OCR
Oxford Cambridge and RSA

Monday 9 June 2025 – Afternoon

A Level Geology

H414/02 Scientific literacy in geology

Time allowed: 2 hours 15 minutes

You can use:
- 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 | | | | | | Candidate number | | | | |

First name(s) ____________________

Last name ____________________

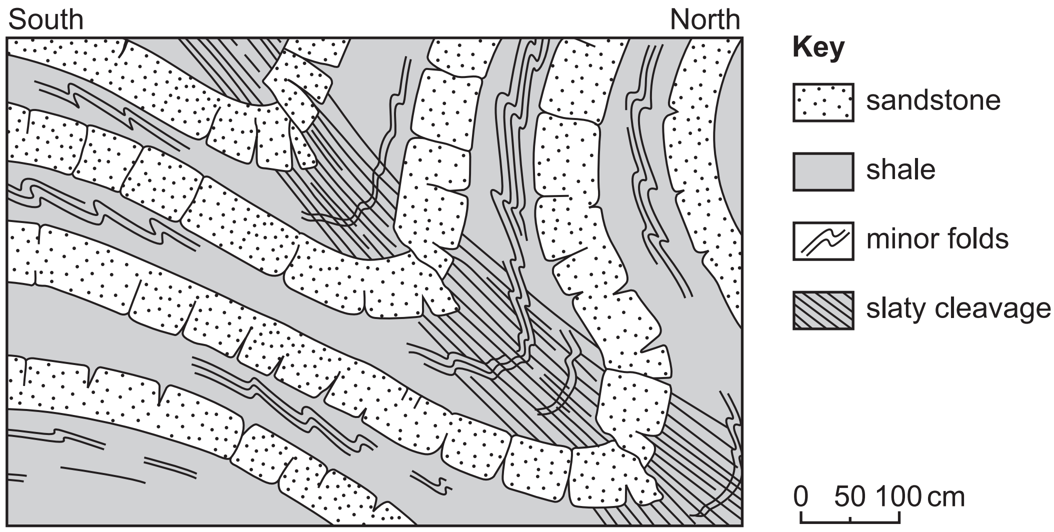
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where 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 **100**.
- 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 **24** pages.

ADVICE
- Read each question carefully before you start your answer.

1

(a) The diagram shows some folded sedimentary rocks in a cliff face.



(i) Label the diagram to show:

- hinge line
- joints
- limb

[3]

(ii) Name the type of force that formed this fold.

.... **[1]**

(iii) Draw arrows on the diagram of the cliff face to indicate the maximum stress directions. **[1]**

(iv) Describe the distribution of the slaty cleavage shown in the diagram **and** explain how this structure formed.

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.... **[2]**

(v) Explain why the minor folds are only found in the shale.

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(b) Draw lines to connect each **term** to the correct **description** of structures that are found in deformed rocks.

Term	**Description**
Boudinage	Ductile flow when subjected to stress and strain
Buckling	Striations resulting from friction
Plunge	Cylinder or lens-like structures forming layers
Slickensides	A fold that has an axis tilted from the horizontal

[4]

(c) Stress and strain result in folding and faulting of rocks.

(i) Define the term **strain**.

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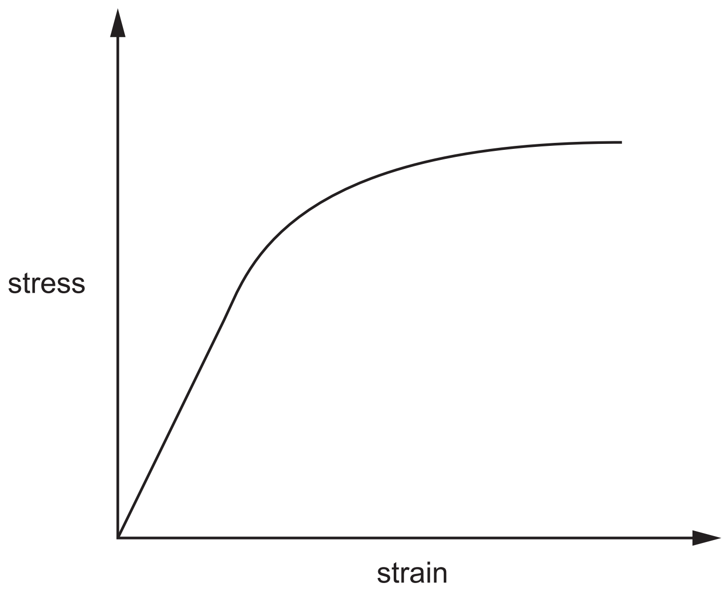
.... **[1]**

(ii) The graph shows the behaviour of a metamorphic rock that has been subjected to stress and strain.



Label the graph to show:

- elastic deformation
- elastic limit
- rupture or faulting **[3]**

(iii) This metamorphic rock was deformed at 350 °C.

Sketch a line on the graph to indicate the behaviour of the rock if it had been deformed at 600 °C. **[1]**

(iv) Describe how confining pressure can affect the deformation of rocks.

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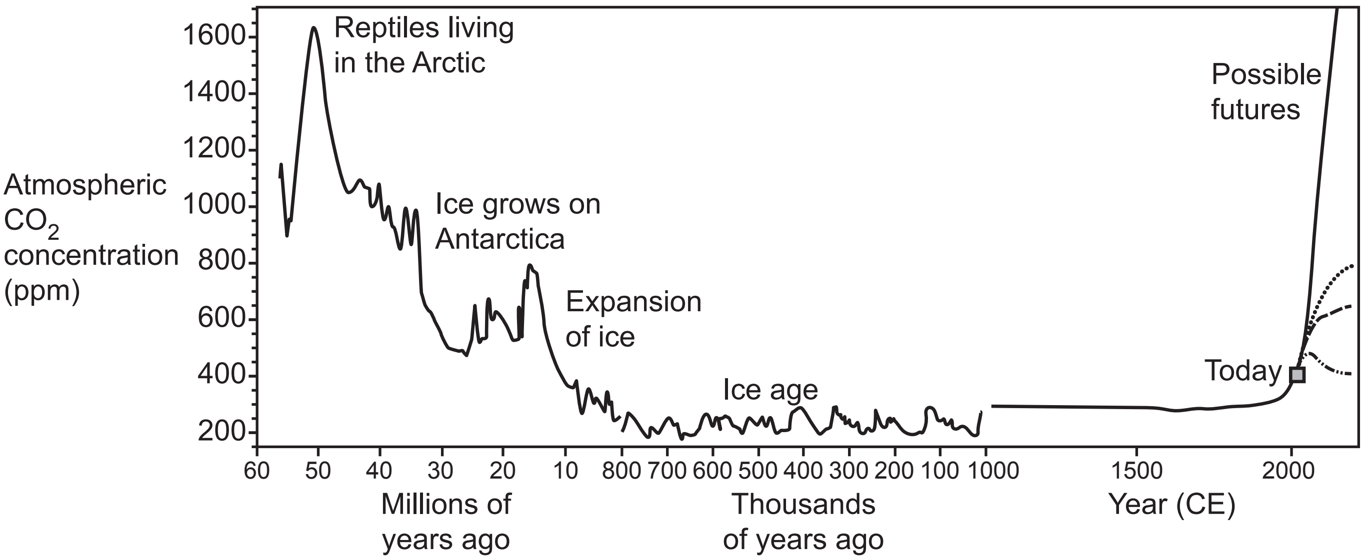
2

(a) Scientists have used microfossils to reconstruct the atmospheric composition of the last 60 million years. Deep sea sediment cores were taken from different parts of the ocean floor. The microfossils were extracted and chemically analysed using several methods, including isotope analysis.

The results are shown in the graph.



(i) Describe and explain the changes in atmospheric CO_2 concentration on the part of the graph labelled 800 to 100 thousand years ago.

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.... **[2]**

(ii) Explain why the chemical composition of the microfossils could be used to determine the atmospheric CO_2 concentration.

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.... **[1]**

(iii) Name a microfossil group that the scientists may have used in their study to determine the atmospheric CO_2 concentration.

.... **[1]**

Turn over

(iv) Explain why it is **not** usual to go back further than 60 million years by analysing deep sea sediment cores.

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.... **[2]**

(b)* Several scientific models have been developed that can predict the likely changes in atmospheric CO_2 concentration in the future.

Some schemes for carbon capture may be successful in offsetting the carbon emissions of industry. These schemes include burying CO_2 in a suitable underground location.

The current concentration of CO_2 in our atmosphere is around 422.8 ppm.

Describe and explain the potential impact of an increase in atmospheric CO_2 concentration on planet Earth if the increases cannot be offset.

Include the following ideas in your answer:

- impact on the environment
- the scale of the potential changes
- comparison with changes from geological history

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.... **[6]**

Extra answer space if required.

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(c)
(i) Describe how Pangaea formed.

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.... **[2]**

(ii) Explain how Pangaea influenced global climate after its formation.

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.... **[2]**

3

(a) A student investigated **three** hematite ore samples (**A**, **B** and **C**) to determine which sample was purest with the highest hematite content.

The formula for hematite is Fe_2O_3.

The student used **two** experiments to investigate the hematite samples:

- Loss on Ignition (LOI)
- Determination of Acid Insoluble Material

Experiment 1 – Loss on Ignition (LOI)

1. Using a pestle and mortar grind sample **A** until it resembles flour.
2. Place a crucible onto a **three** decimal place digital balance and tare the balance so that it reads zero.
3. Carefully measure 5 g of the ground sample **A** into the crucible.
4. Using tongs, heat the crucible in the hottest part of a Bunsen burner flame for five minutes, then put aside on a heatproof mat to cool.
5. Once cool, record the mass of the crucible contents.
6. Record the loss of mass in the table.
7. Repeat this procedure twice more, to gain three values for sample **A**.
8. Repeat steps 1–7 for samples **B** and **C**.

The results are shown in the table.

Sample	**Loss of mass (g)**			**Mean loss of mass (g)**	**Mean percentage change in mass (%)**
	1	**2**	**3**		
A	0.100	0.104	0.146	0.117	
B	0.086	0.090	0.088	0.088	–1.76
C	0.107	0.103	0.108		–2.12

(i) Calculate the mean loss of mass for sample **C**.

Mean loss of mass = ... g **[1]**

(ii) Calculate the mean percentage change in mass for sample **A**.

Mean percentage change in mass = ... % **[2]**

(iii) Suggest **one** improvement that could be made to the design of this experiment.

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.... **[1]**

(b) Experiment 2 – Determination of Acid Insoluble Material

1. Carefully measure 10 g of the ground sample **A** into a beaker.
2. Add 10 cm^3 of 1M nitric acid to the sample and allow the reaction to occur to completion (the reaction has stopped).
3. Transfer the solution into an evaporating dish and place on a tripod over a Bunsen burner in a fume cupboard.
4. Gently heat the solution until all of the liquid has evaporated.
5. Scrape the contents into a weighing boat and place on a **two** decimal place digital balance and record the results.
6. Repeat steps 1–5 for samples **B** and **C**.

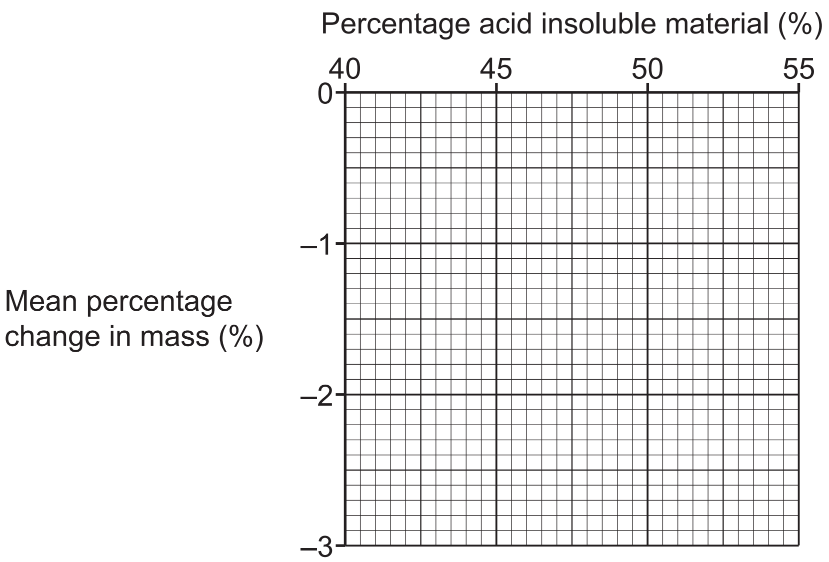
The symbol equation for the initial reaction is:

$Fe_2O_3 + 6HNO_3 \rightarrow 2Fe(NO_3)_3 + 3H_2O$

The results gained were used to calculate the percentage residue of acid insoluble material. The results are given in the table.

Sample	Percentage Acid Insoluble Material (%)
A	44.92
B	53.77
C	47.55

(i) Plot a chart to show the **percentage acid insoluble material (%)** against the **mean percentage change in mass (%)** for samples **A**, **B** and **C**. Draw a line of best fit through the data points.



[2]

(ii) Which type of relationship is shown on the graph you have plotted? Tick (✓) **one** box.

linear ☐ logarithmic ☐ non-linear ☐

[1]

(iii) Name a statistical test that could be used to determine if there is a relationship between the percentage acid insoluble material and the percentage change in mass. Explain your answer.

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.... **[2]**

(c) Evaluate the **two** experiments to assess which of the samples **A**, **B** or **C** is the purest. Give reasons for your answer.

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.... **[4]**

(d) Deposits of metal ore minerals often occur in low concentrations within waste minerals of no economic value.

(i) State the name given to non-economic waste minerals.

.... **[1]**

(ii) Describe **one** method of geochemical exploration that can be used to locate a metal ore deposit.

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.... **[2]**

(iii) Deposits of banded iron-formations (BIFs) are an example of a metal ore deposit formed by sedimentary processes.

Describe and explain how these metal deposits were formed.

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.... **[2]**

(e) Geohazards pose a risk to the mining industry, especially when mines are sited in areas known for earthquakes.

(i) Explain what the term **return period** means when applied to earthquakes.

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.... **[1]**

(ii) Describe **one** method and **one** limitation of predicting a tectonic geohazard.

Method ....

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Limitation ....

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[2]

(iii) Explain how geographical information systems (GIS) can be used to improve disaster planning.

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.... **[1]**

4

(a)

(i) Describe how magnitude can be determined from a seismogram. You may use a labelled diagram in your answer.

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.... **[1]**

(ii) Explain how seismograms can be used to identify shadow zones.

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.... **[2]**

(b)

(i) Describe the **three** mechanisms that drive the movement of tectonic plates.

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[3]

(ii) State which mechanism is considered by scientists to be the most important.

.... **[1]**

(c) Explain how the pattern of magnetic anomalies at mid-ocean ridges form.

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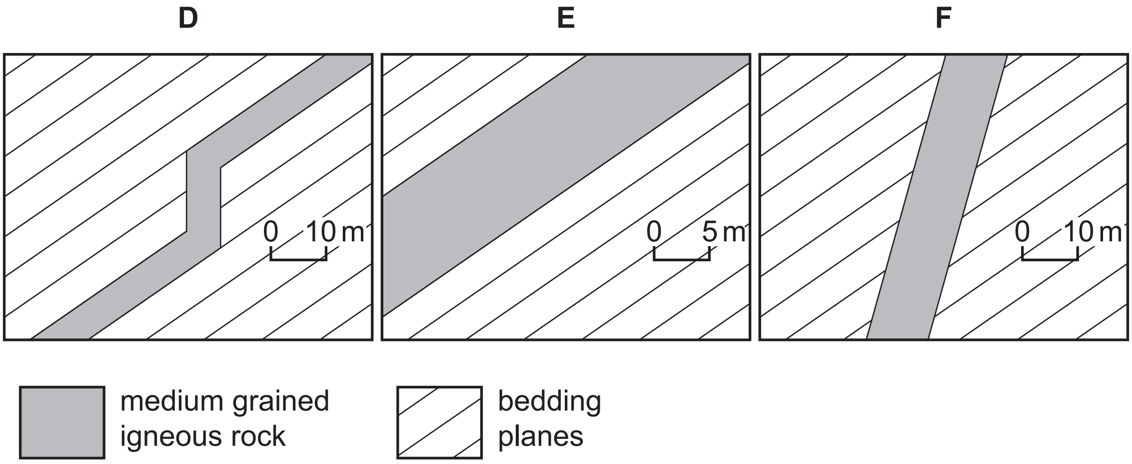
(d) The diagrams show a variety of igneous intrusions that can be associated with plate boundaries.



(i) Use information from the diagrams to identify the type of igneous intrusion.

D ....

E ....

F ....

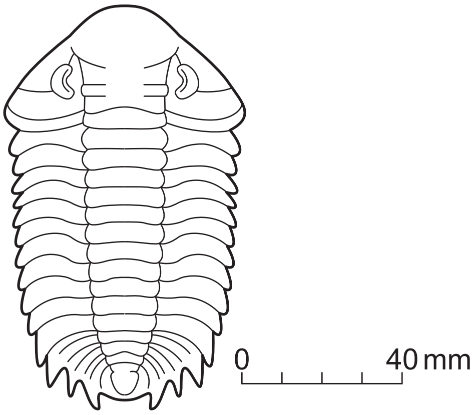
[3]

(ii) Shade the areas on diagram **F** where baked margins will occur. **[1]**

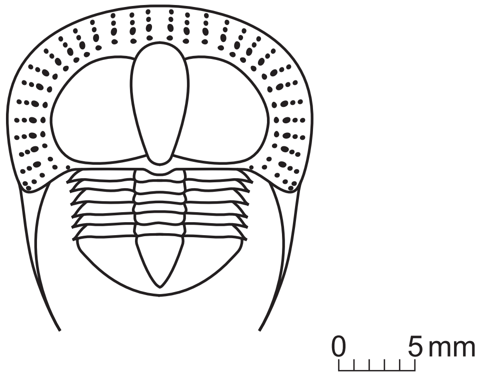
5

(a) Fossils **G** and **H** are both arthropods.

Fossil G



Fossil H



(i) To what group of Arthropoda do both fossils **G** and **H** belong?

.... **[1]**

(ii) Fossils **G** and **H** had different modes of life.

Describe **two** morphological differences between fossils **G** and **H**. Explain how these morphological differences can be used to infer different modes of life.

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.... **[2]**

(iii) Measure the maximum width of fossil **H** and calculate the magnification.

Width ....

Magnification ....

[2]

(iv) The group to which fossils **G** and **H** belong became extinct at the Permo-Triassic boundary.

Suggest **one** piece of evidence for the cause of the Permo-Triassic mass extinction event.

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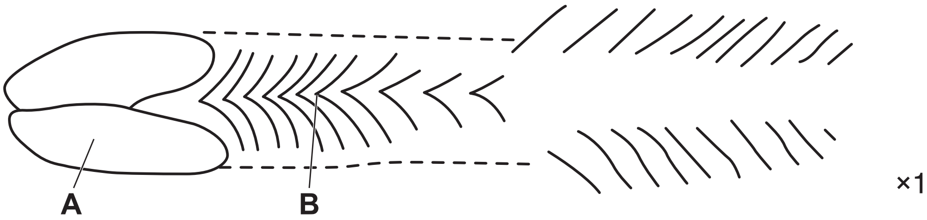
(v) The trace fossil shown was made by the activities of a different arthropod.



Describe the palaeoenvironmental conditions that enabled this trace fossil to have been formed and preserved.

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(b) Lagerstätten deposits are found in basins where specific conditions during deposition provided exceptional preservation of organisms.

The Jurassic Solnhofen Limestone in Germany and the Cambrian Burgess Shale in Canada are examples of Lagerstätten deposits that were produced in different geological settings with different specific sedimentary conditions.

(i) Compare the differences between the geological settings and sedimentary conditions of these **two** Lagerstätten deposits.

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.... **[2]**

(ii) Compare the methods of fossil preservation in these **two** Lagerstätten deposits.

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(iii) Suggest how fossils from the Burgess Shale Lagerstätten deposit provide evidence for the Cambrian explosion.

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(c)
(i) Explain how ideas about uniformitarianism can be applied to the study of facies.

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.... **[1]**

(ii) The Welsh Basin contains turbidites and dark shales, thin impure limestones, reef limestones and red sandstones that were deposited throughout the Lower Palaeozoic periods.

Using ideas about facies associations, explain how a whole basin analysis approach (sedimentology and palaeontology) can be used to infer changing palaeoenvironments in the Welsh Basin.

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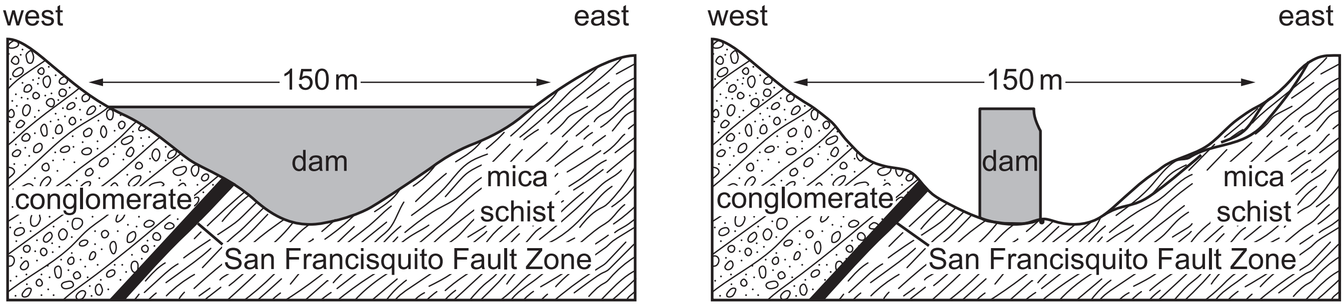
Turn over for the next question

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

Geological factors play a critical role in the planning and construction of dams and tunnels. In the case of the St. Francis Dam, Santa Clarita, California, a series of human errors and poor engineering judgement led to its failure in March 1928.

The diagrams show the 56 m tall concrete gravity arch dam before and after failure.



During evaluation of the suitability of the site, exploratory tunnels were cut into the rock to test water percolation and samples were taken to test rheological strength. The conglomerate unit was not homogenous, consisting of red sandstones grading into conglomerate with veins of gypsum throughout. The mica schist appeared homogenous but was thinly laminated with weak clay, weathered and cross-faulted in many areas. When dry, the conglomerate performed poorly under compressional stress, relative to the mica schist, and when wet it became soft. The initial survey concluded that the conglomerate was suitable for dam construction but that the mica schist was not. Engineers later contested these findings and asserted that the mica schist was hard and of the same nature throughout. Evidence of previous land slips in the mica schist was not acted upon. The San Francisquito Fault was considered inactive and engineers were not concerned about water ingress through the 2 m wide fault zone as it was sealed with fault gouge. Construction of the dam began in 1924.

During construction, to provide 25% additional reservoir storage, the dam's original planned height was increased by 3 m on two separate occasions, with no change to its basal thickness. No cut-off curtains, grout curtains or contraction joints, which allow concrete to crack in a controlled manner as it cools, were incorporated into the dam's design.

By April 1927, the water level in the reservoir was within 1 m of the spillway near the top of the dam and seepage was minimal. In February 1928 a fracture was observed at the base of the dam discharging around 17 litres of water per second. This was dismissed as a contraction crack and left to drain. Over the course of one month the discharge rate doubled and further leaks appeared along the base of the dam with the runoff having a muddy colour. Engineers concluded that these new leaks were of no concern and the dam was safe. Five days later the dam collapsed.

Post failure, it became clear that the dam had been designed to prevent small foundation stresses only and not to accommodate full support of the dam.

(a)
(i)* Using information from the text and your own knowledge of engineering geology:

- Describe and explain the hydrogeological impacts of the dam construction on the strength and stability of the rocks that underlie the St. Francis Dam.
- Explain the likely reasons for the catastrophic failure of the St. Francis Dam.

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Extra answer space if required.

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(ii) Explain why there was an increase in seismic activity as the reservoir filled with water.

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(b) A replacement reservoir and dam were constructed in the nearby Bouquet Canyon. This required the cutting of aqueduct tunnels through the same rock units to carry water to the nearby city of Los Angeles.

Describe **one** geological impact of tunnelling and explain how this can be mitigated.

Impact ....

Mitigation ....

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[2]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.