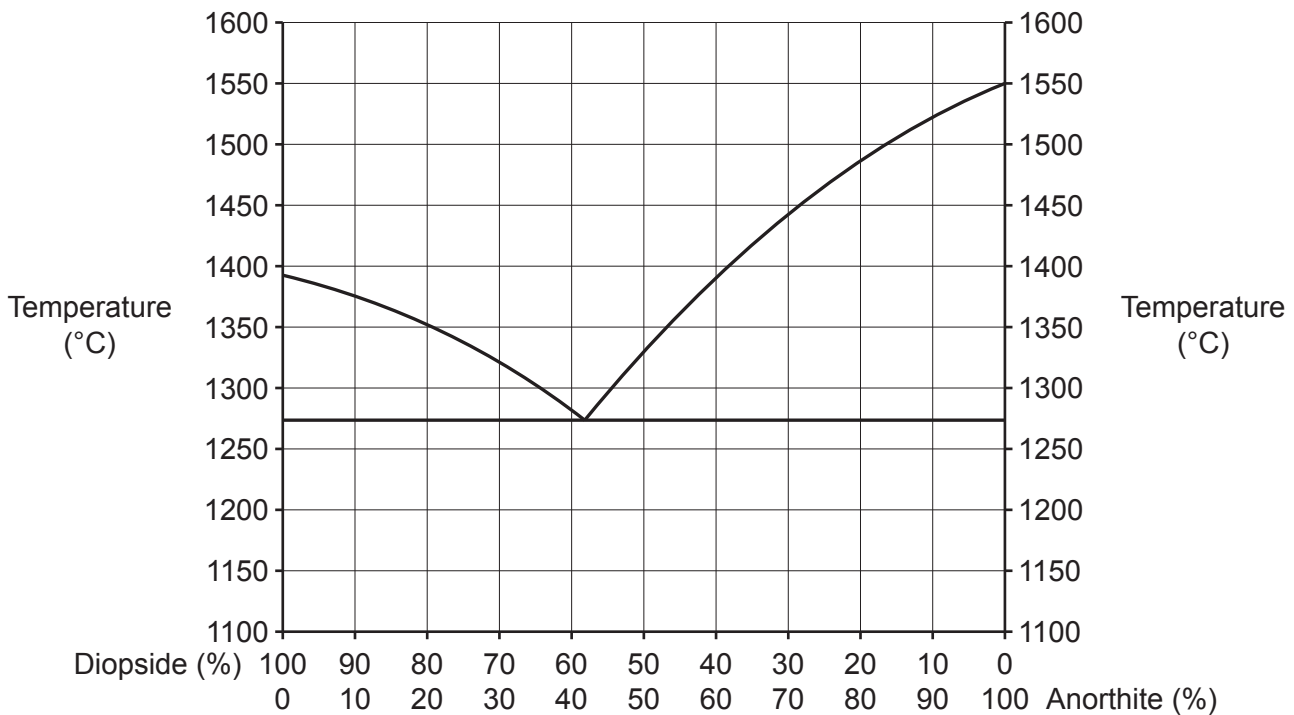
- A** A decrease in the proportion of ^{12}C
- B** A decrease in the proportion of ^{18}O
- C** An increase in the proportion of ^{16}O
- D** An increase in the proportion of ^{18}O

Your answer

☐

[1]

The binary phase diagram shows the diopside-anorthite system.



Use the phase diagram to answer questions **24** and **25**.

A cooling magma has a composition **80% anorthite (An)** and **20% diopside (Di)**.

24 At which temperature will crystallisation begin?

- A** 1274 °C
- B** 1350 °C
- C** 1485 °C
- D** 1553 °C

Your answer

[1]

25 What will be the composition of the first formed crystals?

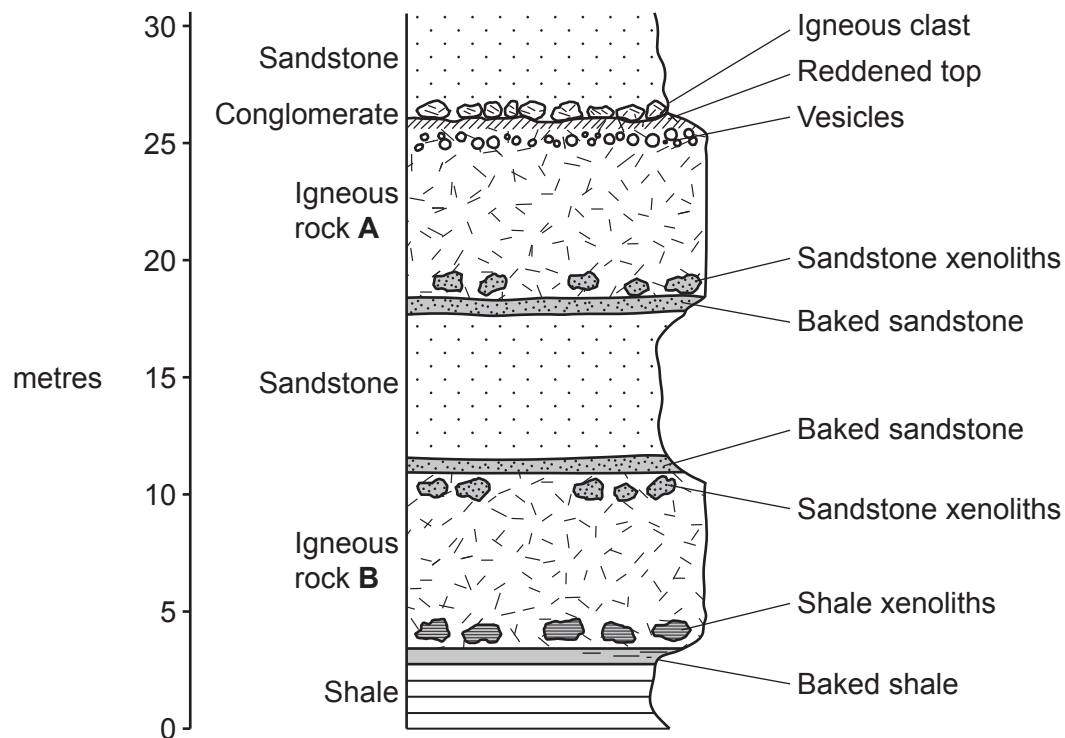
- A** 0% anorthite / 100% diopside
- B** 42% anorthite / 58% diopside
- C** 80% anorthite / 20% diopside
- D** 100% anorthite / 0% diopside

Your answer

[1]

Section B

26 The diagram shows a sequence of igneous and sedimentary rocks exposed in a cliff face.



(a) Identify the types of igneous body formed by rock **A** and rock **B**.

A

B

[2]

(b) Describe **three** characteristics shown on the diagram that allowed you to identify the type of igneous body formed by rock **A**.

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..... [3]

- (c) Describe **two** characteristics shown on the diagram that allowed you to identify the type of igneous body formed by rock **B**.

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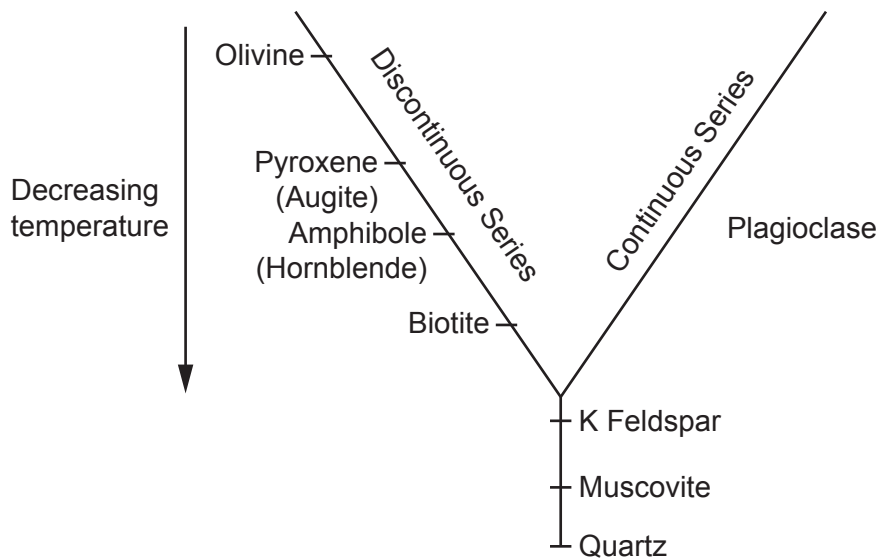
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- 27** Norman L Bowen carried out laboratory experiments to investigate the order of crystallisation of different minerals as magma cools.

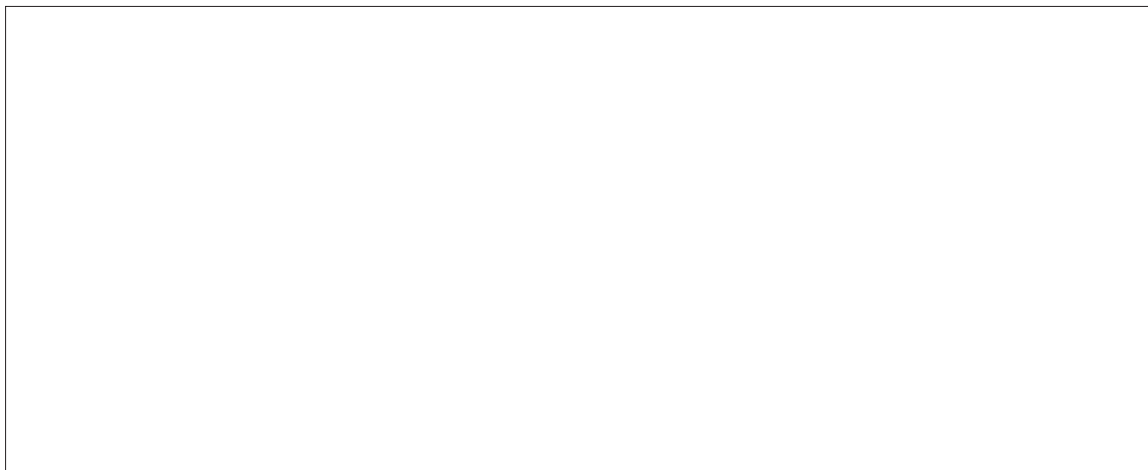
The diagram of Bowen's reaction series shows the results of his investigations.



- (a)** Observations and chemical analyses of zoned plagioclase feldspar crystals provide supporting evidence for the plagioclase continuous solid solution series.

Draw a sketch of a zoned plagioclase crystal.

Label the crystal to show the difference in composition of the centre and the rim of the crystal.



[2]

- (b)** Explain why plagioclase feldspars form a continuous solid solution series.

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[2]

- (c) Olivine crystals can undergo gravity settling through mafic magma to form a cumulate layer at the bottom of a magma chamber.
- (i) Explain how the process of gravity settling of olivine crystals results in changes to magma composition.

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..... [3]

- (ii) Stokes' Law can be used to calculate the velocity at which crystals settle out of magma.

Calculate the velocity at which a 2 mm diameter olivine crystal will settle through mafic magma.

Use the formula: Velocity (v) = $\frac{g \times d^2 \times (\rho_p - \rho_w)}{18\eta}$

Where:

g = the acceleration due to gravity = 9.8 m s^{-2}

d = the diameter of the olivine crystal = 2 mm = $2 \times 10^{-3} \text{ m}$

ρ_p = the density of the solid crystal of olivine = 3800 kg m^{-3}

ρ_w = the density of the liquid mafic magma = 2900 kg m^{-3}

η = the viscosity of the magma = $30 \text{ kg.m}^{-1}.\text{s}^{-1}$

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

Velocity = m s^{-1} [3]

- (d) Describe the process of filter pressing.

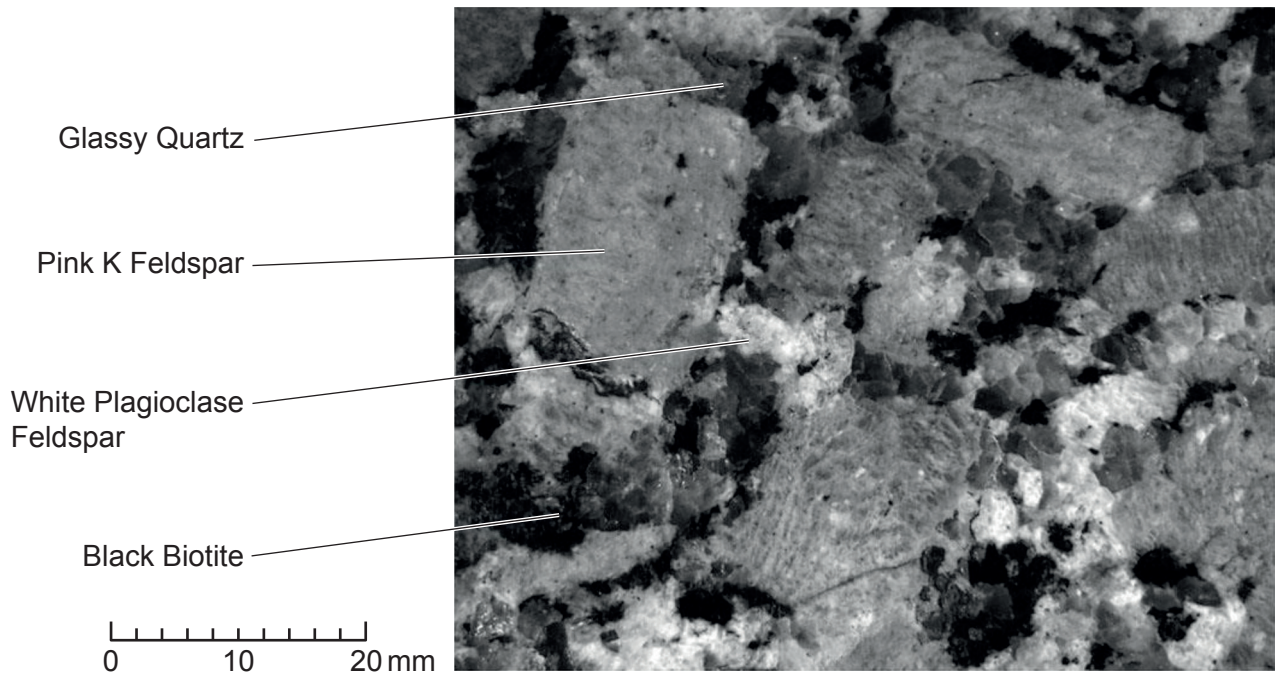
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..... [2]

(e) The photograph shows a specimen of granite.



(i) Explain why this rock is correctly identified as granite.

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..... [2]

(ii) Use evidence from the photograph to explain what can be deduced about the cooling history of this granite rock.

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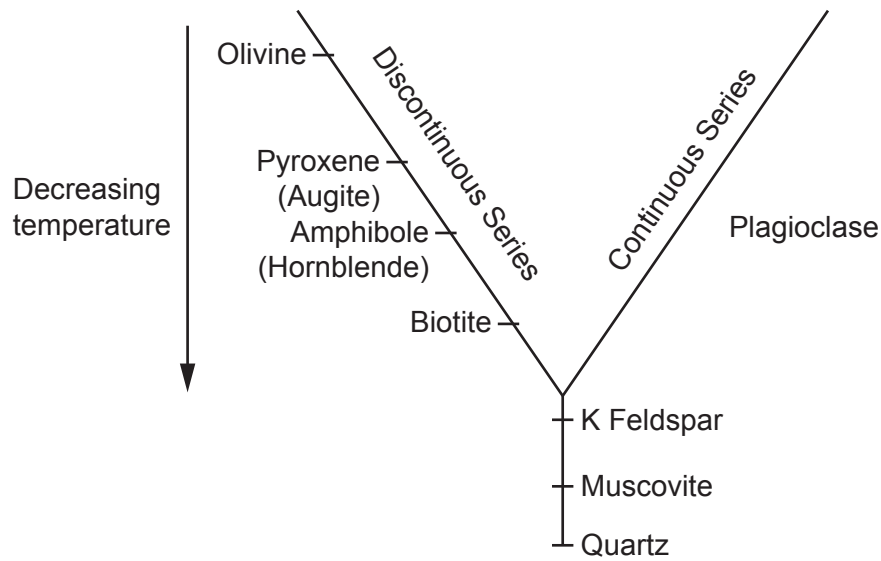
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(f) Bowen's reaction series is shown again for reference.



Evaluate whether evidence from the granite specimen shown in the photograph supports the order of crystallisation of minerals shown in Bowen's reaction series.

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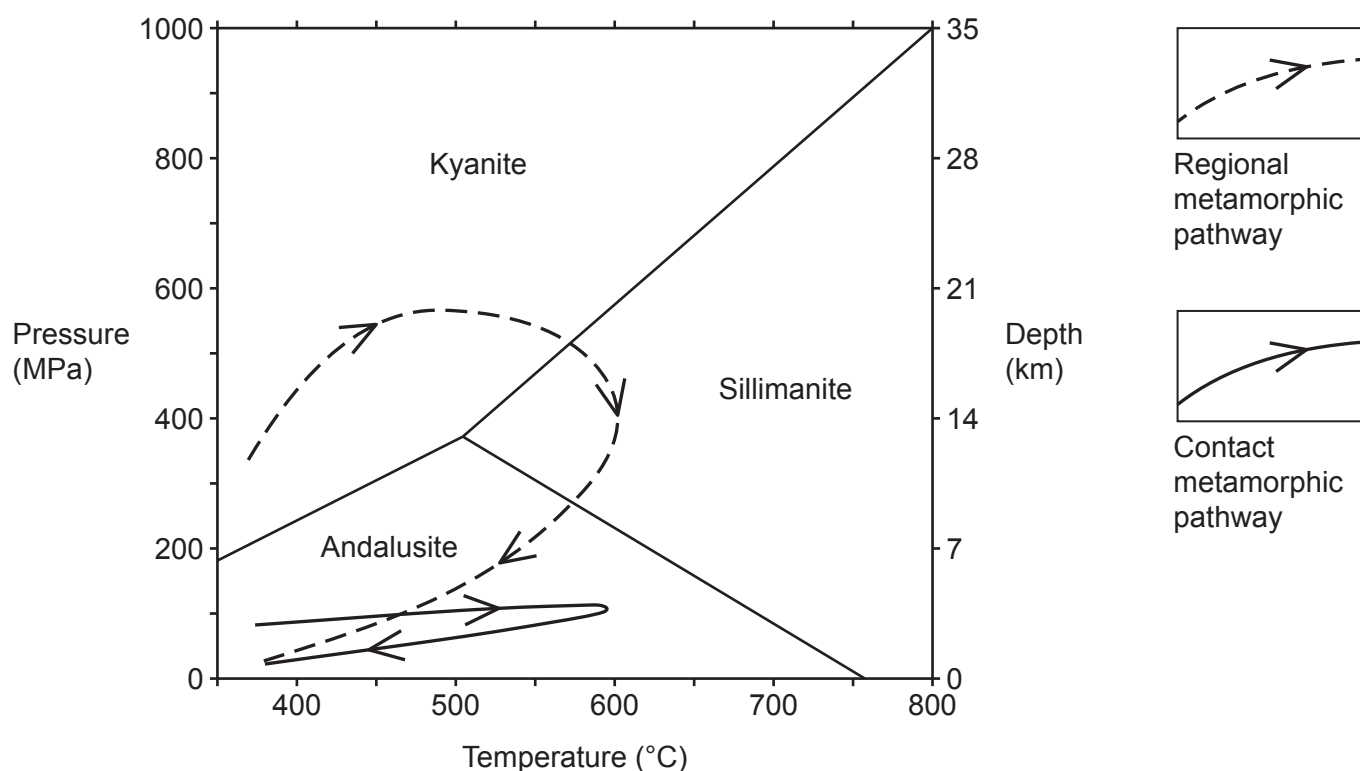
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Rock Type	% of water
Mud	60
Mudstone	35
Shale	7
Slate	3

[6]

Extra answer space if required.

- (b) The pressure-temperature graph shows the stability fields of the metamorphic minerals andalusite, kyanite and sillimanite.



- (i) Describe the relationship between the minerals andalusite, kyanite and sillimanite.

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..... [2]

- (ii) Complete the table to show:

- The maximum pressure reached along the regional metamorphic pathway
- The maximum temperature reached along the contact metamorphic pathway.

Metamorphic pathway	Maximum temperature (°C)	Maximum pressure (MPa)
Regional	605	
Contact		110

[1]

- (iii) Describe and explain how the texture of the metamorphic rocks produced during prograde metamorphism along each pathway would differ.

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..... [2]

- (c) Describe and explain the rock cycle processes that result in retrograde metamorphism.

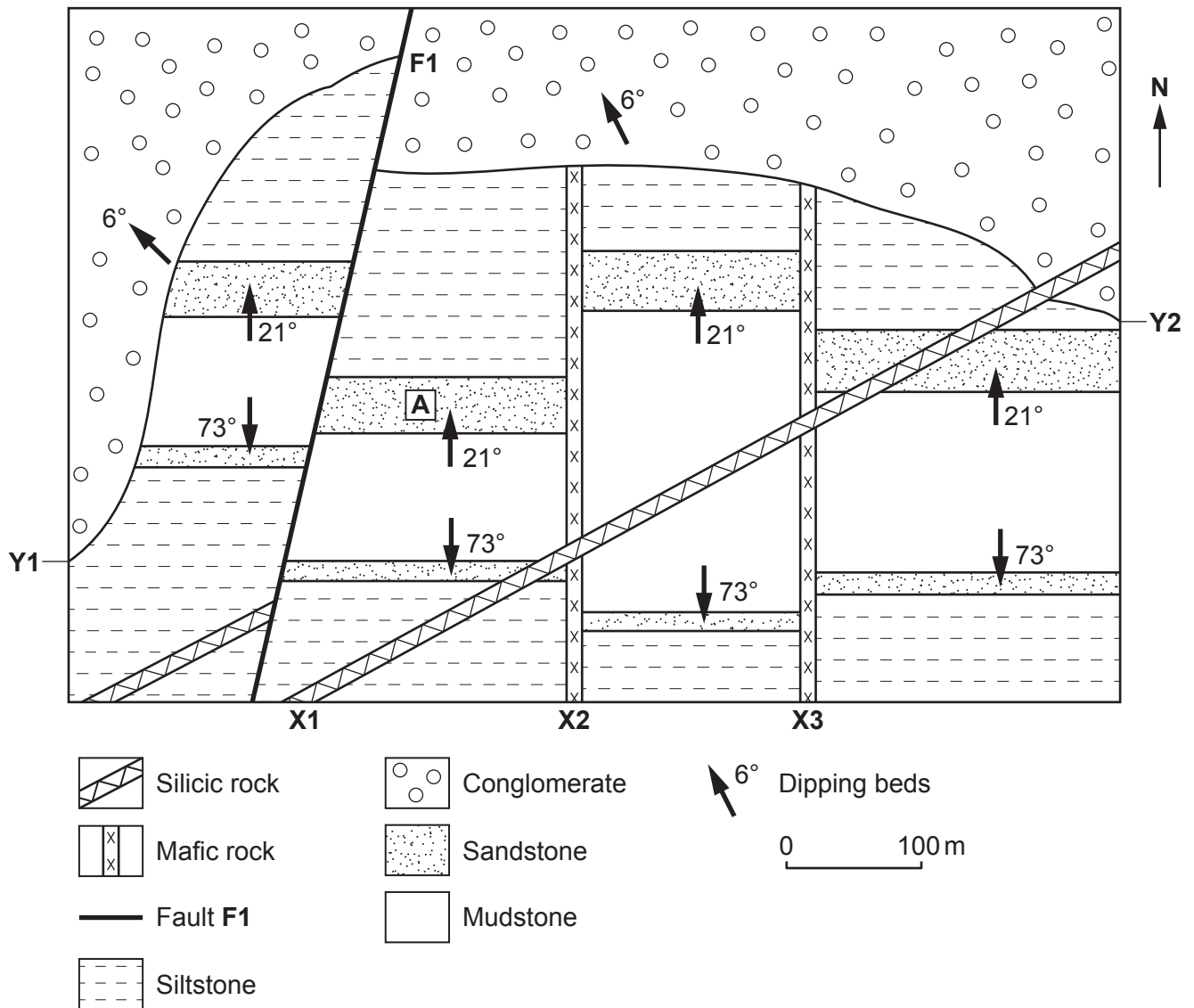
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..... [2]

29 The geological map is of an area where erosion has produced a flat land surface.



(a)

(i) Draw the axial plane trace of the fold to the west of mafic rock X2 on the map. [2]

(ii) Fully describe the fold structure using technical terms.

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..... [2]

- (b) Complete the table to summarise the characteristics of fault **F1** shown on the map.

Type of movement	
Amount of displacement	 metres
Type of tectonic stress	

[3]

- (c) Explain why igneous features **X1**, **X2** and **X3** have been identified as dykes.

.....
 [1]

- (d) Describe the sequence of events that formed the horst structure and dykes between **X2** and **X3** on the map.

.....

 [3]

(e)

- (i) Identify the geological feature along the line from **Y1** to **Y2** on the map.

..... [1]

- (ii) Explain how this feature formed.

.....

 [2]

- (f) The outcrop width of the sandstone unit at location **A** is 40.0 metres.

Calculate the true thickness of the sandstone unit at this location.

= metres [2]
 Turn over

30 Geophysical and exploration drilling techniques can be used to explore for oil and gas in sedimentary basins.

(a) The map shows the results of a gravity survey.

The readings are shown in milligals.

0	-8	-10	-13	-14	-10	-9	0	2
-7	-9	-17	-20	-19	-16	-9	-7	4
-6	-10	-22	-38	-25	-13	-10	-2	4
-2	-14	-25	-36	-28	-15	-8	-5	0
-1	-12	-26	-30	-24	-14	-5	-1	2
0	-10	-24	-27	-25	-12	-4	0	6
3	-4	-16	-21	-20	-10	-7	3	5

(i) Draw 0, -10, -20 and -30 milligal isolines on the map.

[3]

(ii) Identify the type of potential oil and gas trap shown on your completed map.

Explain your answer.

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..... [3]

(iii) Label a **D** on the map where you would drill an exploration borehole to find oil and gas.

[1]

- (b) Explain how microfossils recovered from boreholes are used in oil and gas exploration.

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..... [3]

- (c) Fracking can be used to extract natural gas from rocks in onshore oil and gas basins.

Describe how fracking is carried out.

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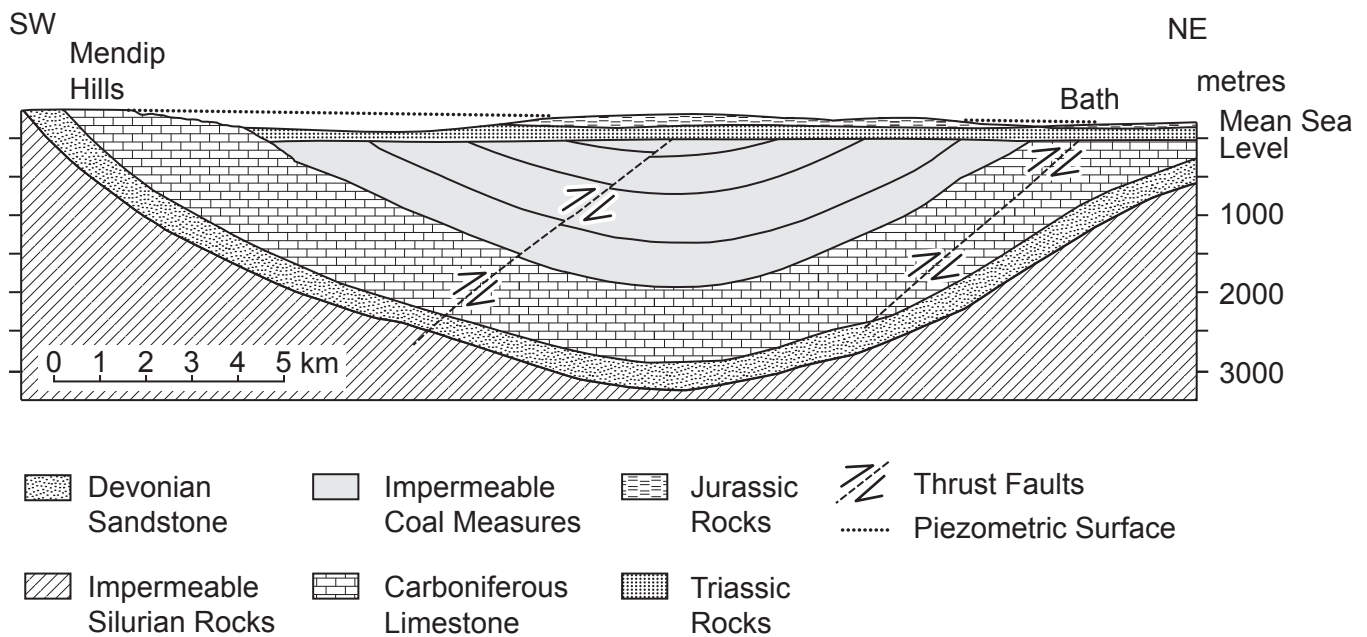
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..... [3]

- 31 The cross-section shows the simplified subsurface geology of the Bristol-Bath basin in SW England.

Hot springs at average temperatures of 45°C emerge from the basin at Bath.



- (a) Geothermometry studies indicate that the water emerging from the hot springs has been heated to a maximum temperature of 86°C .

The average geothermal gradient in the area is $25^{\circ}\text{C km}^{-1}$ and the surface temperature is 15°C .

Calculate the depth at which groundwater with a temperature of 86°C would be found.

= metres [2]

- (b) State the likely source of the groundwater and explain how it entered the Bristol-Bath basin.

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..... [2]

(c)* Describe and explain how the rock types and geological structures in the Bristol-Bath basin have resulted in the formation of springs at Bath.

..... [6]

Extra answer space if required.

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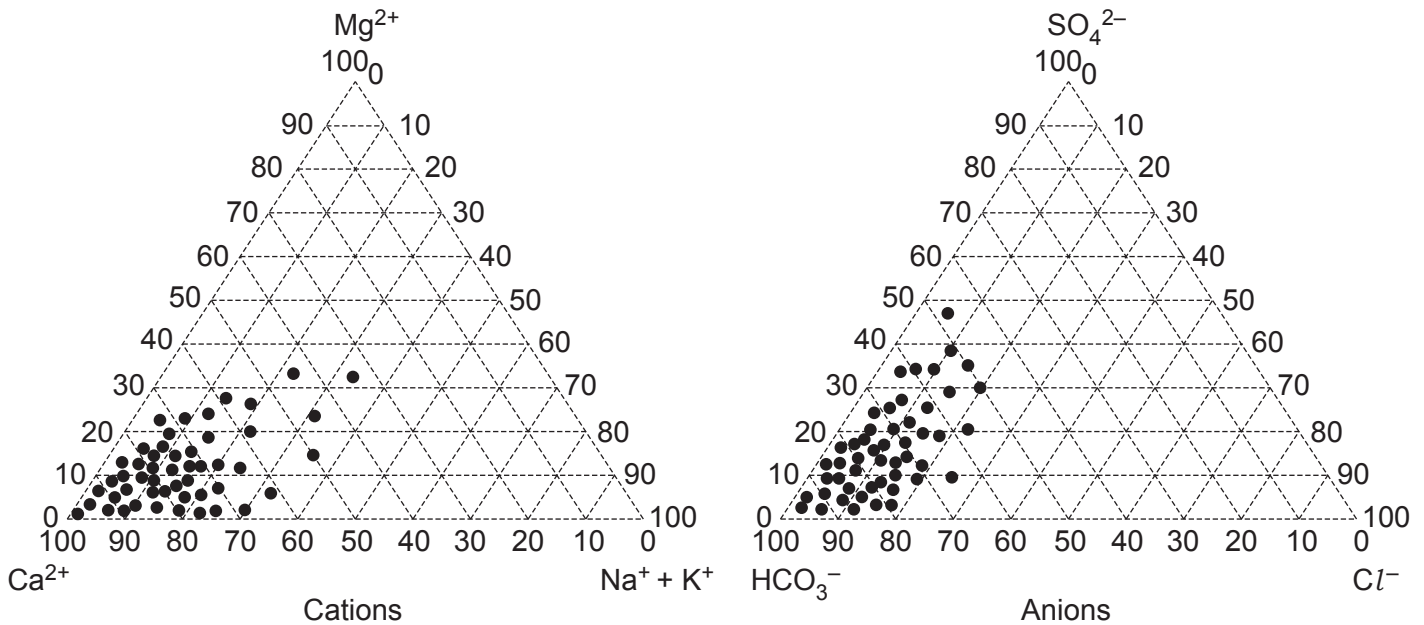
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- (d) The ternary plots show the relative concentrations of selected cations and anions in groundwater samples taken from the Bristol-Bath basin.



- (i) Explain how these chemicals get into groundwater.

.....
 [1]

- (ii) State the term that is used to describe how long these chemicals remain in groundwater.

..... [1]

- (iii) Analyse and describe what the ternary plots show about the cation and anion content of the groundwater in the Bristol-Bath basin.

.....

 [2]

- (iv) Describe and explain the most likely water quality issues that will arise if this groundwater is used for water supply.

.....

 [2]

END OF QUESTION PAPER

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