OCR
Oxford Cambridge and RSA

Tuesday 12 October 2021 – Morning

A Level Geology

H414/02 Scientific literacy in geology

Time allowed: 2 hours 15 minutes

You can use:
- an HB pencil
- a pair of compasses
- 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. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- 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 **32** pages.

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

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Answer **all** the questions.

1 **(a)** **(i)** Explain the term erosion.

....

.... **[1]**

(ii) Describe how the process of erosion can result in the formation of mature sediments.

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.... **[2]**

(b) Sediments and organic materials are transformed into rock during diagenesis. Part of this process involves cementation of the grains.

(i) Describe and explain how sandstones may be cemented by other minerals such as hematite or clay.

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.... **[2]**

(ii) Other than hematite, state the name of another cement.

.... **[1]**

(iii) Peat is largely composed of the elements carbon, hydrogen, oxygen, nitrogen and sulfur.

Describe the chemical changes that occur during diagenesis which allow coal to form from peat.

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.... **[2]**

(c) Stylolites are structures that look like serrated surfaces. They are formed by pressure dissolution in sedimentary rocks.

Stylolites are found commonly in limestone or chalk, but are found less commonly in some other rocks, such as mudstone. The serrated surfaces can only be seen at right angles to the bedding, usually in cliff sections.

Fig. 1.1 shows stylolites found in two different types of rock which formed early during diagenesis. It also shows some detail of fluid movement in the limestone.

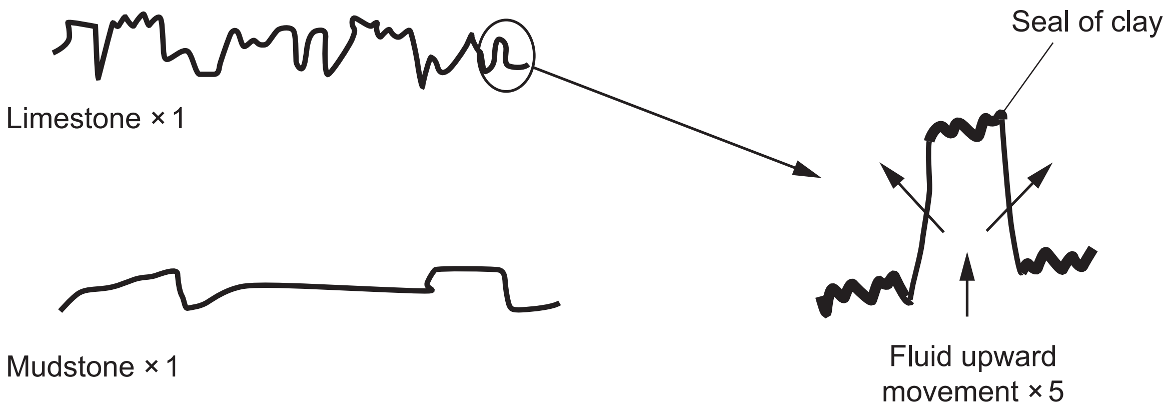

Fig. 1.1

(i) Explain how stylolites form in limestone.

Use the information provided and your knowledge of pressure solution in your answer.

....

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.... **[2]**

(ii) Explain the effect of the formation of stylolites on the porosity and permeability of limestone.

....

.... **[1]**

(iii) Explain the source of the **clay** labelled in **Fig. 1.1**.

....

.... **[1]**

(iv) Give **one** geological reason why stylolitic limestone is used for flooring.

....

.... **[1]**

(d) (i) Identify the sedimentary structures shown in **Fig. 1.2**.

Fig. 1.2

A ....

B ....

C ....

[3]

(ii) Which of the structures, **A**, **B** or **C**, can be used to determine the 'way-up' of a bed?

Tick (✓) **two** boxes.

A ☐

B ☐

C ☐

[1]

(e) Describe how the composition and characteristics of sediments change from the littoral zone (beach), to below the wave base, in a shallow siliciclastic sea.

You may use an annotated diagram to illustrate your answer.

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.... **[3]**

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2 **(a)** A student investigates how modern shells are transported by a current of water. This is the method they follow:

- Put a shallow tray at an incline of 15°, with the lower part of the tray overhanging a sink.
- Place six mussel shells in the centre of the tray, in the pattern shown in **Fig. 2.1**. The mussels should be laid concave-side down and with the umbones pointing to the centre.
- Connect rubber tubing to a tap and place the end at the top of the tray in the middle.
- Turn the tap on and allow water to overflow into the sink.
- Turn the tap off when one of the shells reaches the bottom of the tray.
- Use a compass clinometer to record the orientations of the six mussel shells, at the long axis.
- Repeat this method.

The student's results were recorded in **Table 2.1**.

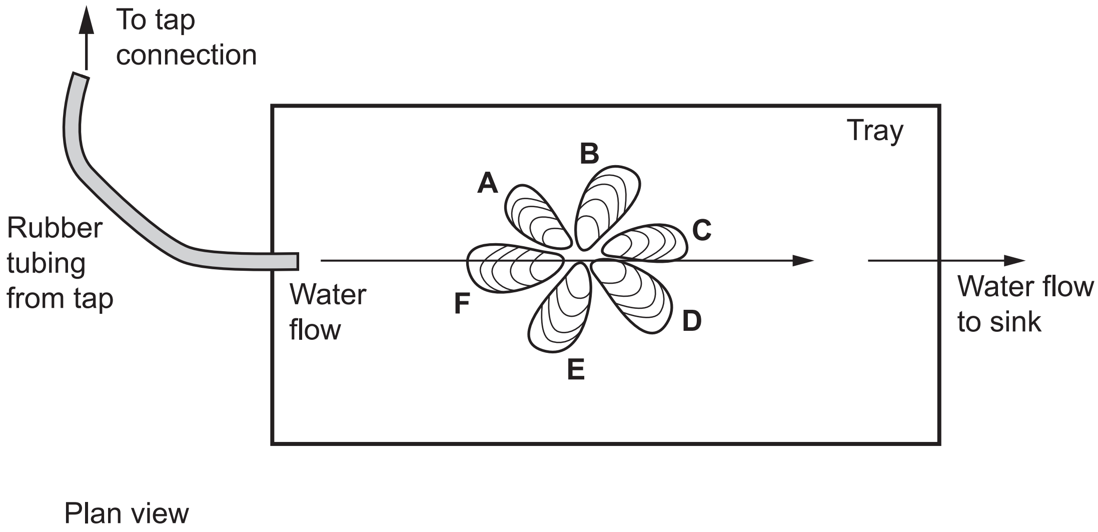

Fig. 2.1

Shell	Orientation of shell in degrees (°)			
	First experiment		Second experiment	
	Raw data	Data after correction	Raw data	Data after correction
A	259	**079**	260	....
B	095	**095**	222	....
C	016	**016**	012	....
D	249	**069**	328	....
E	268	**088**	055	....
F	070	**070**	355	....
Average		....		....

Table 2.1

(i) Correct the data for the second experiment in **Table 2.1** so that all values lie between 0 and 180°. Record these values in **Table 2.1**. **[2]**

(ii) Calculate the average values for both experiments. Record these values in **Table 2.1**. **[1]**

(iii) Give **two** reasons to explain the differences between the two averages in **Table 2.1**.

1 ....

....

2 ....

....
[2]

(iv) Suggest **one** improvement that could be made to the method.

....

.... **[1]**

(v) Evaluate if this experiment could be used as a model to explain the distribution of shells in some sedimentary rocks.

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.... **[3]**

(b) The student wanted to see if they could conduct a different experiment to look at the effect of attrition on the preservation of shells.

Suggest a method they could follow in a school laboratory to investigate the effect of attrition on the preservation of modern shells.

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.... **[4]**

3 **(a)** Information from seismograms can be used by seismologists to locate the epicentre of an earthquake.

Fig. 3.1 shows simplified seismograms from three seismometers from the same earthquake.

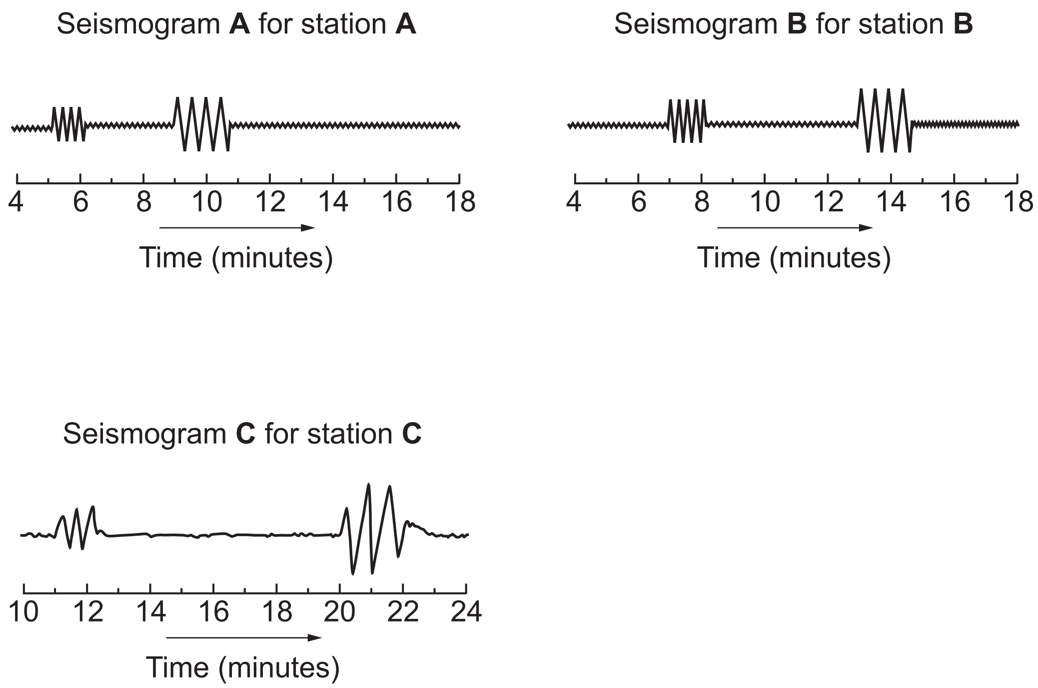

Fig. 3.1

(i) Using the seismograms in **Fig. 3.1**, measure the difference in the first P and S wave arrival times for seismograms **B** and **C**.

Seismogram **A** has been completed for you.

	P and S wave arrival time difference (min)
Seismogram **A**	4
Seismogram **B**	
Seismogram **C**	

[2]

(ii) **Fig. 3.2** shows time–distance curves for P and S waves.

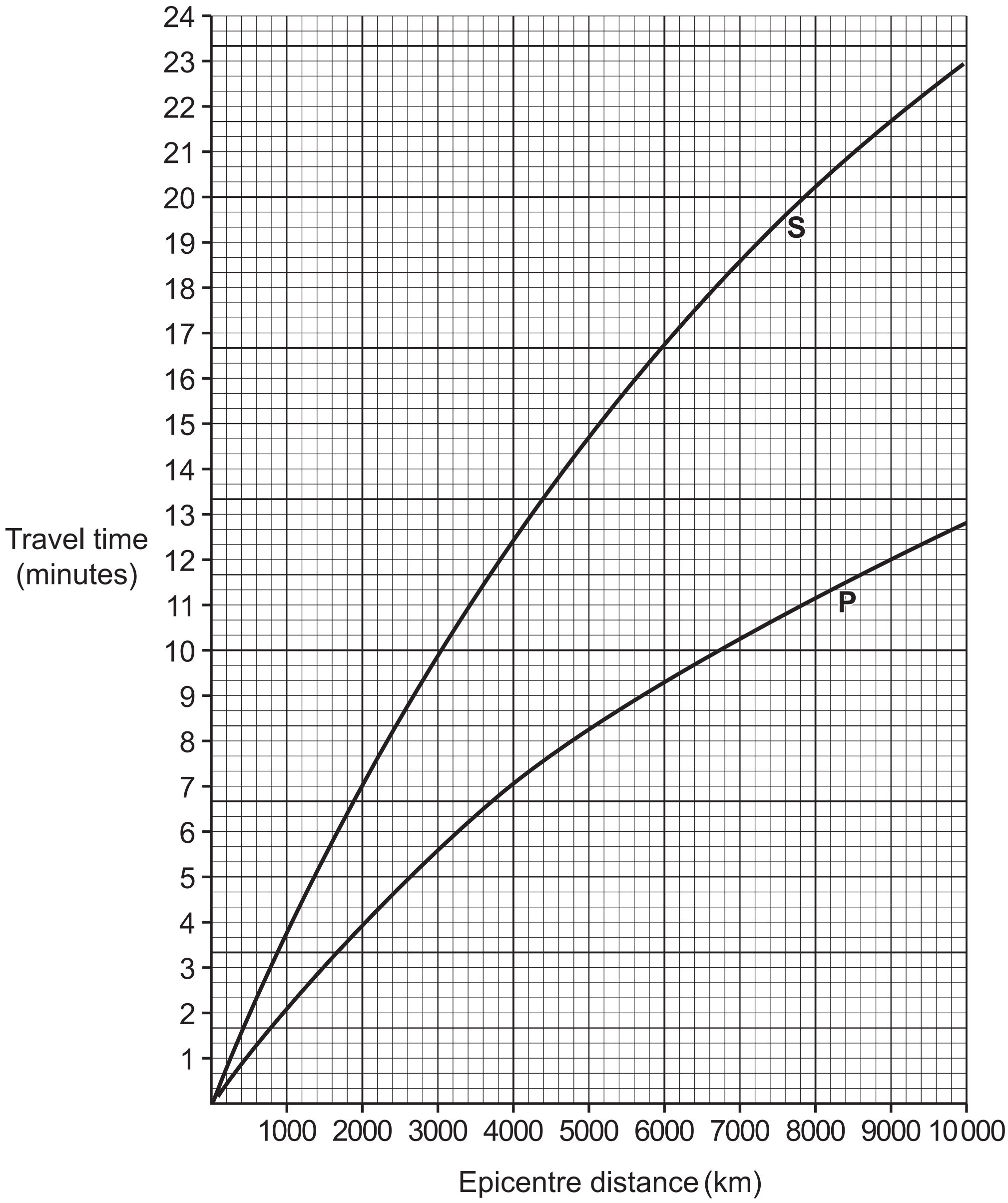

Fig. 3.2

Using your answers from **3(a)(i)** and the time–distance curves in **Fig. 3.2**, determine the distance from the epicentre for stations **B** and **C**.

Station **A** has been determined for you.

Station **A** distance ....2800.......... km

Station **B** distance .... km

Station **C** distance .... km

[2]

(iii) The geographical locations for seismometer stations **A**, **B** and **C** are shown on the map in **Fig. 3.3**.

Using the distance from epicentre data for all three stations, locate and label the epicentre of the earthquake on the map.

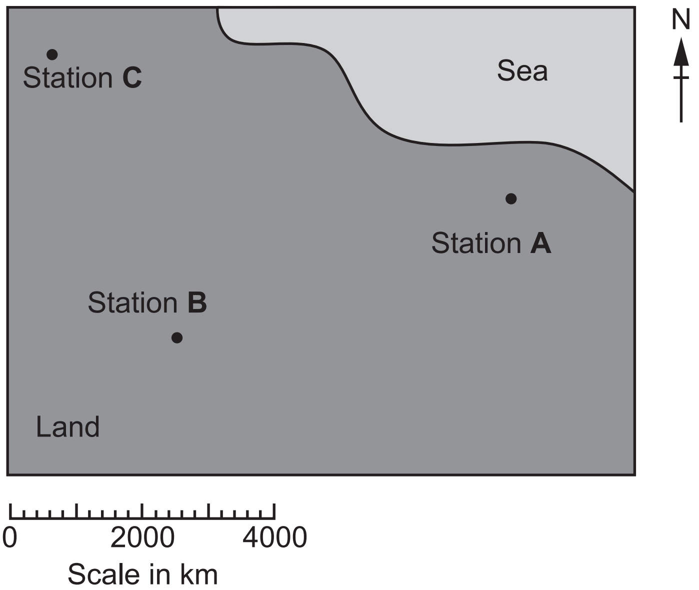

Fig. 3.3

[Answer on Fig. 3.3]

[3]

(b) Seismic tomography is a technique that allows the creation of 2D or 3D virtual images from an analysis of the behaviour of seismic waves as they pass through a section of the Earth.

Fig. 3.4 shows a cross-section through Fiji and Tonga with slower than average and faster than average P-wave velocities highlighted.

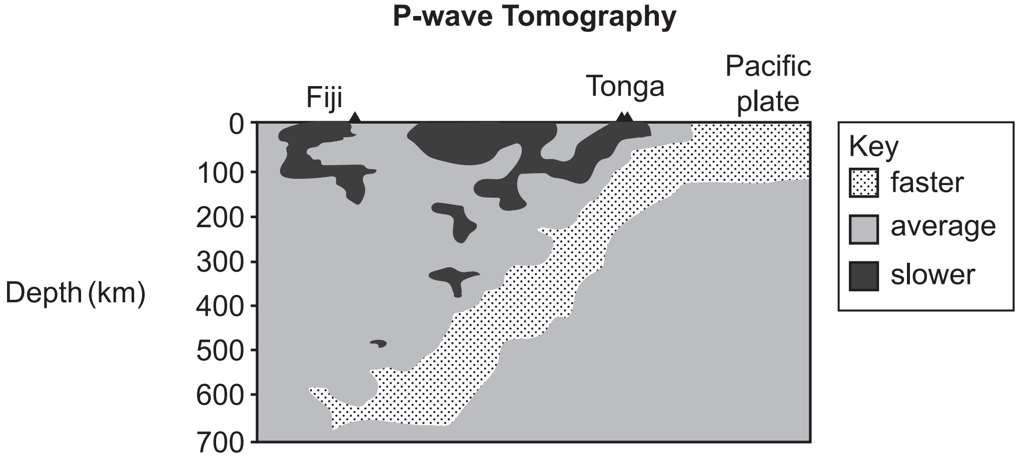

Fig. 3.4

(i) Identify the geological feature shown in **Fig. 3.4**.

....

.... **[1]**

(ii) Explain the reasons for the positive **and** negative P-wave velocity anomalies.

....

....

....

....

.... **[2]**

(iii) Describe how seismic tomography can be used to determine the position of the asthenosphere.

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.... **[1]**

(iv) Explain why there are only shallow focus earthquakes at mid-ocean ridges.

....

.... **[1]**

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4 Archbishop James Usher, a 17th Century biblical scholar, calculated the age of the Earth as 5650 years. Early geoscientists accepting this age, needed to explain how all of the geology that they could see could have formed in such a short space of time. This led to the development of the theory of catastrophism, in part supported by the work of the 18th Century French naturalist and zoologist Georges Cuvier.

James Hutton, an 18th Century Scottish geologist, considered the Earth to be much older than this and he proposed an alternate theory to that of catastrophism.

Fig. 4.1 shows a field sketch of the geology observed by James Hutton at Siccar Point on the East coast of Scotland.

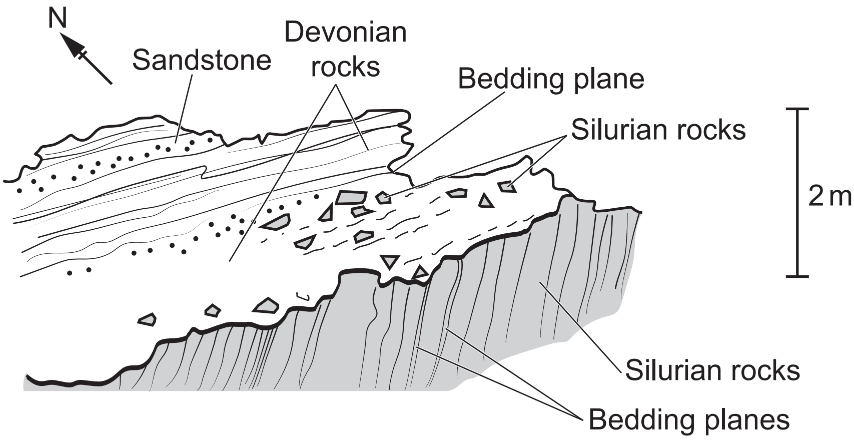

Fig. 4.1

(a) (i) Describe **one** piece of evidence that supports the theory of catastrophism.

....

.... **[1]**

(ii) Name the alternative theory **and** the physical process proposed by James Hutton.

Alternative theory ....

Physical process .... **[2]**

(iii) Explain what is meant by the statement 'The present is the key to the past'.

....

....

.... **[1]**

(iv) State **two** relative dating principles that can be seen in **Fig. 4.1**.

1 ....

2 ....
[2]

(v) Explain how one of the named methods in **4(a)(iv)** can be used to establish the sequence of geological events.

....

....

.... **[1]**

(vi) Explain how biostratigraphy could be used to correlate the sequence of rocks at Siccar Point with those elsewhere in Scotland.

....

.... **[1]**

(vii) What are included fragments **and** how might they affect the process of relative dating?

....

....

....

....

.... **[2]**

(viii) Explain how the work of William Smith supports the theory proposed by James Hutton.

....

....

.... **[1]**

(b) **(i)** Sedimentation rates have been used to calculate the age of the Earth.

Describe **two** limitations of using this method.

1 ....

....

2 ....

....
[2]

(ii) A core through Devonian rock shows that 141 metres of sediment was deposited over a period of 7.2 million years.

Calculate the average rate of sedimentation in mm per year.

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

Rate of sedimentation = ... mm per year **[2]**

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(c) The geological map shown in **Fig. 4.2** can be used to identify a series of sedimentary and structural events. Some have been listed and numbered (not in chronological sequence).

1. Deposition of coal
2. Uplift & Tilting 15º W
3. Deposition of siltstone
4. Strike Slip Fault
5. Deposition of sandstone
6. Uplift & Tilting 5º E
7. Deposition of conglomerate
8. Folding E-W

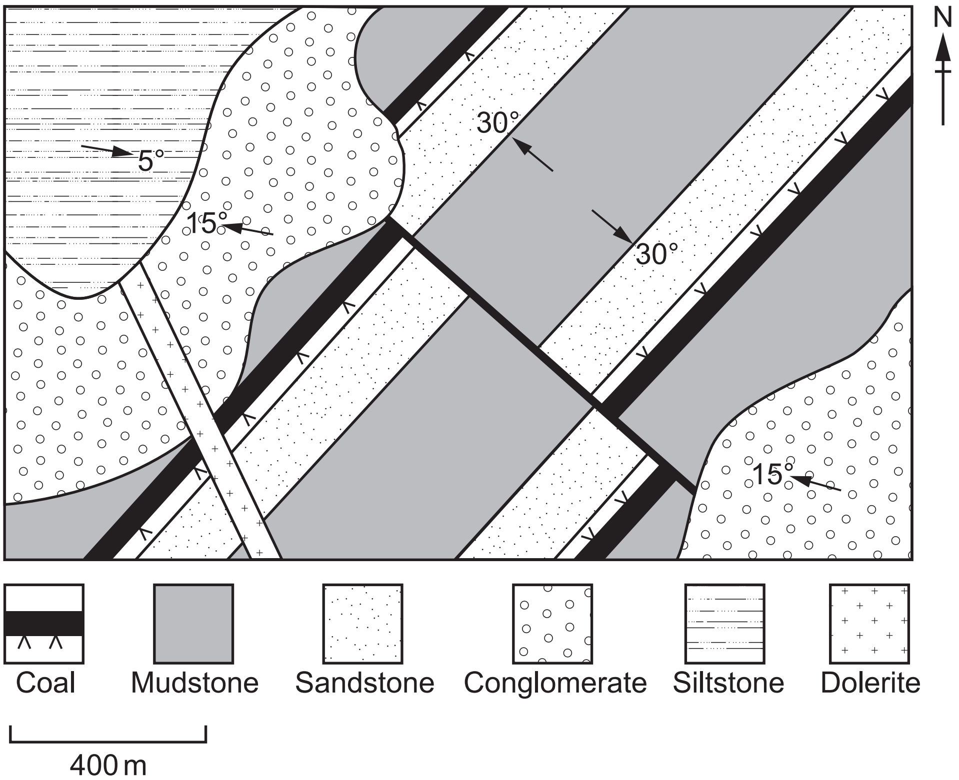

Fig. 4.2

(i) Complete the table of structural events from youngest to oldest by writing the correct number from the list of events shown in **Fig. 4.2**.

Structural Events	**Number**
Youngest	
Oldest	

[1]

(ii) Complete the table of sedimentary events from youngest to oldest by writing the correct number from the list of events shown in **Fig. 4.2**.

Sedimentary Events	**Number**
Youngest	
Oldest	

[1]

5 **(a)** Pressure due to the mass of overlying rocks interacts with pore pressure from fluids within any void spaces and can be significant when considering slope stability. **Fig. 5.1** shows a number of rock layers, their thicknesses and their unit weights, and the position of the water table.

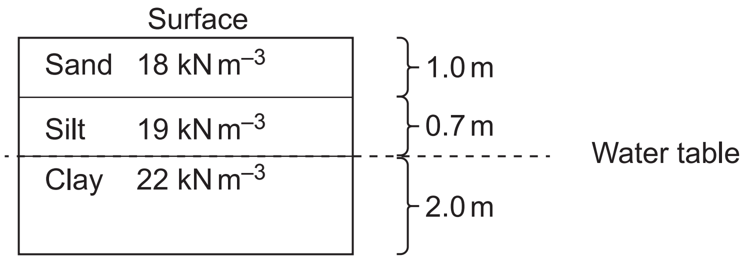

Fig. 5.1

Pore pressure $\mu = g_w h_w$

g_w = 9.81 kN m^{-3}

h_w = depth below water table

Total normal stress σ = sum of the unit weight of all of the layers

Effective stress $\sigma^1 = \sigma - \mu$

(i) Calculate the effective stress at the base of the clay layer shown in **Fig. 5.1**.

Effective stress = ... kN m^{-2} **[3]**

(ii) Addition of water is a common cause of slope failure.

Describe **one** method of slope stabilisation that could mitigate against water.

....

.... **[1]**

(b) In 1999 a landslide, composed of 45 000 km^3 of mud, rock and concrete, struck a city in the Philippines. Heavy rainfall due to tropical cyclone Olga intensified the normal monsoon rainfall and a total of 565 mm of rainwater fell in 3 days, the equivalent of 120 days' normal rainfall. Developers claimed that this unusually high rainfall was the only reason for the landslide. However, geologists examining the scene considered that other factors may have been in play. The landslide destroyed 379 houses in the area.

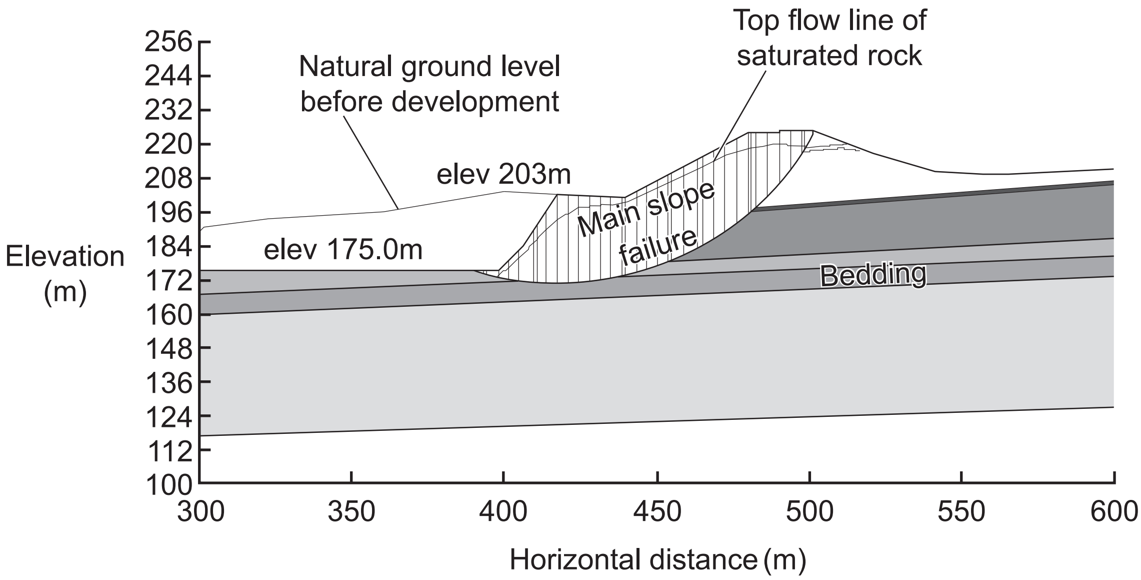

Fig. 5.2

The underlying geology of the affected area was comprised of heavily fractured interbedded siltstones, sandstones and clays with varying degrees of permeability and shear strength. X-ray phase analysis of clay samples taken from under the houses showed high levels of smectite, up to 58%, whilst in the wider area illite dominates the clay composition with smectite as low as 7%. Bedding planes in the mountains to the North and East of the area varied from horizontal to having an 8° South West dip. See **Fig. 5.2**.

Development of the area began in 1991. Excavation into the hill sides led to the construction of low-cost concrete housing units with shallow foundations on slopes of up to 25°. Due to the known flash-flood risk, trenches were dug between houses to divert run-off. However, these retained water which seeped into the foundations.

Prior to this, over-quarrying of the mountain ranges around the city and rainforest clearing in the vicinity of the area had been allowed to continue unchecked.

In 1994, 5 years before the landslide, hairline fissures began to open up in the walls and pavements around the area.

(i)* Evaluate the developers' claim that heavy rainfall alone could have been the cause of the landslide.

.... **[6]**

Additional answer space if required.

....

(ii) Describe and explain **one** chemical ground improvement strategy that could have been used to improve the area prior to the housing development.

....

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....

....

.... **[2]**

(iii) Geotechnical site investigations were not completed prior to the housing development and building commenced before planning was approved.

Describe **two** techniques that would have been included in a geotechnical site investigation.

1 ....

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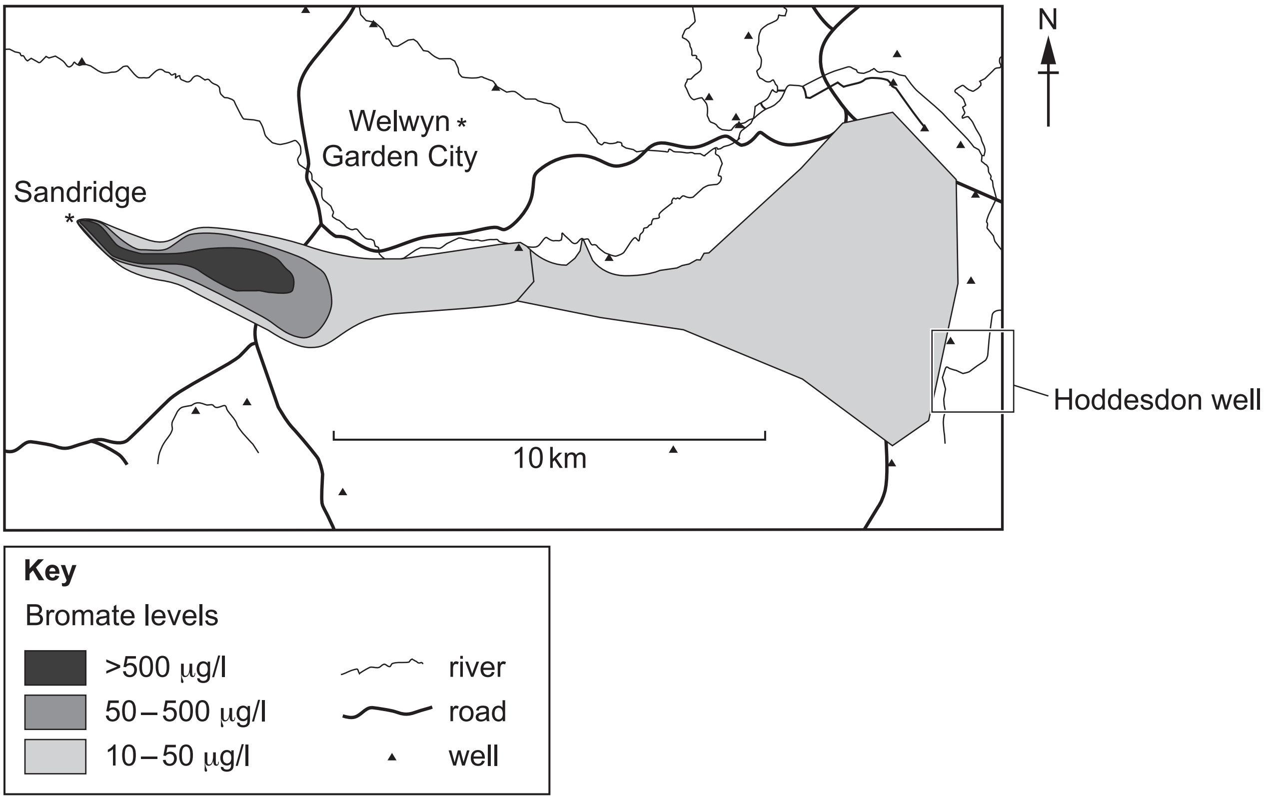
2 ....

....
[2]

6 A bromate pollution plume, in the Hertfordshire chalk, was discovered in the mid 2000s. The plume, shown in the map below, stretched 20 km to the East from Sandridge. The source of the contamination was a former chemical factory in the village of Sandridge. The brownfield site was redeveloped for housing but not all contaminated subsurface material was removed.



(a) Data from Hoddesdon well shows fluctuations in bromate levels. Safe levels for drinking water are 10 μg/l.

(i) Explain why the water authority consider that bromate levels in the groundwater will increase in drought years.

....

.... **[1]**

(ii) Diluting water from the Hoddesdon well with clean water from elsewhere will lower the overall concentration of bromate.

The Hoddesdon well produces 1200 m^3 of water per day.

Clean water is available from a well in Hertfordshire at 1820 m^3 per day. This well does not contain any bromate.

Calculate the highest acceptable concentration of bromate in the Hoddesdon well to achieve a diluted concentration of 10 μg/l once mixed.

Bromate concentration = ... μg/l **[2]**

(iii) Describe **two** steps that could be taken to reduce the bromate pollution.

1 ....

....

2 ....

.... **[2]**

(b) Engineering works were required on the chalk bedrock near Welwyn Garden City to mitigate localised subsidence.

Explain the likely cause of this subsidence.

....

....

.... **[1]**

7 Read the information below, then answer the questions that follow.

Who were the Archosaurs?

Archosauria ('ruling reptiles') are a group of animals known as diapsid amniotes, generally classed as reptiles. They belong to the phylum Chordata and many are also tetrapods due to the evolution of fin bones into limb bones.

Diapsids ('two arches') is a name given to the two temporal openings, or holes, in each side of their skulls which are close to the eyes. This evolutionary change is believed to have occurred in early representatives of the group, as far back as the Permian, well before the age of the true dinosaurs. This reduction in the skull bone content is thought to have allowed the skull to be lighter providing more space for muscles and tissues, and may have increased the flexibility of the skull when the animal was feeding. This reduction in skull bone content continued in later tetrapods and was coupled with fusion of multiple bones in the skull, presumably to increase skull strength.

All extant forms of the Archosaurs are amniotes and they lay fertilised eggs on land. It is believed that this was also the case for the extinct forms. These are distinguished from anamniotes, such as fish and amphibians, who lay eggs in water.

Archosaurs have both living and extinct representatives. Extant forms include birds and crocodilians. Extinct forms include pterosaurs and dinosaurs. The classification can be simplified into two major groups, as shown in **Fig. 7.1**.

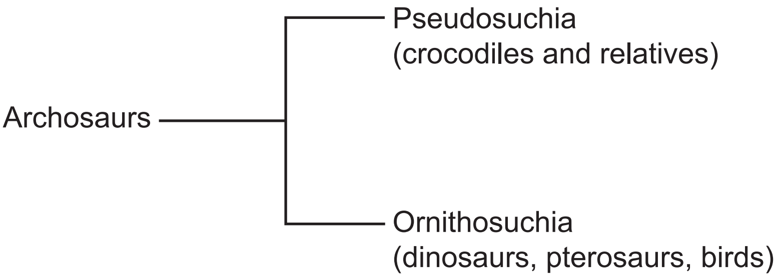


Fig. 7.1

These two groups of Archosaurs show differences in their arrangement of bones, especially in the ankle joint, as shown in **Fig. 7.2**. There were also other evolutionary skeletal changes in teeth, leg bones, and toes.

Key
T Tibia
F Fibula
A Astragalus
C Calcaneum

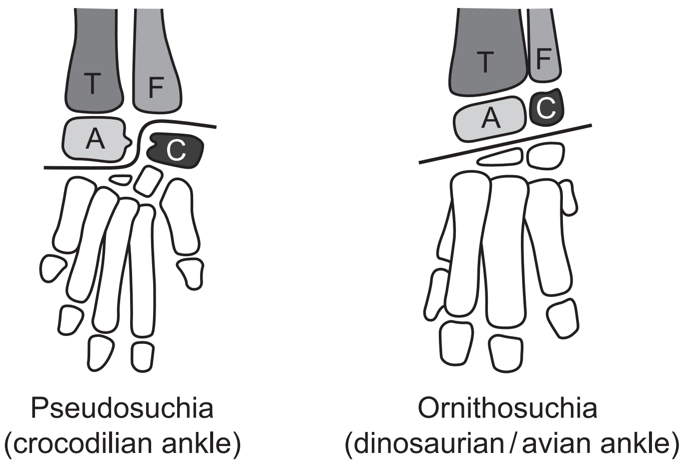


Fig. 7.2

Archosaurs in the fossil record are diverse and the living representatives of the Archosaurs (birds and crocodiles) are not typical. This group includes tiny animals of only a few centimetres, such as hummingbirds, to giant dinosaurs around the size of a bus. It includes animals that walked on two legs, and those who walked on four. Fliers and swimmers. Nectar feeders, herbivores and carnivores.

(a) **(i)** Using the information, describe the characteristics of a tetrapod.

....

.... **[1]**

(ii) Give **two** advantages of reptiles being diapsid amniotes.

1 ....

....

2 ....

....
[2]

(iii) Describe **one** morphological difference between the eggs laid by amniotes and those laid by anamniotes (amphibians).

....

.... **[1]**

(iv)* The evolution of locomotion in the Archosaurs followed different paths, resulting in morphological differences between Pseudosuchia (crocodilians) and Ornithosuchia (dinosaurs, pterosaurs and birds).

Use information from the article provided as well as your knowledge of reptile, dinosaur and bird evolution to evaluate the suitability of morphology to mode of life.

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.... **[6]**

Additional answer space if required.

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(b) Several features of dinosaurs are described in the table.

Complete the table to classify the features as belonging to Saurischian sauropods (SS), Saurischian therapods (ST), or Ornithischian (O) dinosaurs. Each feature may belong to one or more than one dinosaur group.

Description of dinosaur feature	Dinosaur classification (SS, ST and/or O)
Short and flattened peg shaped teeth	
Large olfactory lobes	
Hinged jaw containing teeth suitable for grinding	
Primitive hips with pubis bone which points forward	

[4]

(c) Several groups of reptiles evolved flight in the Mesozoic, including the pterosaurs, which were not dinosaurs. A fossil of one of these pterosaurs, *Wukongopterus*, was found in China in 2009. It has been dated to the late Jurassic. It has been described as a carnivore and was around the size of a pigeon. The skeleton was incomplete.

The skeletal outline of a *Wukongopterus* is shown in **Fig. 7.3**.

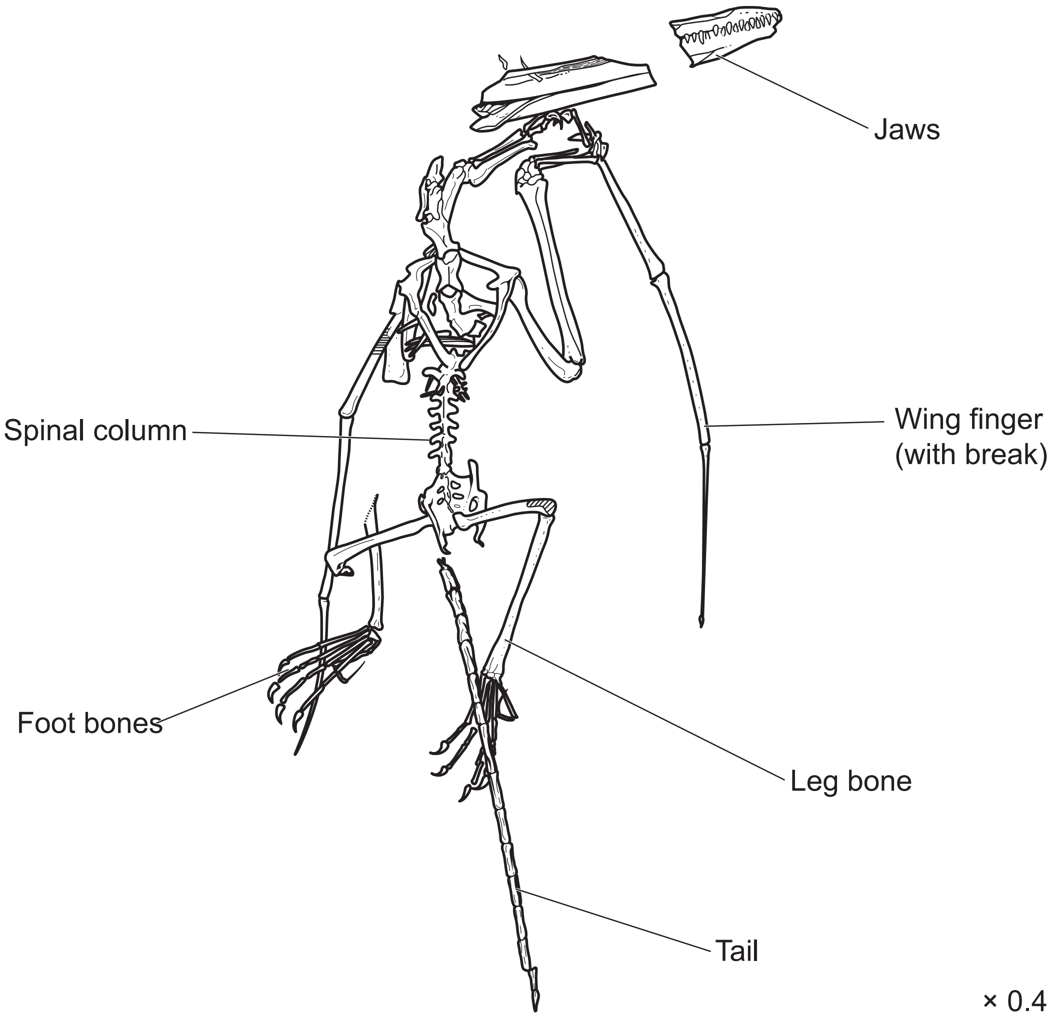

Fig. 7.3

Describe how pterosaurs and bird evolution could be described as convergent. Use the information provided about *Wukongopterus* and your knowledge of the evolution of birds in your answer.

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.... **[4]**

END OF QUESTION PAPER