Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A480U30-1

S24-A480U30-1-R1

MONDAY, 17 JUNE 2024 – AFTERNOON

GEOLOGY – A level component 3
Geological Applications

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**15**	
	2.	**15**	
Section B	**3.**	**8**	
	4.	**12**	
	5.	**10**	
	6.	**5**	
	7.	**10**	
Section C option		**14** **12**	
		10 **12**	
		6	
	Total	**105**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a calculator
- a ruler
- a protractor
- the Geological Map Extract

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions in sections **A** and **B**.

Answer all questions in **one** option only in section **C**.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 3 sections, **A**, **B** and **C**.

Section A: 30 marks. Answer **both** questions. You are advised to spend about 35 minutes on this section.
Section B: 45 marks. Answer **all** questions. You are advised to spend about 50 minutes on this section.
Section C: 30 marks. Answer all the questions in **one** option only. You are advised to spend about 35 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in questions **10**, **13** and **16**.

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SECTION A

Answer **all** questions in the spaces provided.

1. **Figure 1a** is a simplified plate tectonic map of the Caribbean region showing the location of Haiti.

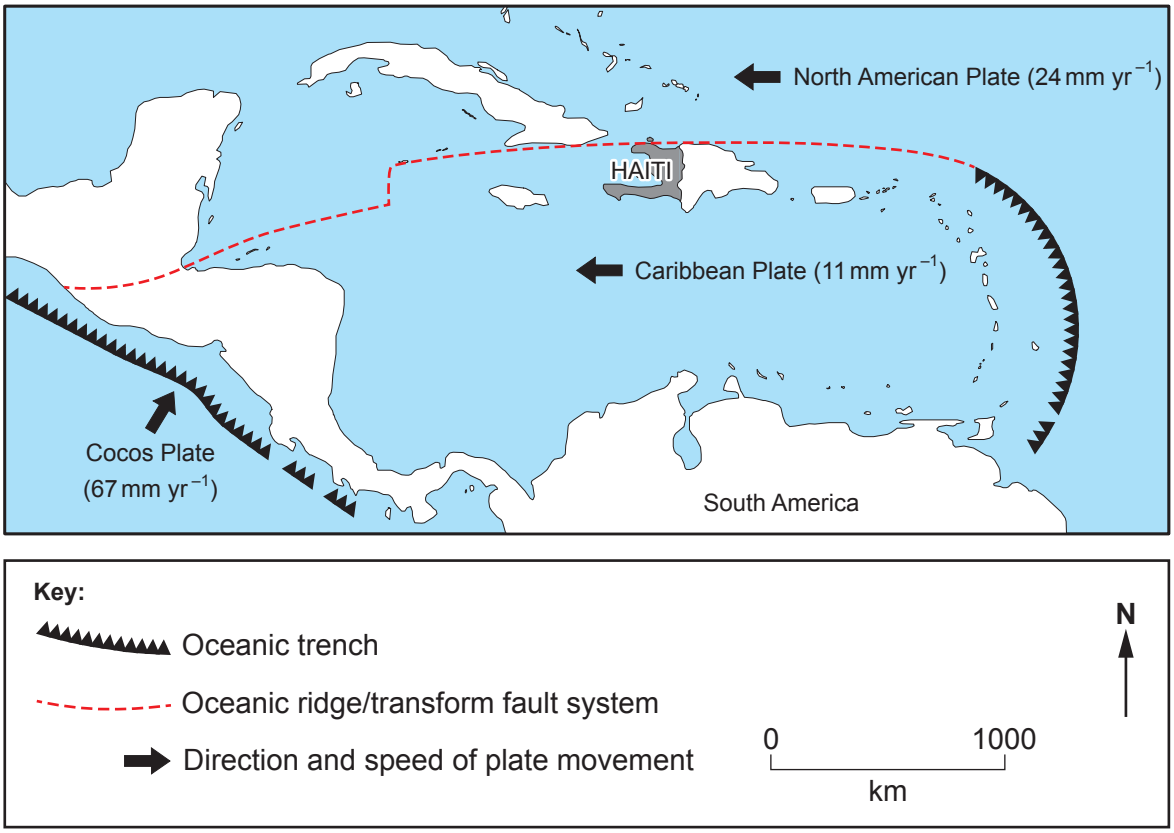

Figure 1a

(a) Refer to **Figure 1a**.

Explain why Haiti is at risk from high magnitude earthquakes. [3]

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Figure 1b is a map of Haiti showing the modified Mercalli intensity zones estimated from a M_W7.0 earthquake on 12 January 2010. The death toll was estimated at 300,000.

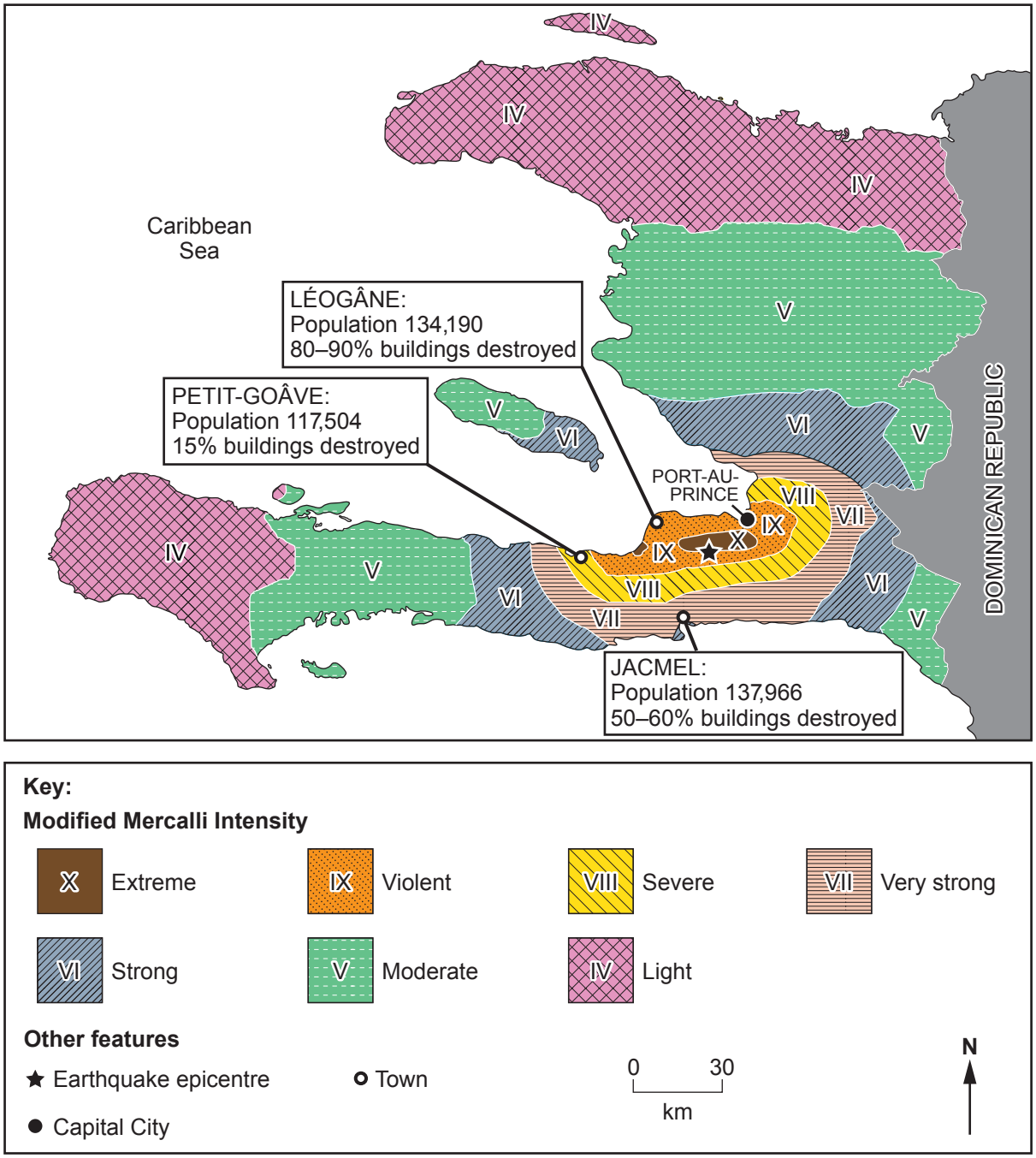

Figure 1b

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(b) Refer to **Figure 1b**.

(i) Describe the relationship between the modified Mercalli intensity of this earthquake and the distance from the epicentre. [1]

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(ii) Explain why the amount of destruction in Léogâne was significantly greater than in Petit-Goâve. [2]

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(iii) Jacmel suffered significantly greater destruction than Petit-Goâve despite being in an area of lower modified Mercalli intensity. Using your knowledge and **Figure 1b**, suggest reasons why this was the case. [3]

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(c) The city of Port-au-Prince is built on the relatively level floor of a large river valley underlain by uncemented Quaternary deposits. Explain how the ground conditions could have contributed to the destruction in the city. [2]

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(d) Since records began in 1964, the Port-au-Prince region had experienced only one earthquake with a magnitude greater than 4.0. Explain why this lack of seismic activity made the impact of the 2010 earthquake so devastating. [4]

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2. **Figure 2a** is a cross-section through disused mine workings near Bath in southwest England. Limestone was extracted from the 17th to 19th centuries using the 'pillar and stall' method. The site was developed as a housing estate in the second half of the 20th century.

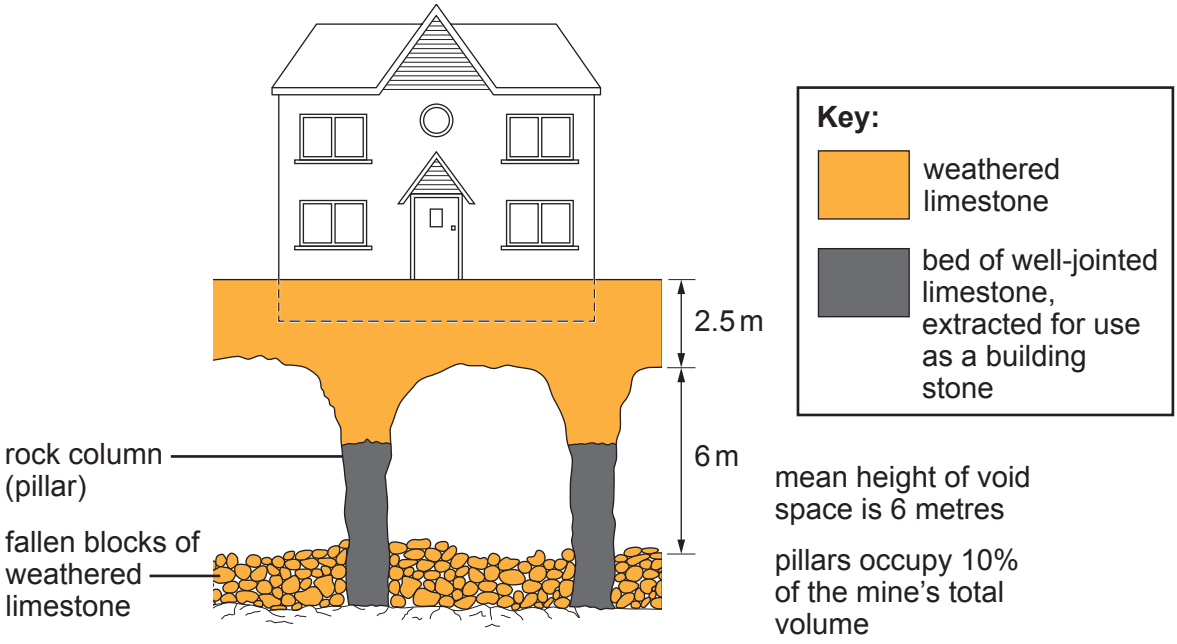

Figure 2a

Figure 2b is a map of the extent of the subsurface mine workings.

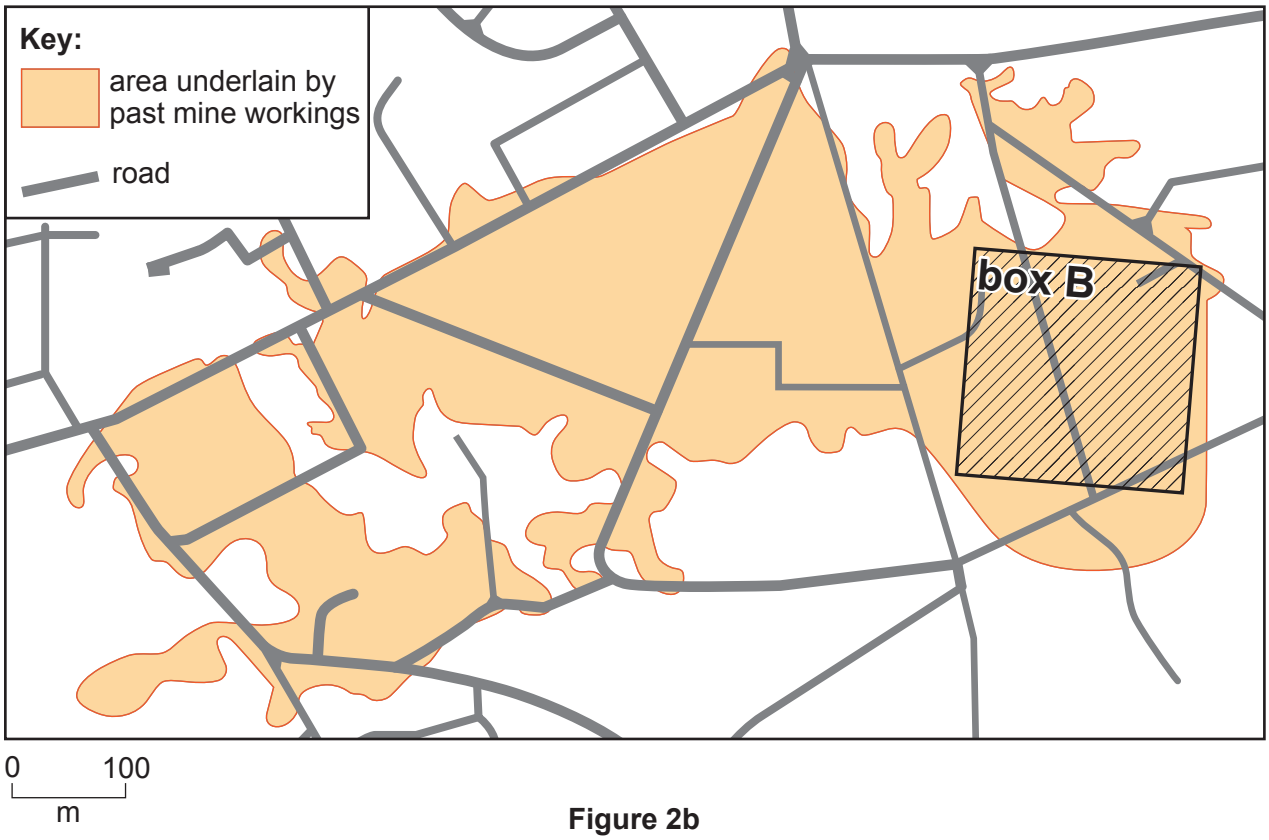

Figure 2b

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(a) Refer to **Figure 2a**.

(i) Describe how the extraction of geological materials in this area has created a geohazard. [2]

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(ii) The risk from this geohazard increased with time, after mining activity ceased. Explain why this was the case. [3]

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(b) Refer to **Figure 2a** and **Figure 2b**.

The mine workings in this area were infilled by 2009 after a 5-year project to reduce the risk of the geohazard.

(i) Calculate the area affected by the mine workings in **box B**. Show your working. [2]

..... m^2

(ii) **Box B** represents 20% of the total area affected by the mine workings. Calculate the total area affected by these mine workings. [1]

..... m^2

(iii) Calculate the volume of material that was required to infill the void space between the pillars in the total mine workings. State the units in your answer. Show your working. [3]

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(iv) "All historic pillar and stall mine workings should be infilled with waste material to reduce their geohazard risks for the construction of buildings."
Evaluate this statement with reference to the example in **Figures 2a** and **2b**. [4]

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SECTION B

Answer **all** questions in the spaces provided.

Questions **3–7** relate to the **British Geological Survey 1:50 000 geological map** extract of Ulverston 48 (Solid edition)

3. Refer to **box A** on the **geological map**.

(a) Using the key on the **geological map**, complete **Table 1** by identifying the information represented by the symbols at the following grid references (GR) in **box A**. [2]

Grid Reference (GR)	Feature	Dip amount (degrees)	Direction of dip	Orientation/trend
211868	•	•	NW	
226862	•			•

Table 1

(b) The thickness of the Gawthwaite Formation **(Gte)** is variable.

(i) Using only the **generalised geological column**, calculate the maximum thickness of the Gawthwaite Formation **(Gte)**.
Show your working. [2]

Maximum thickness ..... m

(ii) The true thickness of the Gawthwaite Formation **(Gte)** in **box A** is **500 m**. Explain the evidence from **box A** for this statement. [2]

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(iii) Using only the **geological map**, describe the evidence which suggests that the true thickness of the Gawthwaite Formation **(Gte)** decreases to the southeast of the map. [2]

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4. **Figure 4a** is a photograph of a vertical section showing details of rock types and grain size variations together with bedding and cleavage planes within the Gawthwaite Formation **(Gte)**.

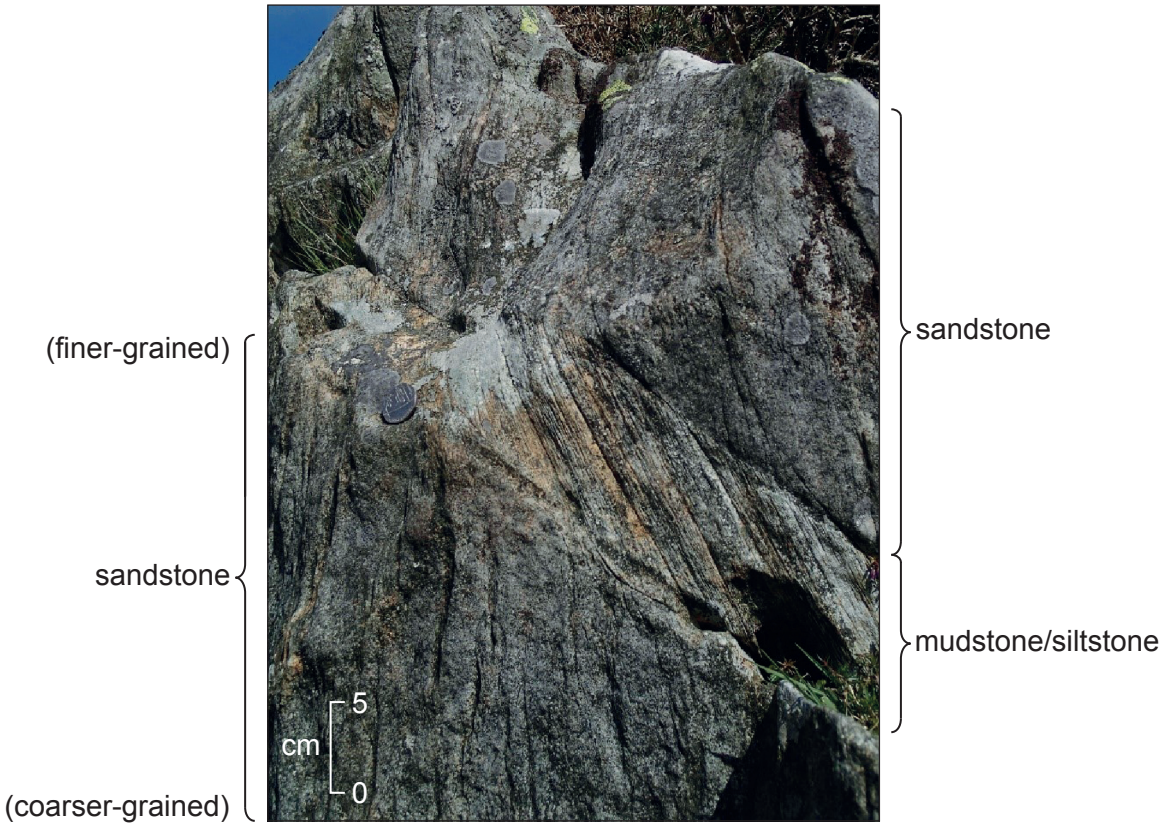

Figure 4a

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(a) (i) Draw and annotate a field sketch of **Figure 4a** in the space below to identify the main features of the geology. [4]

(ii) Explain **one** possible reason for the change in dip angle of the cleavage planes within this section. [2]

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(b) **Table 2** is a partially completed tally chart for 30 dip directions of cleavage planes within the Windermere Supergroup on the **geological map**.

Direction	N	NE	E	SE	S	SW	W	NW
Tally	𝍸 ///			𝍸 𝍸	𝍸 //			///
Total	•	•	•	•	•	•	•	•

Key:

/ = 1 cleavage dip direction **𝍸 = 5 cleavage dip directions**

Table 2

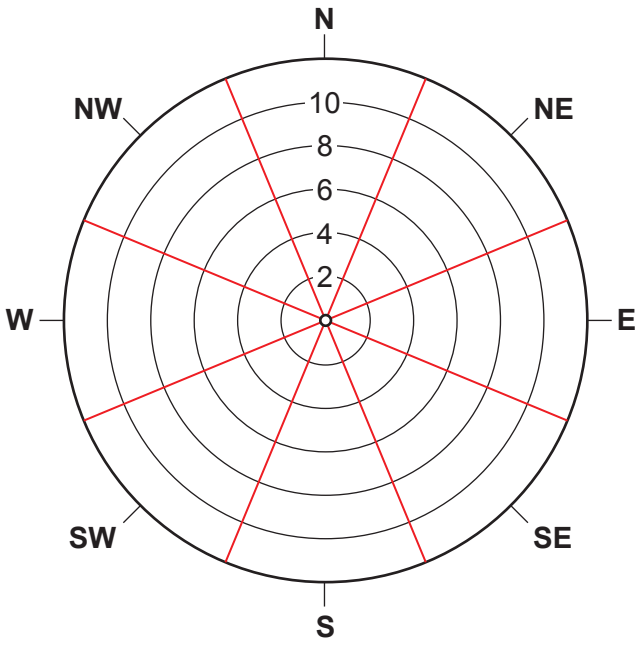

Figure 4b

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(i) The tally in **Table 2** does not include the dip directions of the **two** cleavage measurements within **box A** on the **geological map**. Add these to the tally and complete the totals for the data set. [2]

(ii) Complete the rose diagram **(Figure 4b)** to show the dip directions for the 30 cleavage planes in the completed data set in **Table 2**. [2]

(iii) The cleavage planes formed at the same time as the folding. Explain the evidence from the **geological map** and **Figure 4b** that supports this conclusion. [2]

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5. (a) The Kirkby Fault is a strike-slip fault that has been reactivated by later dip-slip movement.

Refer to the **geological map**.

(i) Calculate the net horizontal displacement of the Moorhowe Formation **(Mho)** by the Kirkby Fault in **box B**. Show your working. [2]

Net horizontal displacement ..... m

(ii) State **one** piece of evidence in **grid square 2383** that the Kirkby Fault is a strike-slip fault. Describe this type of strike-slip movement. [2]

Evidence .....

Description .....

(iii) State **one** piece of evidence from the **geological map** that the Kirkby Fault has been reactivated by dip-slip movement. [1]

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(b) Describe the evidence you would look for in the field to confirm the direction of movement on the Kirkby Fault. [2]

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(c) A student correctly stated that the two faults to the north of the Kirkby Fault on the **geological map** (marked **P** and **Q** on the **cross-section**) were each formed

- by the same principal stresses
- acting in the same directions

as those that caused the later reactivation of the Kirkby Fault.
Explain the evidence for these conclusions. [3]

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6. **Figure 6** shows part of the microgranite intrusion (***F*^{G}**) that crops out in **box C** on the **geological map**.

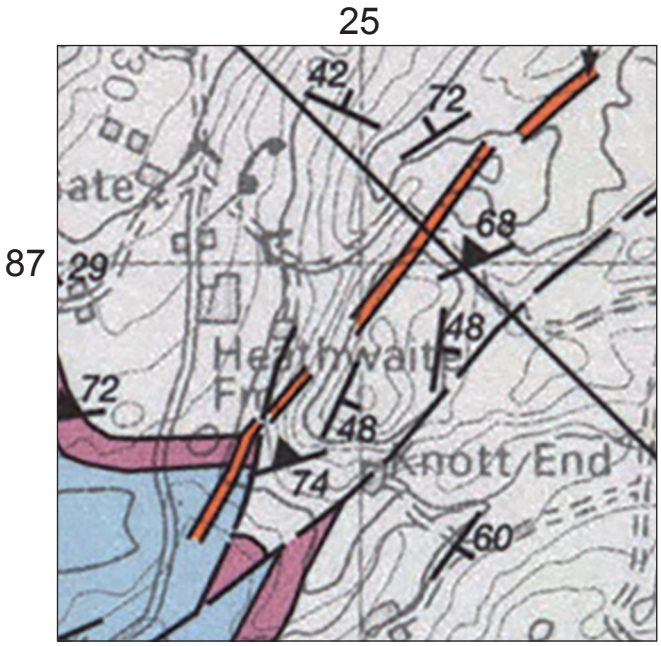

Figure 6

Refer to **Figure 6** and the **geological map**.

(a) Describe the outcrop pattern of the microgranite intrusion (***F*^{G}**). [2]

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(b) "The microgranite intrusion (***F*^{G}**) on the **geological map** is younger than the surrounding beds and faults." Evaluate the evidence for this statement from **Figure 6**. [3]

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7. **Figure 7** shows photographs of sedimentary structures on a bedding surface forming the back wall of the disused Eccle Riggs Quarry **(GR 211868)** in **box A** within the Gawthwaite Formation **(Gte)**.

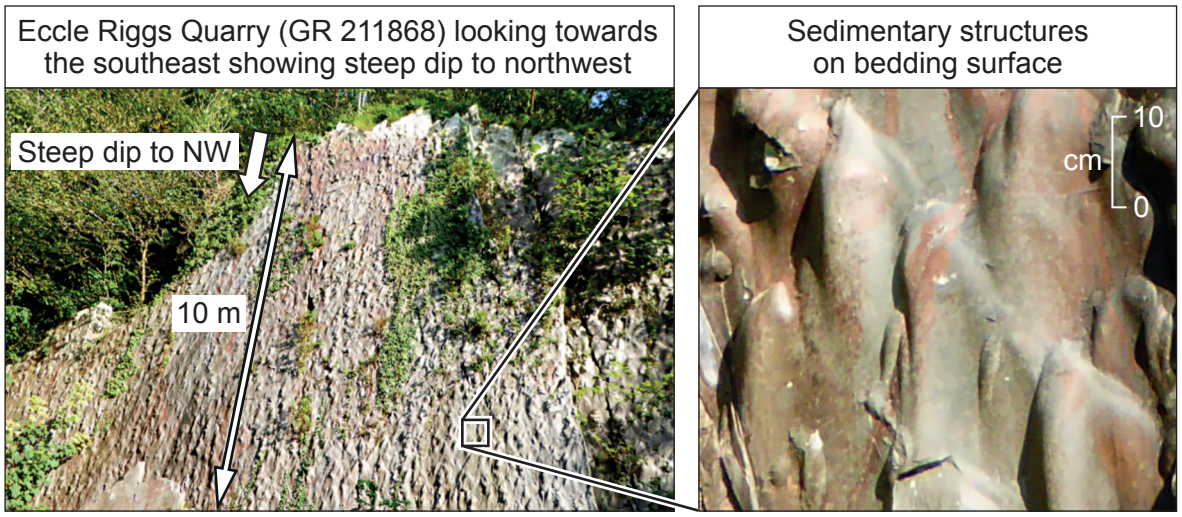

Figure 7

(a) (i) Describe the sedimentary structures on the bedding surface. [2]

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(ii) A student concluded that 'the sedimentary structures formed from a palaeocurrent flowing towards the northwest'.
With reference to **box A** and **Figure 7**, evaluate this statement. [4]

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(b) Outline the evidence from

- **Figure 4a**
- **Figure 7**
- the **geological map**
- the **geological column**

to suggest that the Gawthwaite Formation **(Gte)** was deposited rapidly, in a marine environment that deepened towards the southeast. [4]

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SECTION C

Answer the questions from only **one** option.

Tick (✓) **one** of the boxes below to indicate which **one** option you have selected.

☐ **Option 1: Quaternary Geology** page 24

☐ **Option 2: Geological Evolution of Britain** page 32

☐ **Option 3: Geology of the Lithosphere** page 40

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Option 1: Quaternary Geology

If you have chosen this option, answer **all** the questions within this option.

8. **Figure 8a** is simplified geological map of part of the coast in the south of the British Isles.

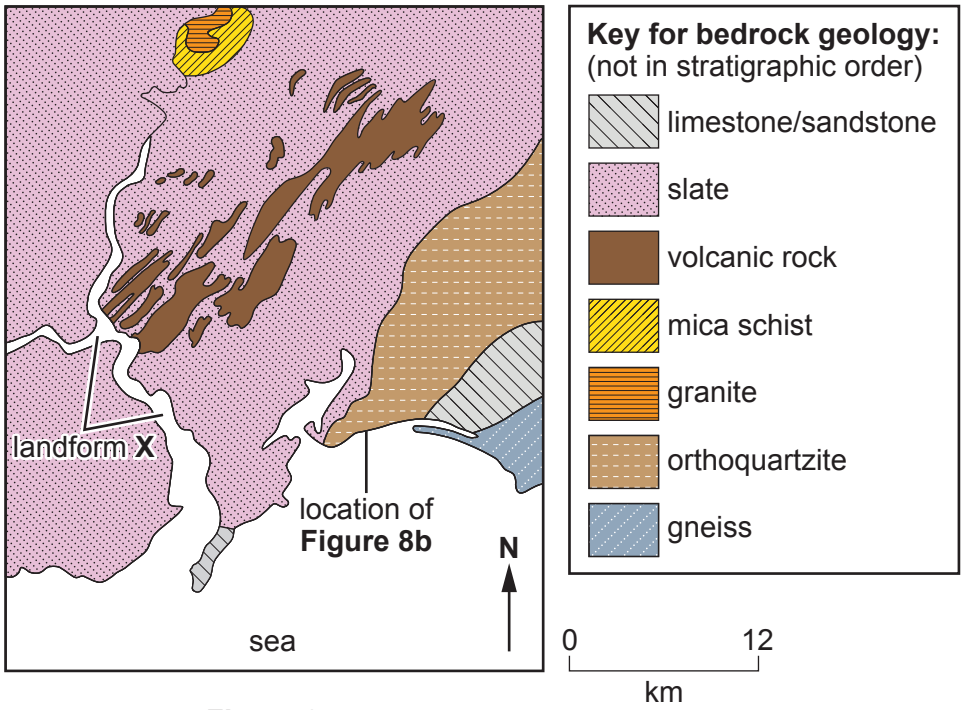

Figure 8a

Figure 8b is a field sketch of the coastal geology at the location indicated on **Figure 8a**.

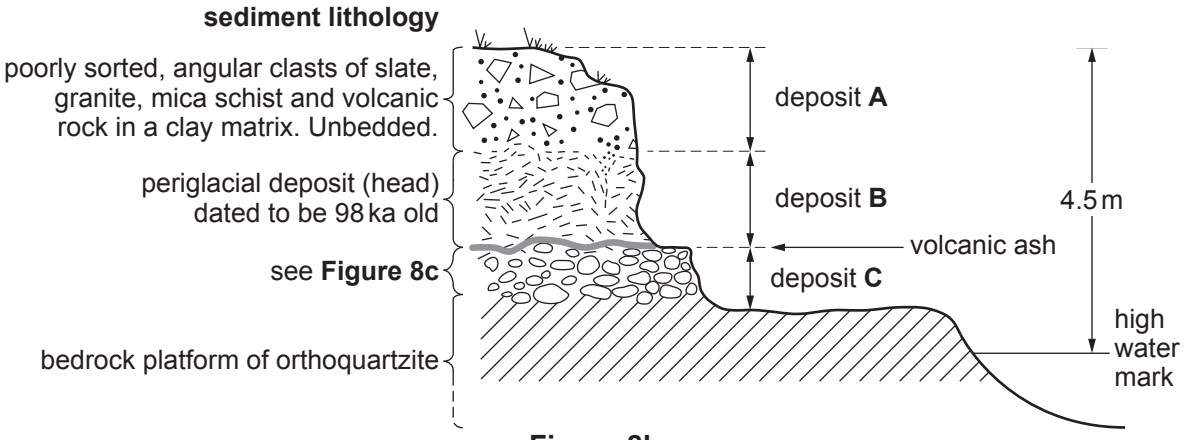

Figure 8b

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Figure 8c is a photograph of deposit **C** on **Figure 8b**.

Figure 8c

(a) Refer to **Figure 8a** and **Figure 8b**.

Deposit **A** has been interpreted as having been deposited by a glacier flowing from the northwest. Explain how the composition and texture of deposit **A** support this conclusion. [2]

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(b) Refer to **Figure 8b** and **Figure 8c**.

(i) State the name of the landform represented by deposit **C** in **Figure 8b**. [1]

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(ii) Explain how the evidence from deposit **C** indicates that sea level in the past was higher than present. [2]

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(c) (i) A sample of the volcanic ash was collected from the sequence shown in **Figure 8b**. It was tested and found to contain:

- 400,000 atoms of ^{40}K and
- 33 atoms of ^{40}Ar.

Calculate the radiometric age of the volcanic ash using the formula. Show your working. [3]

$$t = \frac{ln\left(\frac{N_D}{N_P} + 1\right)}{\lambda}$$

Where: t = time
N_D = number of daughter atoms
N_P = number of parent atoms
λ = decay constant (5.543×10^{-10} yr^{-1} for the ^{40}K-^{40}Ar method)

..... Ma

(ii) Explain why it was not possible to determine a radiocarbon date from the marine shells in deposit **C**. [2]

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(d) Refer to **Figure 8a**, **Figure 8b** and **Figure 8c**.

Landform **X** indicates that sea level in the past was lower than present.

(i) State the name of the landform **X** in **Figure 8a**. [1]

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(ii) Explain why this coastline shows evidence of both higher and lower sea levels in the Quaternary period. [3]

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9. **Figure 9** shows the brain volume of selected hominin species together with the changes in some environmental factors and one of Milankovitch's cycles through recent geological time.

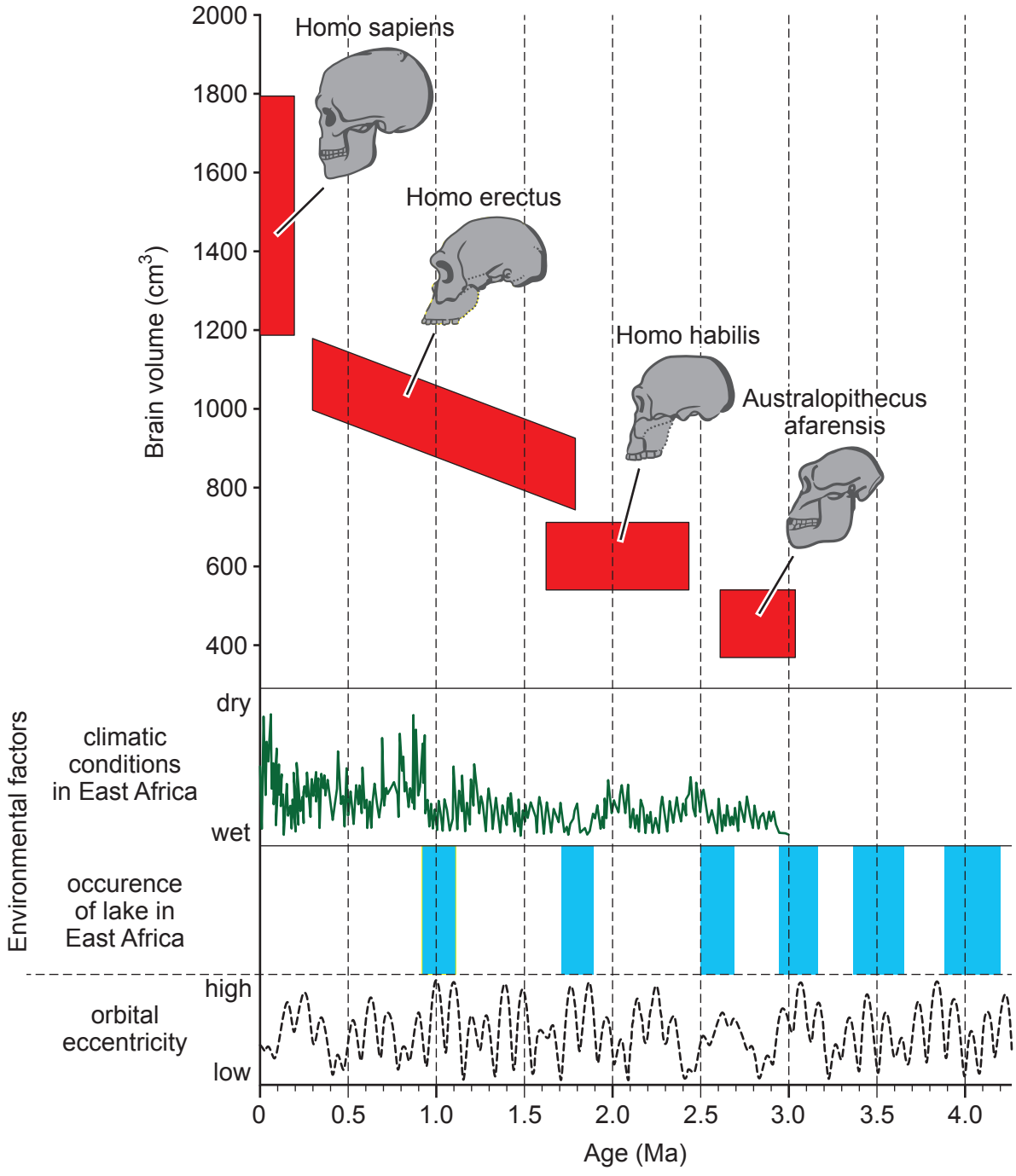

Figure 9

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(a) Refer to **Figure 9**.

(i) Describe the change in hominin brain size from 3 Ma to present. [2]

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(ii) Describe the changes in the climate in East Africa from 3 Ma to present. [2]

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(iii) Suggest why hominin brains evolved in response to these climatic changes. [3]

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(b) A student stated that 'Milankovitch cycles, such as orbital eccentricity, did not affect human evolution'.
Evaluate this statement with reference to the data in **Figure 9**. [3]

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10. Explain how fossils of pollen, invertebrates (for example beetles) and vertebrates (for example mammoths) provide evidence for climatic fluctuations in Britain during the Quaternary period. [6 QER]

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Option 2: Geological Evolution of Britain

If you have chosen this option, answer **all** the questions within this option.

11. **Figure 11a** is a simplified geological map of one of the Garvellach Islands off the west coast of Scotland.

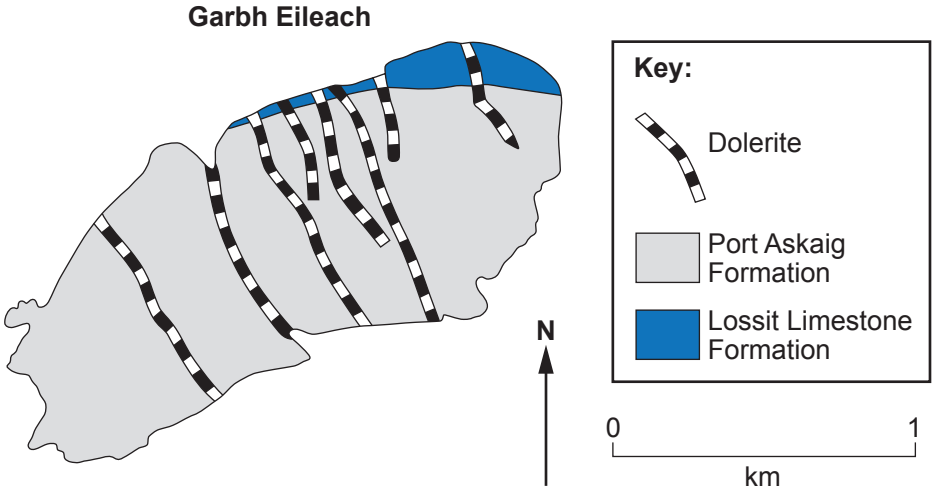

Figure 11a

Figure 11b is a photograph of Rock **J** in the Port Askaig Formation on **Figure 11c**.

Figure 11b

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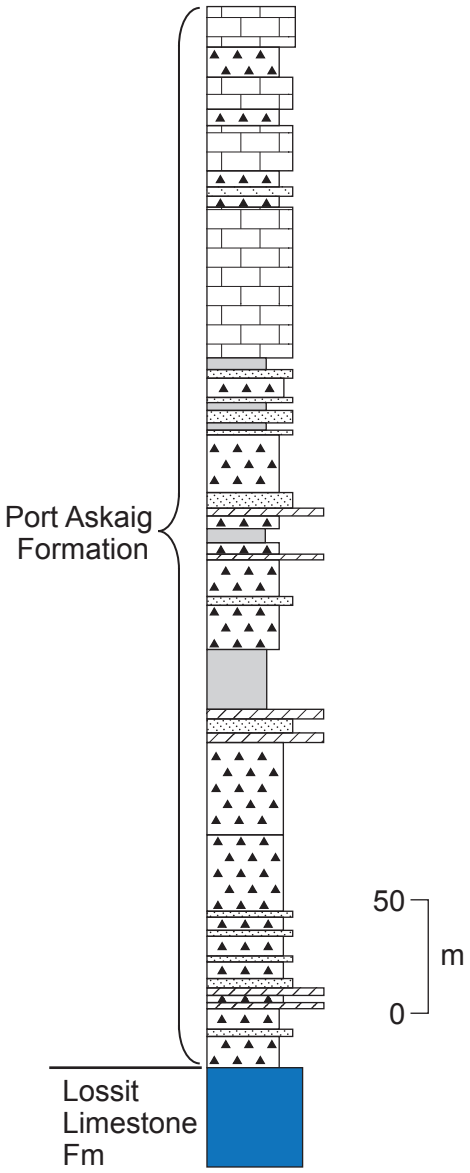
Figure 11c is a simplified graphic log of some of the Neoproterozoic sedimentary sequence exposed on the Garvellach Islands.



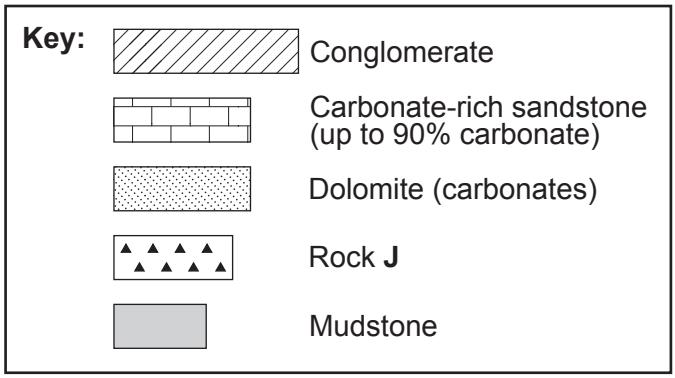


Figure 11c

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(a) Refer to **Figure 11b**.

(i) Describe the texture of Rock **J** in **Figure 11b**. [2]

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(ii) Rock **J** is thought to have been deposited during a global Snowball Earth glaciation in the Neoproterozoic. Suggest the processes that deposited Rock **J**. [2]

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(b) Refer to **Figure 11c**.

(i) Explain what the occurrence of the carbonate-rich sandstones suggests about how the Snowball Earth glaciation may have ended. [3]

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(ii) A student suggested that 'the Neoproterozoic Snowball Earth was not a single glacial event'.
Explain the evidence from the Port Askaig Formation for this interpretation. [2]

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(c) Refer to **Figure 11a**.

(i) A sample of the dolerite shown in **Figure 11a** was tested and found to contain:
- 40,000 atoms of ^{40}K and
- 1300 atoms of ^{40}Ar.

Calculate the radiometric age of the dolerite. Show your working. [3]

$$t = \frac{ln\left(\frac{N_D}{N_P} + 1\right)}{\lambda}$$

Where: t = time
N_D = number of daughter atoms
N_P = number of parent atoms
λ = decay constant (5.543×10^{-10} yr^{-1} for the ^{40}K-^{40}Ar method)

..... Ma

(ii) Explain **two** pieces of evidence that suggest the dolerite is linked to the opening of the Atlantic Ocean. [2]

Evidence 1

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Evidence 2

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12. **Figure 12** is a simplified geological map of northern England showing the thickness of subsurface granitic plutons intruded during the Caledonian Orogeny.

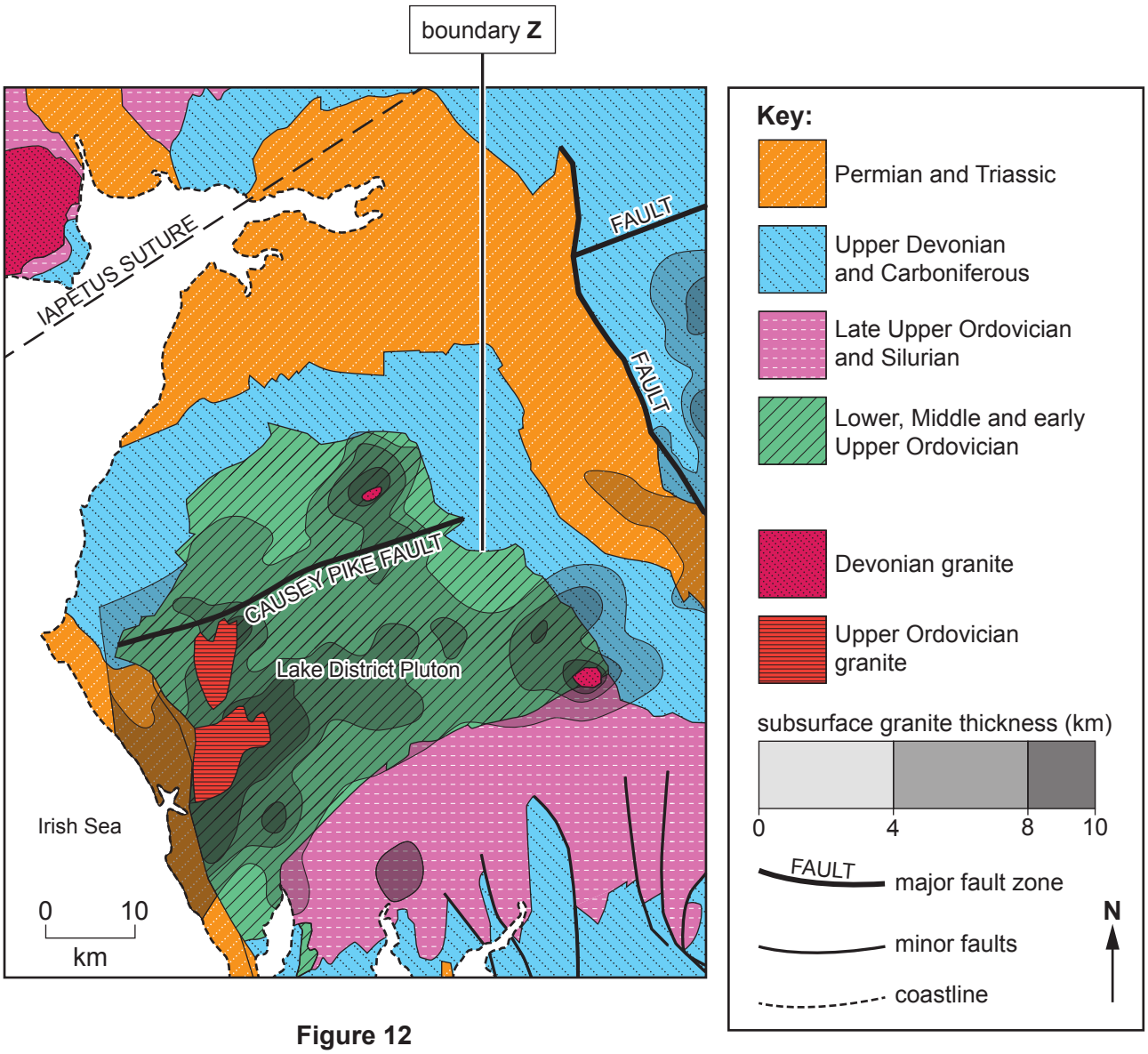

Figure 12

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(a) Refer to **Figure 12**.

(i) State the type of boundary represented by boundary **Z** on **Figure 12**. [1]

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(ii) The Causey Pike Fault formed during the Caledonian Orogeny.
Explain the evidence for this statement. [3]

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(b) (i) Explain **one** geophysical technique that could be used to map the subsurface granite thickness of the Lake District Pluton shown in **Figure 12**. [3]

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(ii) A student stated that 'the intrusion of granites from both the Upper Ordovician and the Devonian reflect different types of plate tectonic margins at different stages of the Caledonian Orogeny'.
Evaluate this statement. [3]

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13. Explain how the geological evidence in Britain from the Mesozoic era indicates changing sea levels over geological time. [6 QER]

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Option 3: Geology of the Lithosphere

If you have chosen this option, answer **all** the questions within this option.

14. **Figure 14a** is a map of part of the Southern Atlantic showing the Tristan da Cunha hotspot at the end of a volcanic chain that extends to the African continent along the Tristan da Cunha-Walvis volcanic chain.

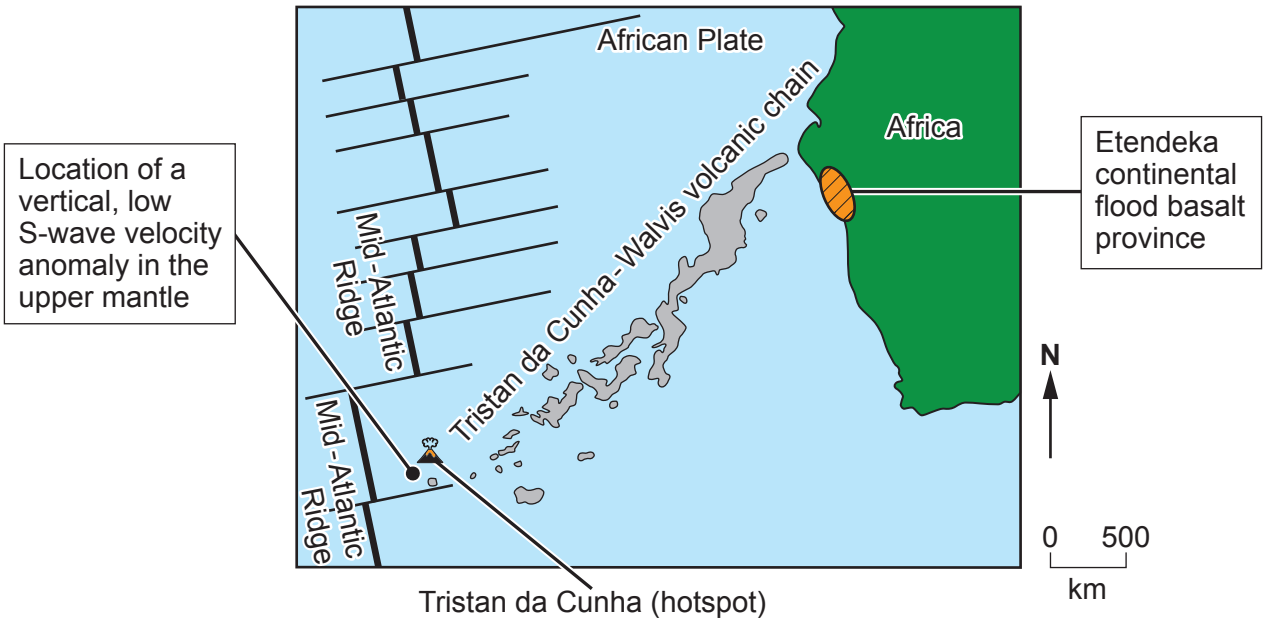

Figure 14a

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Figure 14b shows the age of volcanic lavas obtained along the Tristan da Cunha – Walvis volcanic chain.

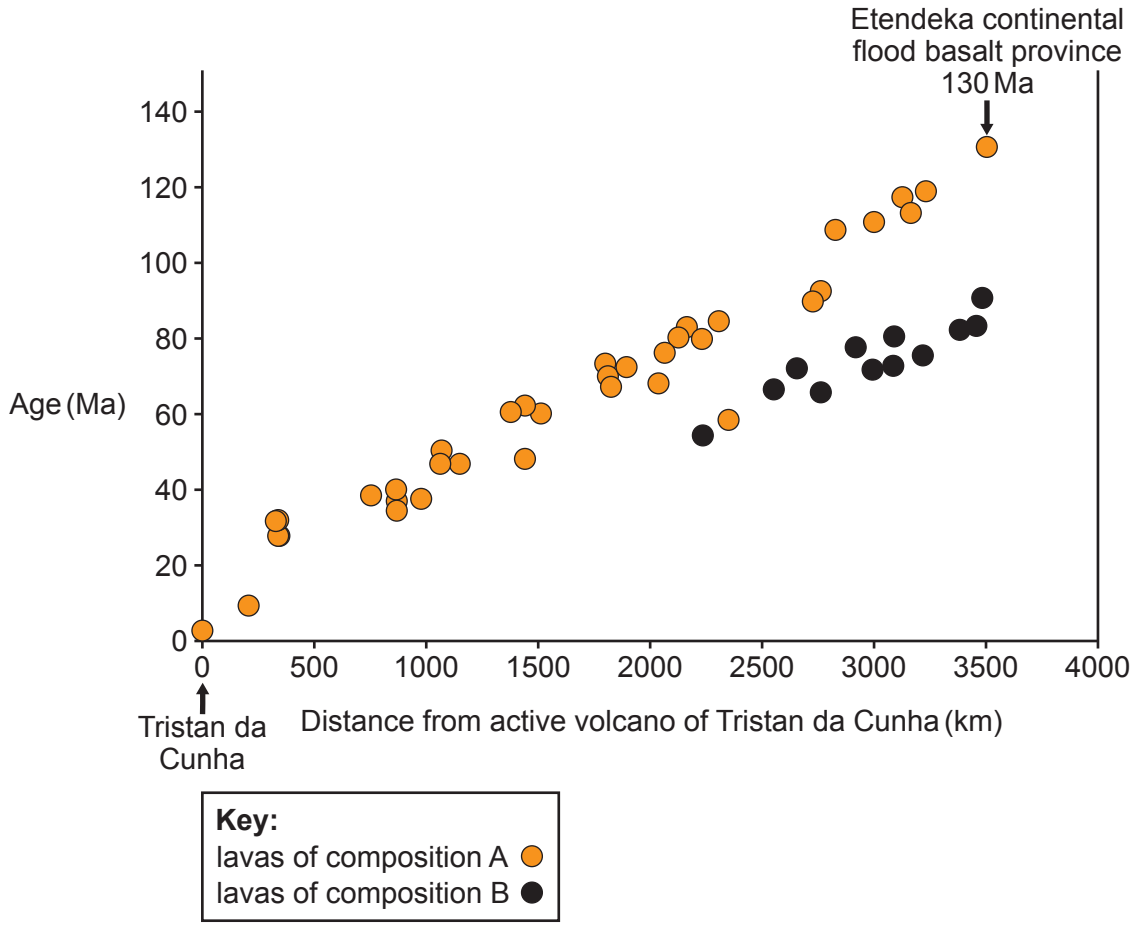

Figure 14b

Refer to **Figure 14a** and **Figure 14b**.

(a) (i) State the age range of lavas at a distance of 3000 km from Tristan da Cunha. [1]

Age range .....

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(ii) A sample of lava was collected at a distance of 2500 km along the volcanic chain from Tristan da Cunha. It was tested and found to contain:

- 40,000 atoms of ^{40}K and
- 1900 atoms of ^{40}Ar.

Calculate the radiometric age of the lava using the formula.
Show your working. [3]

$$t = \frac{ln\left(\frac{N_D}{N_P} + 1\right)}{\lambda}$$

Where: t = time
N_D = number of daughter atoms
N_P = number of parent atoms
λ = decay constant (5.543×10^{-10} yr^{-1} for the ^{40}K-^{40}Ar method)

..... Ma

(b) Explain how **Figure 14b** can be used to show that the African plate is moving with a speed of approximately 27 mm yr^{-1}. [2]

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(c) (i) Evaluate the evidence from **Figure 14a** and **Figure 14b** for the existence of a mantle plume associated with the Tristan da Cunha hotspot. [3]

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(ii) Refer to **Figure 14b**. Describe the characteristics of the lavas from the Tristan da Cunha-Walvis volcanic chain that might lead scientists to question the mantle plume origin of some of the lavas. [3]

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15. **Figure 15a** shows the pathways through continental lithosphere of three P-waves (P_1, P_2 and P_3) produced by an artificial explosion at the surface. **Figure 15b** is a seismogram of the arrivals of the three P-waves that have travelled to a distant seismograph along the pathways indicated in **Figure 15a**.

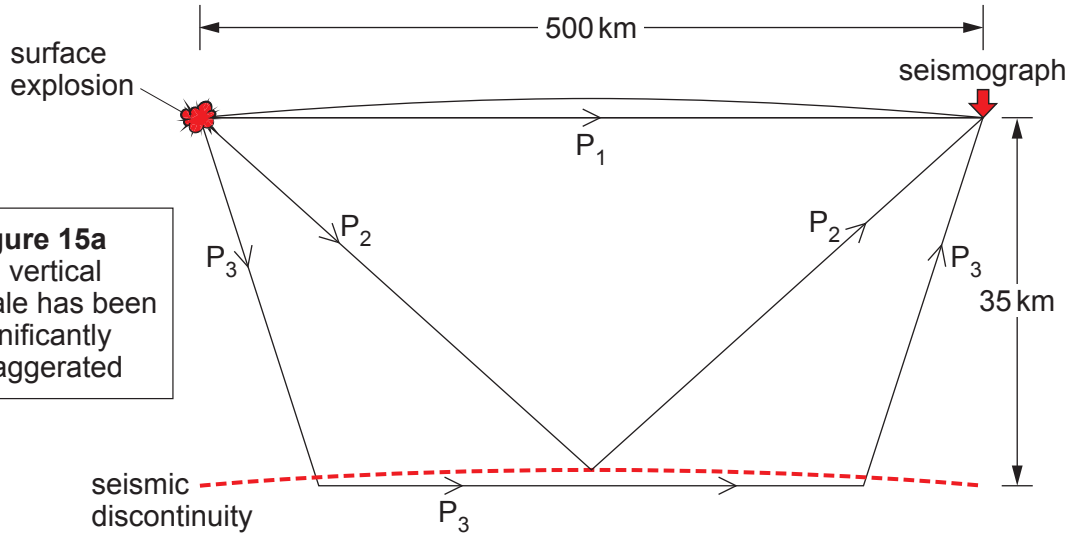

Figure 15a the vertical scale has been significantly exaggerated

Figure 15a

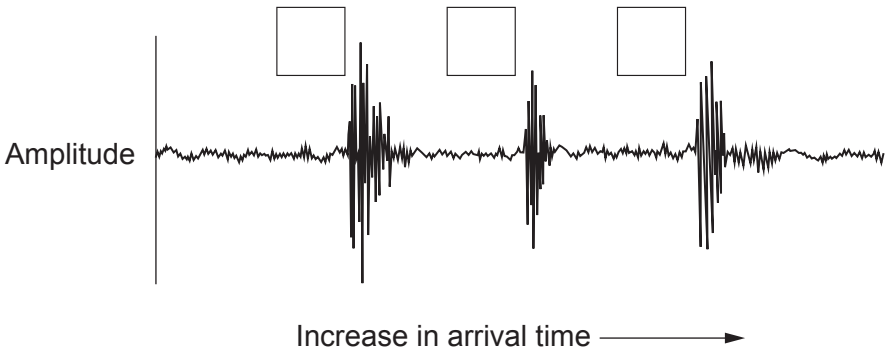

Figure 15b

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Refer to **Figure 15a** and **Figure 15b**.

(a) (i) State what is meant by a seismic discontinuity. [2]

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(ii) Explain what this seismic discontinuity suggests about the change in rock **properties** at a depth of 35 km within the Earth. [3]

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(b) (i) Describe the paths followed by the P-waves, $\mathbf{P_2}$ and $\mathbf{P_3}$, in **Figure 15a**. [2]

$\mathbf{P_2}$ path .....

$\mathbf{P_3}$ path .....

(ii) Indicate on the seismogram **(Figure 15b)** the order in which P-waves arrived at the seismograph. You should indicate which P-wave arrival corresponds to which wave path by inserting the labels ($\mathbf{P_1}$, $\mathbf{P_2}$ and $\mathbf{P_3}$) into the appropriate box on **Figure 15b**. [2]

(iii) Explain the order of arrival of the three P-waves ($\mathbf{P_1}$, $\mathbf{P_2}$ and $\mathbf{P_3}$) in **Figure 15b**. [3]

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16. Describe the origin of sedimentary basins formed by lithospheric loading (foreland basins) and the structural deformation of sediments associated with these basins. [6 QER]

END OF PAPER

6

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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Acknowledgements

Figure 4a: http://englishlakedistrictgeology.org.uk/users/UserFiles/Image/Chapters/chapter5h.jpg
Photograph Clive Boulter

Figure 7: 'Donkey Rocks' (Eccle Riggs Quarry). Photograph P. Loader

Figure 8c: Photograph Michael Walsh

Figure 11b: https://islaygeology.org/wp-content/uploads/2018/11/p8251051-1024x768.jpg Photograph David J Webster

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