Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A480U30-1

Z22-A480U30-1

eduqas Part of WJEC

TUESDAY, 21 JUNE 2022 – MORNING

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.**	**5**		
	4.	**11**		
	5.	**13**		
	6.	**16**		
Section C option		**12**	**11**	
		12	**13**	
		6		
	Total	**105**		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:
- a calculator
- a ruler
- the Geological Map Extract (Chesterfield)

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 alongside each question or part-question.

The assessment of the quality of extended response (QER) will take place in questions **9**, **12** and **15**.

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SECTION A

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

1. (a) **Figure 1a** is a map of 20th century Mexican earthquakes.

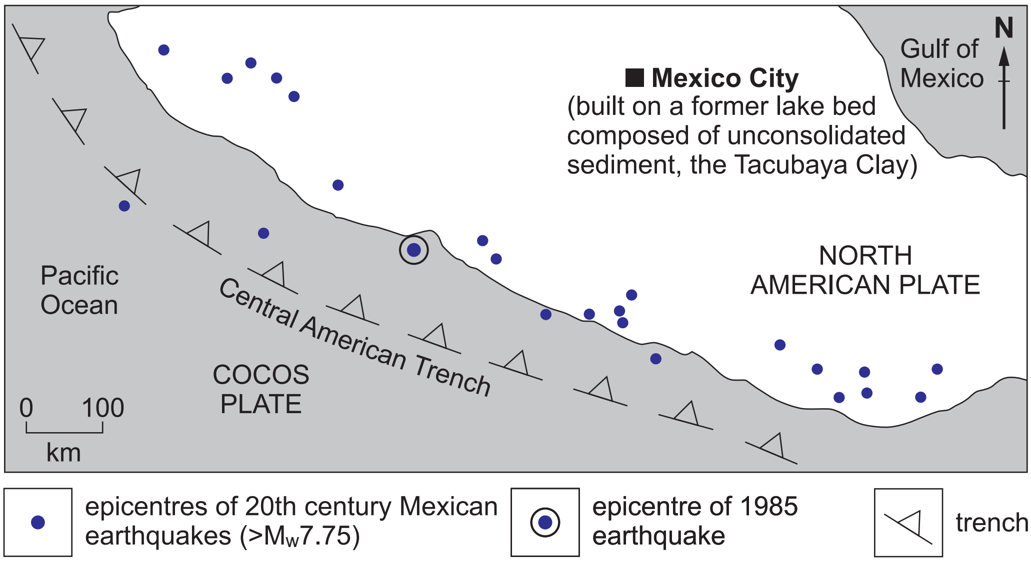

Figure 1a

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

(i) Determine the distance, in kilometres, from the epicentre of the 1985 earthquake to Mexico City. [1]

.... km

(ii) Calculate the time, in seconds, that it took the surface seismic waves to reach Mexico City from the epicentre of the 1985 earthquake if their velocity was $3.9\,km\,s^{-1}$. Show your working. [2]

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(iii) With reference to **Figure 1a** only, explain why Mexico City is at risk from seismic geohazards. [3]

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(b) **Figure 1b** shows some of the effects of the 1985 earthquake (M_w 8.1) in part of Mexico City.

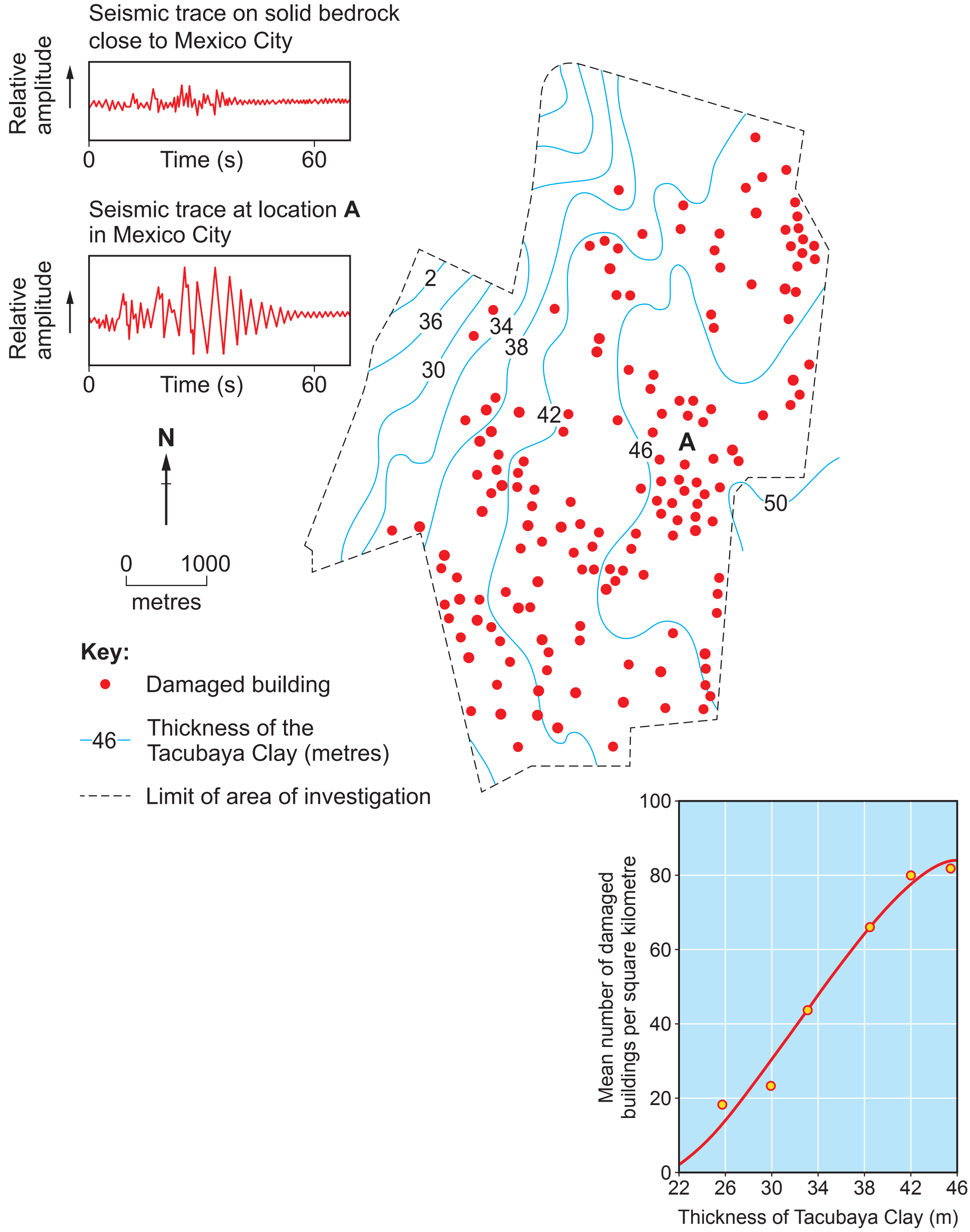

Figure 1b

Examiner only

Refer to **Figure 1b**.

(i) Describe the differences in the seismic traces between solid bedrock close to Mexico City and location **A** in Mexico City. [2]

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(ii) Describe and explain the relationship between the thickness of the Tacubaya Clay and the mean number of buildings that were damaged in this earthquake. [4]

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Examiner only

(c) **Figure 1c** shows the relationship between the percentage of damaged buildings in the 1985 Mexico City earthquake and the height of those buildings.

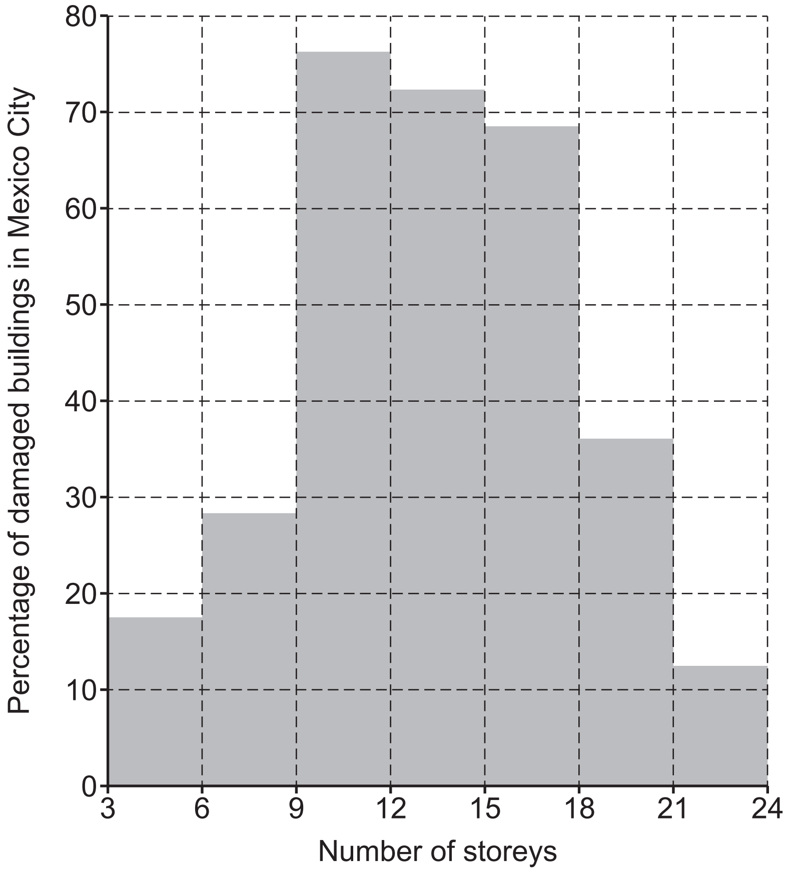

Figure 1c

Refer to **Figures 1b** and **1c**.

"The thickness of the Tacubaya Clay was not the only factor that affected the damage to buildings in Mexico City caused by the 1985 earthquake"

Evaluate this statement with reference to the evidence from Mexico City. [3]

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2. **Figure 2** is a cross-section through an area where radon gas has been detected.

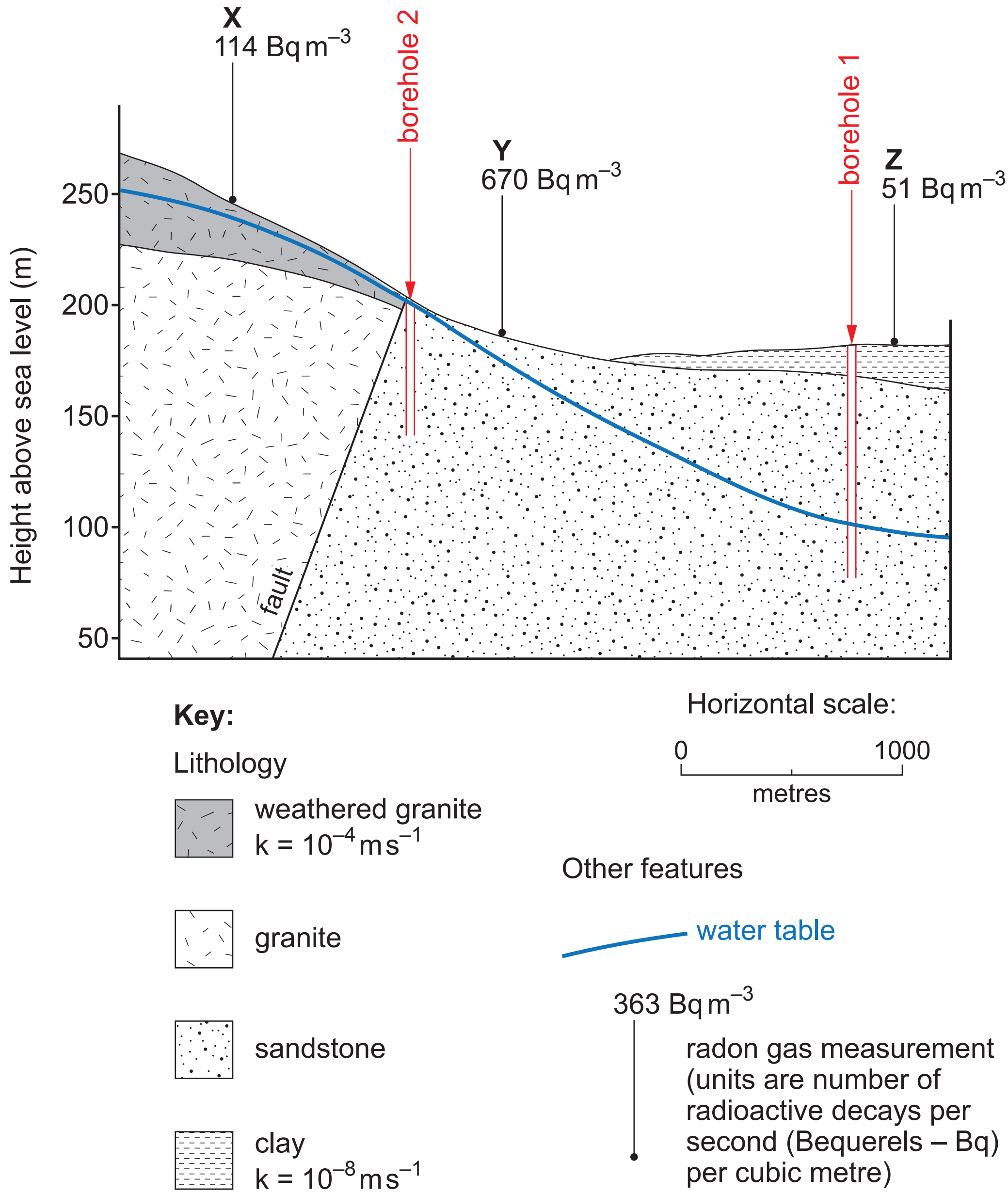

Figure 2

Refer to **Figure 2**.

(a) (i) State **one** risk to the local population created by the concentration of radon gas. [1]

....

(ii) Suggest the most likely geological origin of the radon gas detected in this area. [2]

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Examiner only

(b) The values of hydraulic conductivity (k) for weathered granite and clay are shown on **Figure 2**.

(i) Calculate the hydraulic conductivity (k) of the sandstone using Darcy's Law. [3]

$$Q = kA\left(\frac{h_2 - h_1}{L}\right)$$

where: $Q = 2.5 \times 10^{-2}\ m^3 s^{-1}$ (flow rate)
$A = 1.0\ m^2$ (cross-sectional area)
$h_2 - h_1$ = difference in height of water table in boreholes 1 and 2 (m)
L = horizontal distance between boreholes 1 and 2 (m)

Show your working.

k = ... $m s^{-1}$

(ii) Explain the geological reasons for the differences in the radon gas measurements at locations **X**, **Y** and **Z**. [4]

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(c) (i) Explain how radon gas measurements might be used to monitor earthquake activity along the fault. [3]

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(ii) Explain **one other** monitoring method that could be used to attempt to predict seismic hazards. [2]

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SECTION B

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

Questions **3–6** relate to the **British Geological Survey geological map** extract from the Chesterfield Sheet 112 (Solid and Drift)

3. Refer to the **geological map** and key.

(a) Using the key on the **geological map**, complete **Table 3** by stating the superficial deposit found at the grid reference (**GR**) indicated and the probable mode of formation of the superficial deposit where appropriate. [3]

Grid reference (**GR**)	Superficial deposit	Formation
303570	•	•
330555	•	Freeze-thaw processes during the Quaternary

Table 3

(b) Refer to the **generalised geological column**, key and **box H** on the **geological map**.

Complete **Table 4** by inserting the following events from **box H** in order of their relative ages – oldest at the base.

Ashover Grit (**AsG**) landslide Head (Bh) [2]

Relative age	Events
Youngest	•
	•
Oldest	•

Table 4

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Examiner only

4. **Figure 4** shows a limestone fragment containing fossils. It was found by a student within the Head (Bh), at **GR 342565** on the **geological map**. The student was able to accurately locate the position of the rock fragment in the field without the use of GPS.

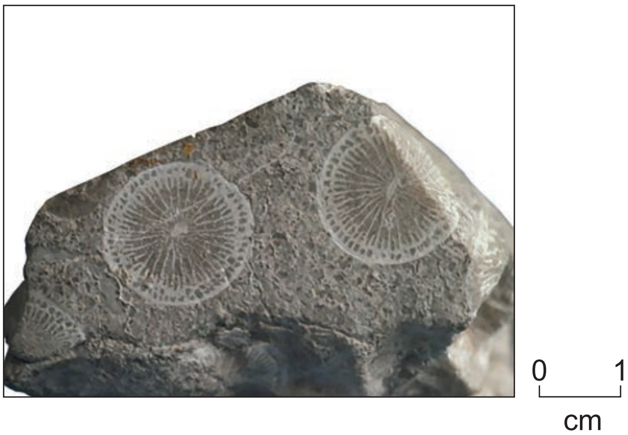

Figure 4

(a) Explain how the student might have located the position of this rock fragment in the field using traditional navigation and basic field survey skills, without the use of GPS. You may choose to illustrate your answer with an annotated diagram. [3]

Examiner only

(b) (i) State the fossil group to which the fossils within the fragment in **Figure 4** belong. Give **one** reason for your choice. [2]

Fossil group ....

Reason ....

....

(ii) Describe the environment of deposition indicated by the presence of these fossils. [3]

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(iii) The presence of these fossils in the Head (Bh) appears to contradict the environment of deposition indicated by the Head. Explain this apparent contradiction. [3]

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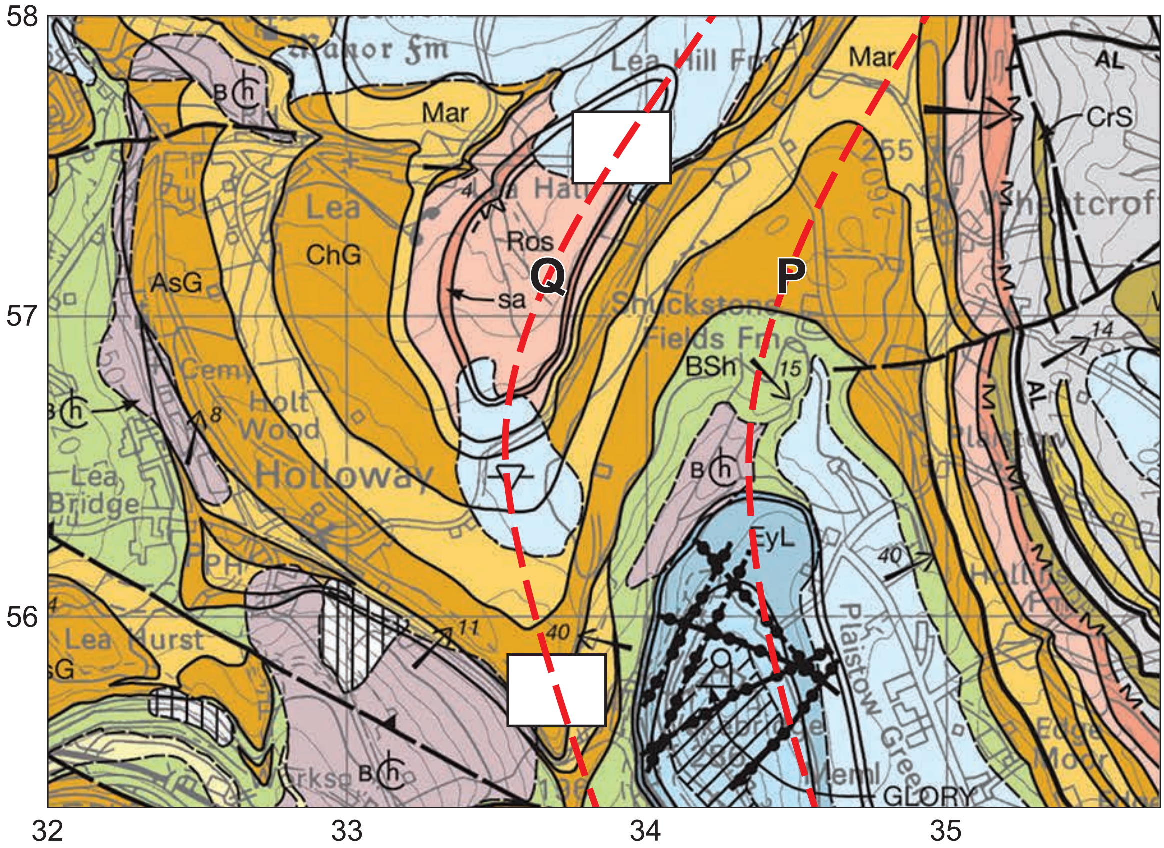
5. The axial plane traces of two plunging folds (**P** and **Q**) are marked on **Figure 5a**.



Key:
Axial plane trace (arrow heads show direction of plunge)

Figure 5a

(a) Refer to **Figure 5a** and the **geological map**.

(i) Complete **Table 5** by stating the evidence from the **geological map** for the characteristics of fold **P**. [3]

Characteristics of fold **P**	Evidence
Antiform	•
Anticline	•
Plunge to the N–NNE	•

Table 5

(ii) In each of the **two** blank boxes on **Figure 5a**, indicate the direction of plunge of fold **Q** at both locations. Use the plunge symbol in the key. [2]

 (A480U30-1)

Examiner only

(iii) A student described the plunging folds as having a wavelength of approximately 0.75 km. Evaluate this conclusion. [2]

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(b) Refer to the line of section **S–T** on the **geological map** and the sketch cross-sections (**W**, **X**, **Y** and **Z**) in **Figure 5b**.

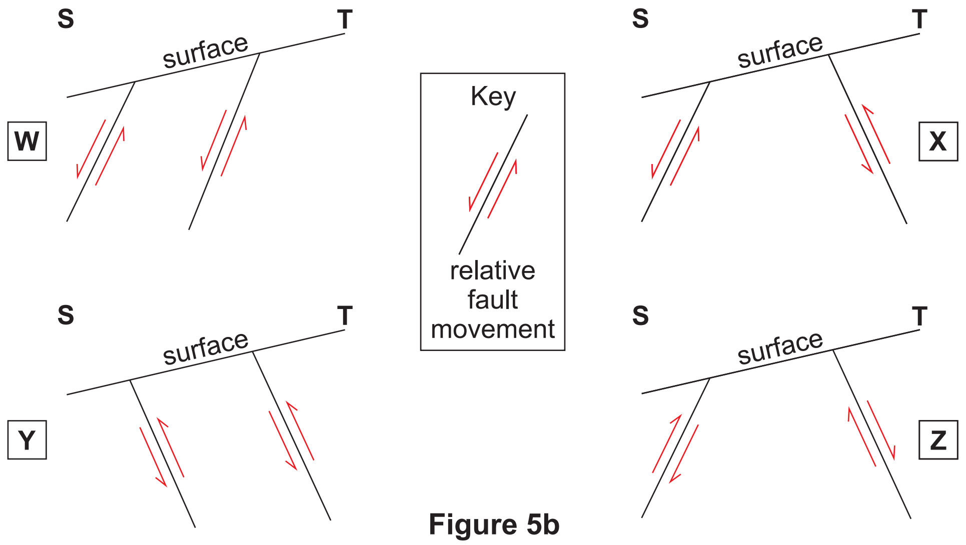

Figure 5b

(i) State which of the sketch cross-sections (**W**, **X**, **Y** or **Z**) is most likely to represent the geological structure along the line of section **S–T**. Justify your answer. [3]

Sketch cross-section along **S–T** (**W**, **X**, **Y** or **Z**). ☐

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(ii) A student concluded that the faults on the **geological map** were formed
- by compression
- but with different principal stress directions to those that formed the major folds

Evaluate these conclusions with reference to evidence from the **geological map**. [3]

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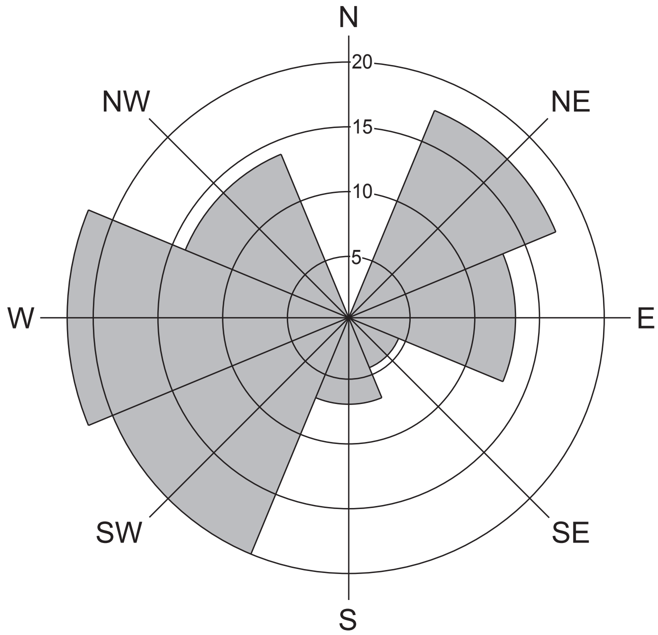
 (A480U30-1) **Turn over.**

Examiner only

6. **Figure 6** is a rose diagram showing the distribution of landslides in the Chesterfield region (which includes the area of the **geological map**) based on the direction the landslide slope faces (slope aspect).

A student undertook a field investigation into the orientation of these landslides to test the hypothesis that slope aspect was important in landslide development.



Numbers refer to observed landslide frequency

Figure 6

Table 6 is a partly completed chi-squared test used to test the null hypothesis (H_0) that "there is no significant orientation of the landslides".

Landslide Orientation	Observed frequency (O)	Expected frequency (E)	(O – E)	$(O - E)^2$	$\frac{(O-E)^2}{E}$
N	14	14	0	0	0
NE	18	14	4	16	1.14
E	13	14	–1	1	0.07
SE	4	14	–10	100	7.15
S	7	14	•	•	•
SW	20	14	6	36	2.57
W	22	14	8	64	4.57
NW	14	14	0	0	0
Total	112	112	**chi-squared value**		**19.00**

Table 6

Examiner only

(a) Refer to **Figure 6** and **Table 6**.

(i) Complete **Figure 6** by plotting the observed frequency (O) of landslide orientations to the North (N) shown in **Table 6**. [1]

(ii) Complete the blank cells in **Table 6** for landslide orientations to the South (S). [2]

Degrees of Freedom	Probability										
	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59
	Non-significant								Significant		

Table 7

(iii) Using the significance chart (**Table 7**) explain why the chi-squared value of these data means the null hypothesis (H_0) can be rejected at the **0.01** confidence level. [2]

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(iv) Explain why it was important to test the data in the rose diagram statistically before making conclusions. [2]

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(b) Explain how the freeze-thaw process might contribute to mass movement on slopes. [3]

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Examiner only

(c) Refer to the **geological map** and **geological cross-section (J–K)**.

The following conclusions are from a report into landslides in the Chesterfield area.

"In addition to slope aspect, landslide development appears to be directly influenced by

- dip angle and direction of the bedrock
- bedrock type
- river erosion
- the formation of the superficial Head deposit."

Evaluate the report's conclusions with reference to the **three** landslides labelled **A**, **B** and **C** on the **geological map**. [6]

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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.

☐ Quaternary Geology ☐ Geological Evolution of Britain ☐ Geology of the Lithosphere

Option 1: Quaternary Geology

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

7. **Figure 7a** is a reconstruction of Antarctic sea surface temperature change over the last 40 Ma.

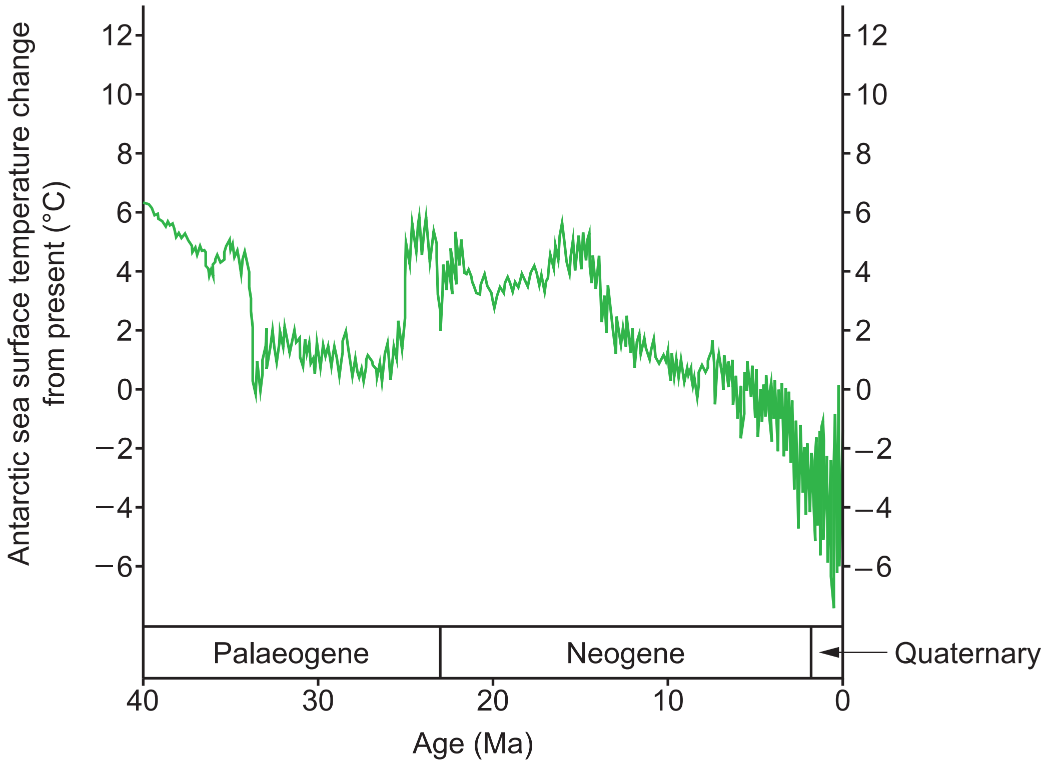

Figure 7a

Examiner only

(a) Refer to **Figure 7a**.

(i) Describe the change in Antarctic sea surface temperature over the last 40 Ma. [2]

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(ii) Explain how oxygen isotope evidence from oceanic sediments could be used to reconstruct sea surface water temperature over the last 40 Ma. [2]

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Examiner only

(b) **Figure 7b** shows the likely position of continents and oceanic circulation in the Palaeogene. **Figure 7c** shows the position of continents and oceanic circulation in the Quaternary.

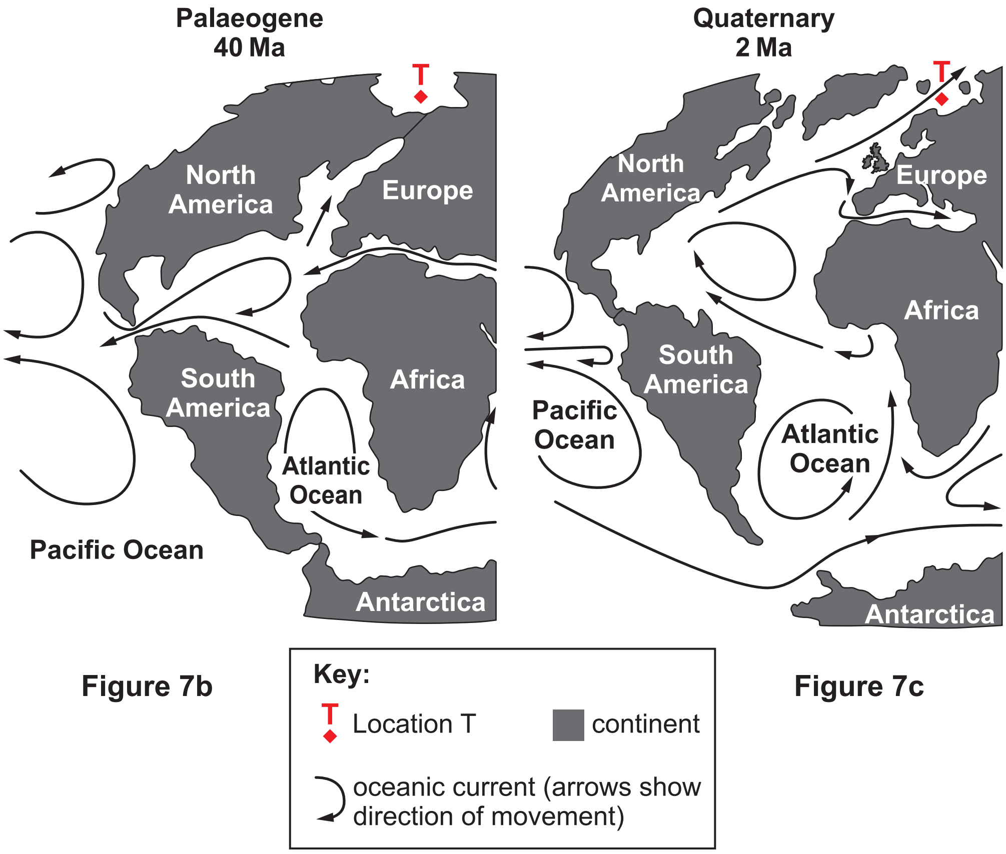

Figure 7b

Figure 7c

Refer to **Figure 7b** and **Figure 7c**.

(i) Describe how the changing position of the continents since the Palaeogene has altered patterns of oceanic circulation in the Atlantic and Pacific Oceans. [3]

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(ii) Explain how the changes in oceanic circulation may have led to the change in Antarctic sea surface temperature over the last 40 Ma shown in **Figure 7a**. [2]

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Examiner only

(iii) Suggest how the changes in oceanic circulation might have affected sea surface temperatures in Northern Europe at **Location T** over the last 40 Ma. Give a reason for your answer. [3]

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Examiner only

8. **Figure 8** is a tree pollen diagram from a site at an altitude of 450 m in the Brecon Beacons, Wales, that was glaciated in the past.

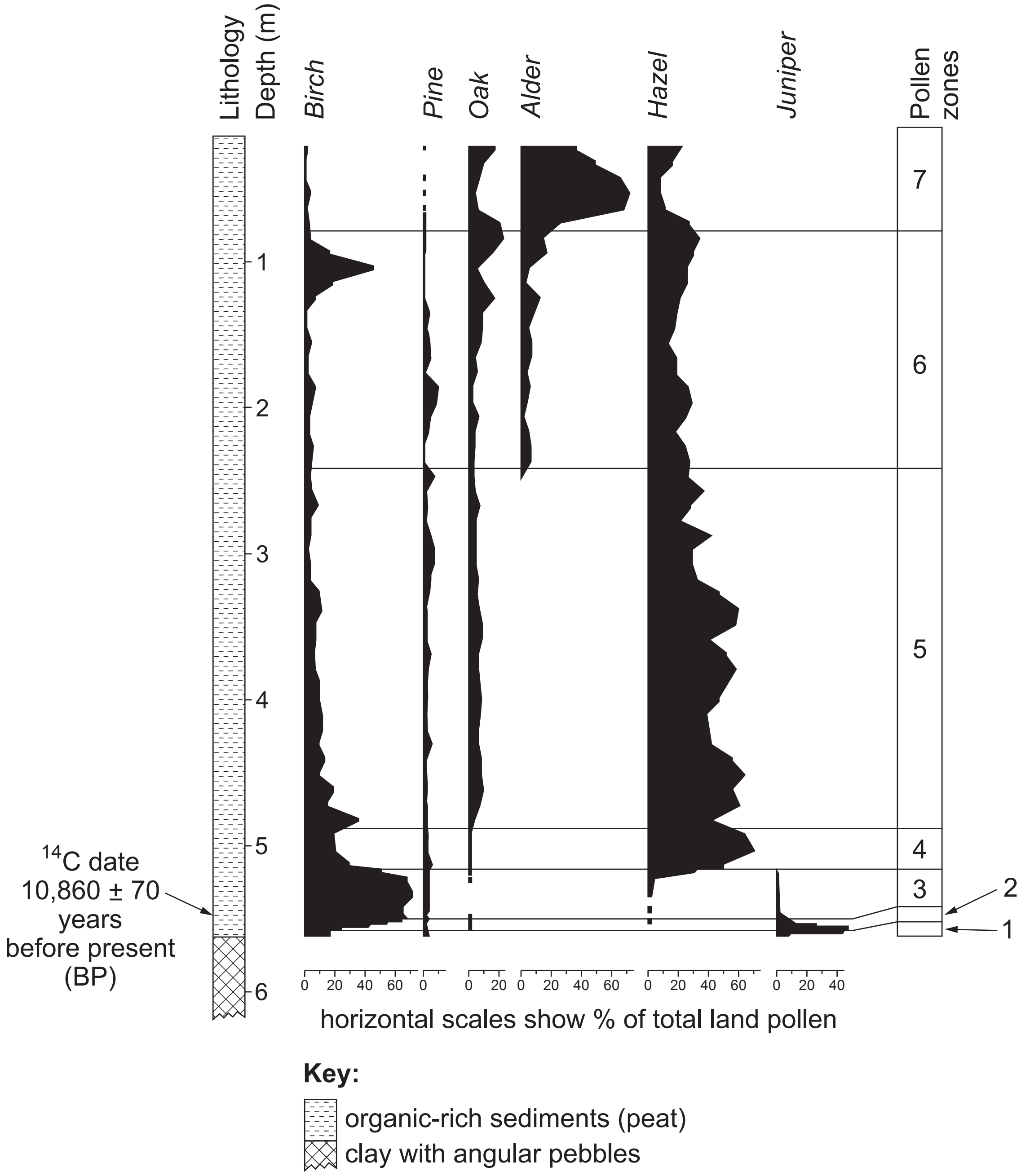

Figure 8

Refer to **Figure 8**.

(a) No pollen was found in this location at a depth of 6 metres. Suggest **one** reason for this. [1]

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Examiner only

(b) (i) Juniper has been identified as a "pioneer species" that occupies bare ground rapidly after a change in climate.
State how **Figure 8** supports this interpretation. [2]

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(ii) Describe the changes in the tree pollen in pollen zones **2**, **3** and **4**. [3]

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(iii) Suggest why the abundance of oak and alder changes in pollen zones **5**, **6** and **7**. [2]

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(c) "Pollen analysis provides more complete evidence of climatic fluctuations than the vertebrate fossil record in Britain during the Quaternary period."
Evaluate this statement. You should refer to **Figure 8** in your answer. [4]

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Examiner only

9. Explain the limitations of dating deposits and events during the Quaternary of Britain. [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.

10. **Figure 10a** is a seismic section through part of the North Sea.
Figure 10b is an interpretation of the geology in the section.

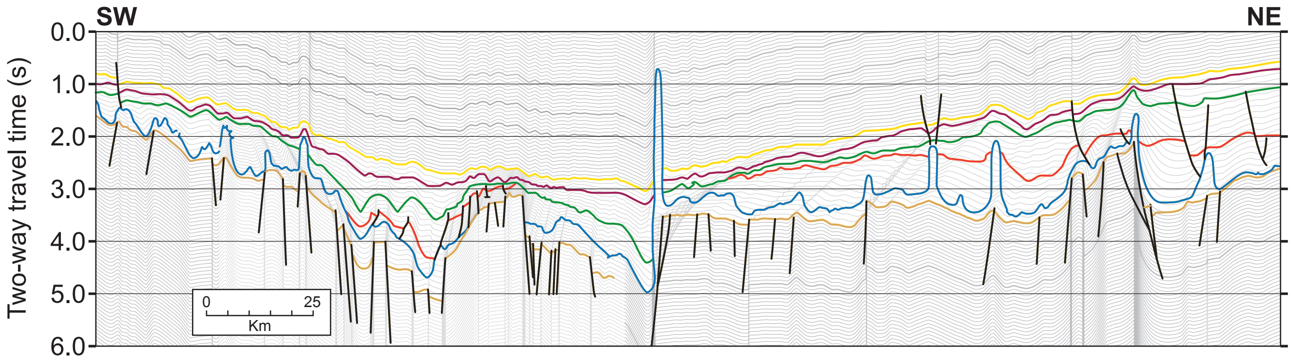

Figure 10a

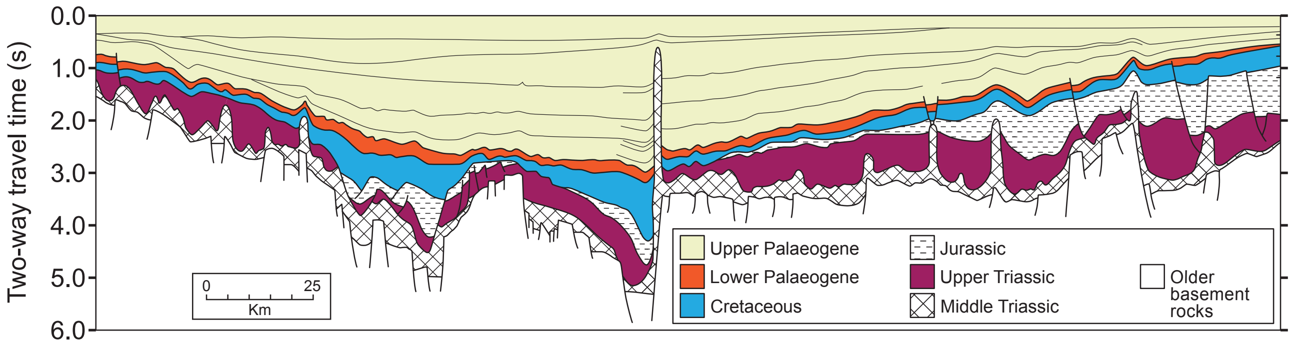

Figure 10b

(a) Refer to **Figure 10a**.

Explain what is meant by "two-way travel time". [2]

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(b) Refer to **Figure 10b**.

The Middle Triassic rocks of the North Sea area contain thick deposits of salt.

(i) Explain how thick deposits of salt were laid down in the British area during the Triassic. [2]

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Examiner only

(ii) Explain why the Middle Triassic rocks cut across younger rocks in some places. [2]

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(c) The faulting shown on **Figure 10b** is largely related to the opening of the North Atlantic Ocean.

Refer to **Figure 10b**.

(i) State the type of stress (compression or tension) to which these rocks were subjected.

Stress type ....

Explain the reasons for your choice. [2]

Explanation: ....

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(ii) A student suggested that “the North Sea area continued to subside after the tectonic stress had ceased”.
Evaluate this statement with reference to the geological evidence. [3]

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11. **Figure 11a** is a simplified geological map of the Builth Wells Inlier, an area in Wales. **Figure 11b** shows the three types of graptolite named in the key to **Figure 11a**.

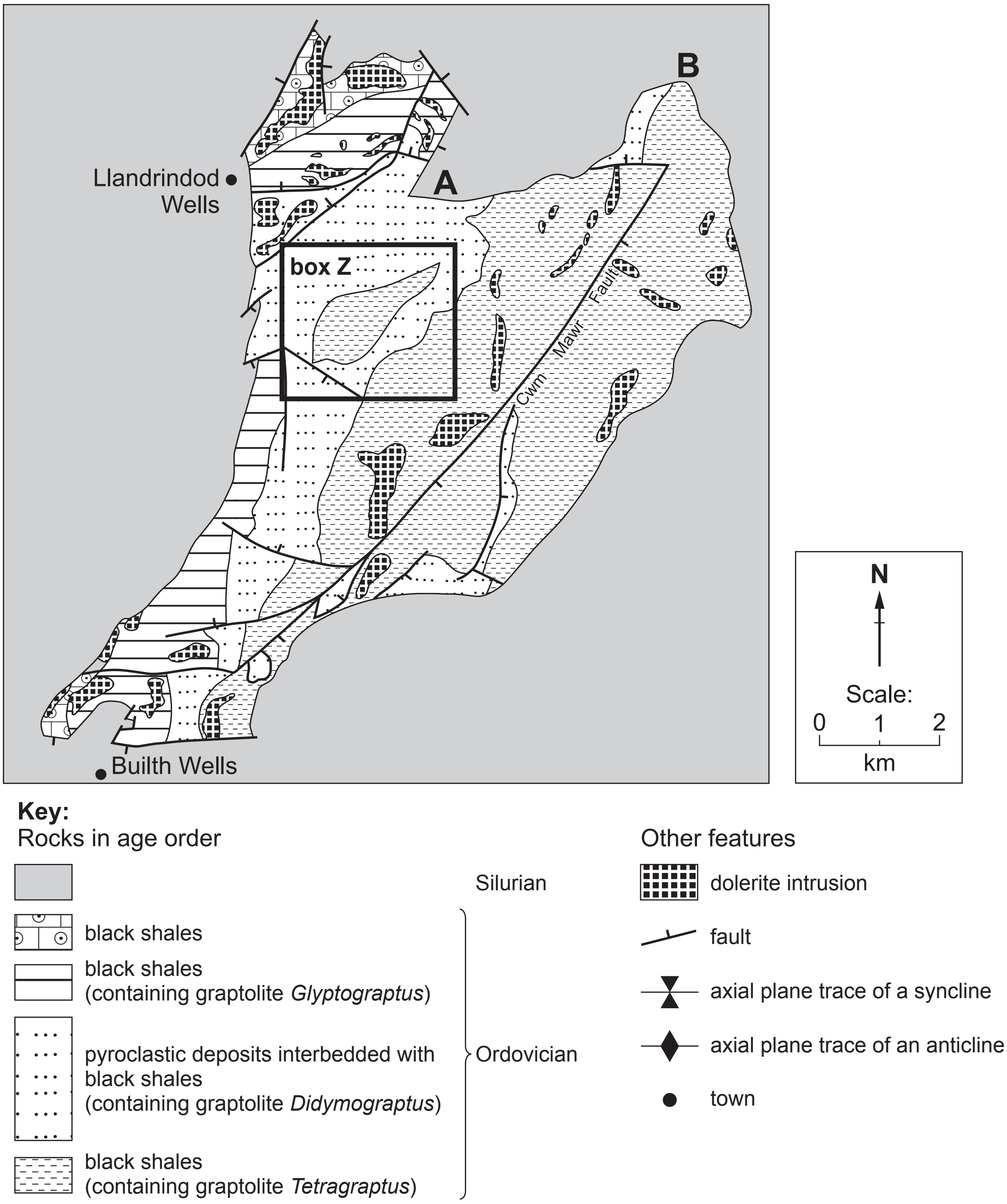
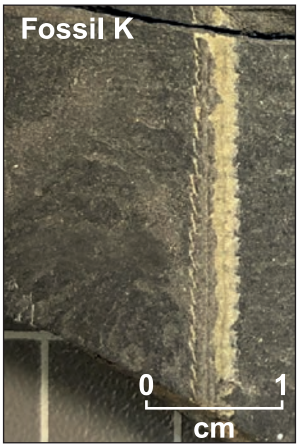


Figure 11a

Examiner only



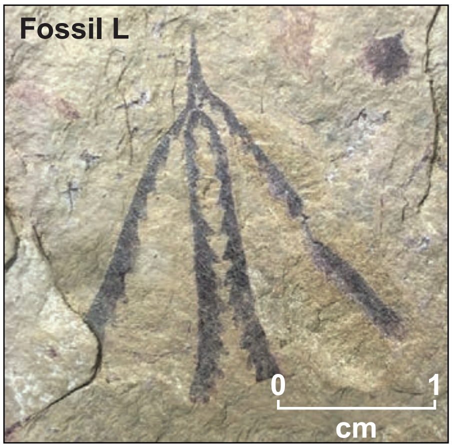


Figure 11b

(a) State the type of boundary between the Ordovician and Silurian rocks from locations **A** to **B** on **Figure 11a**. Give **one** reason for your answer. [2]

Type of boundary: ....

Reason: ....

....

(b) Refer to **Figures 11a** and **11b**.

(i) With reference to the key in **Figure 11a**, state which of the fossils, **J**, **K** or **L** shown in **Figure 11b** is *Glyptograptus*. Give **two** reasons for your answer. [3]

Fossil: [ ]

Reasons: ....

....

....

(ii) The sedimentary environment of this area during the Ordovician has been interpreted as "a low energy marine environment". Explain why this interpretation is regarded as being correct. [3]

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Examiner only

(c) The rocks in **box Z** on **Figure 11a** have been folded.

(i) Mark in **box Z** the axial plane trace of **one** fold, using the correct symbol from the key. Describe the evidence for your choice of fold type. [2]

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(ii) A student suggested that "the rocks of the Builth Wells Inlier were deformed during an early stage of the Caledonian Orogeny".
Evaluate this statement with reference to the evidence on **Figure 11a**. [3]

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13

Examiner only

12. Explain how palaeomagnetic data in some British rocks provides evidence for the change in latitude of Britain through geological time. [6 QER]

6

Option 3: Geology of the Lithosphere

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

13. **Figure 13a** shows the age distribution of orogenic belts in the continental area of North America. **Figure 13b** shows a simplified cross-section along the line **W–X** on **Figure 13a** as it might have looked 5 Ma ago.

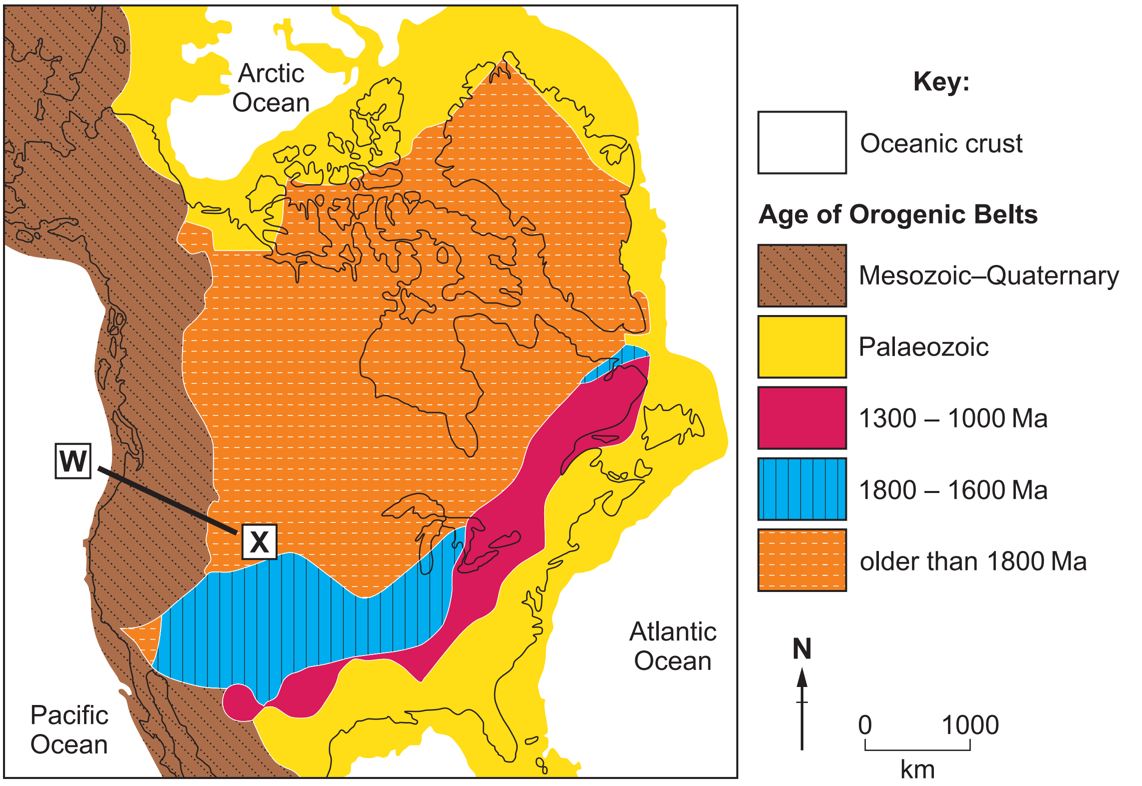

Figure 13a

Cross-section along the line **W–X** as it might have looked 5 Ma ago (not to scale)

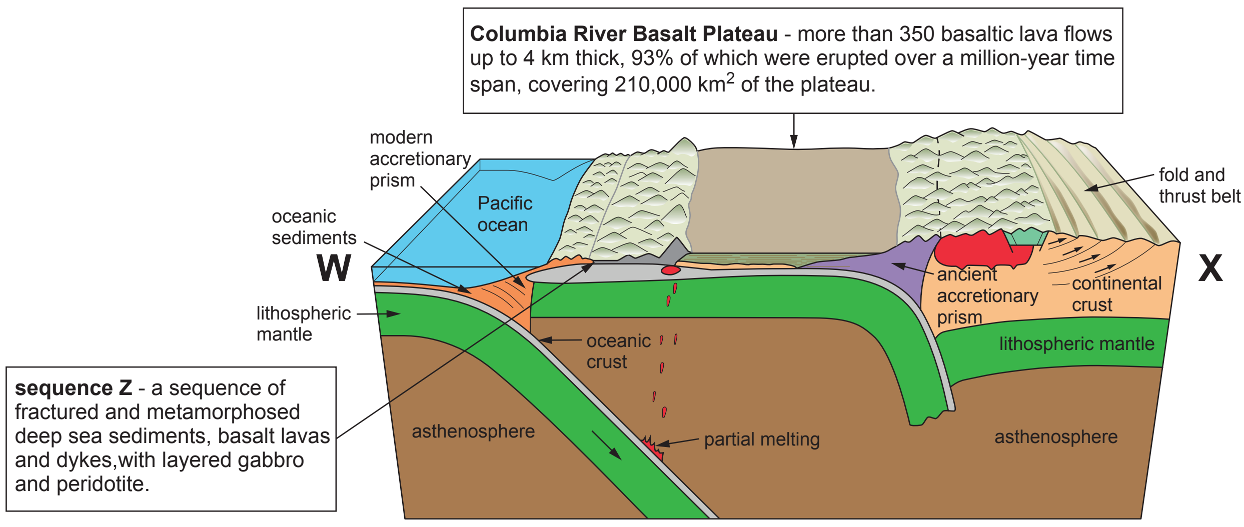

Figure 13b

Examiner only

(a) With reference to **Figure 13a**, describe the age distribution of orogenic belts in the continental area of North America. [3]

(b) Refer to **Figure 13b**.

State the name for the sequence of rocks labelled **Z** in **Figure 13b**. Explain your answer. [2]

Name

Explanation

(c) The Columbia River Basalt Plateau in **Figure 13b** is an example of a large igneous province (LIP), interpreted as the product of a mantle plume. Explain the evidence in **Figure 13b** which might support this interpretation. [3]

(d) Explain how the processes operating in **Figure 13b** have contributed to the age distribution of rocks in **Figure 13a**. [4]

12

Examiner only

14. **Figure 14a** is a model of partial melting associated with continental lithosphere showing the geothermal gradient (geotherm), together with the melting point curve (solidus) for the crust and upper mantle. **Figure 14b** is a variation of the model with a thinner continental lithosphere.

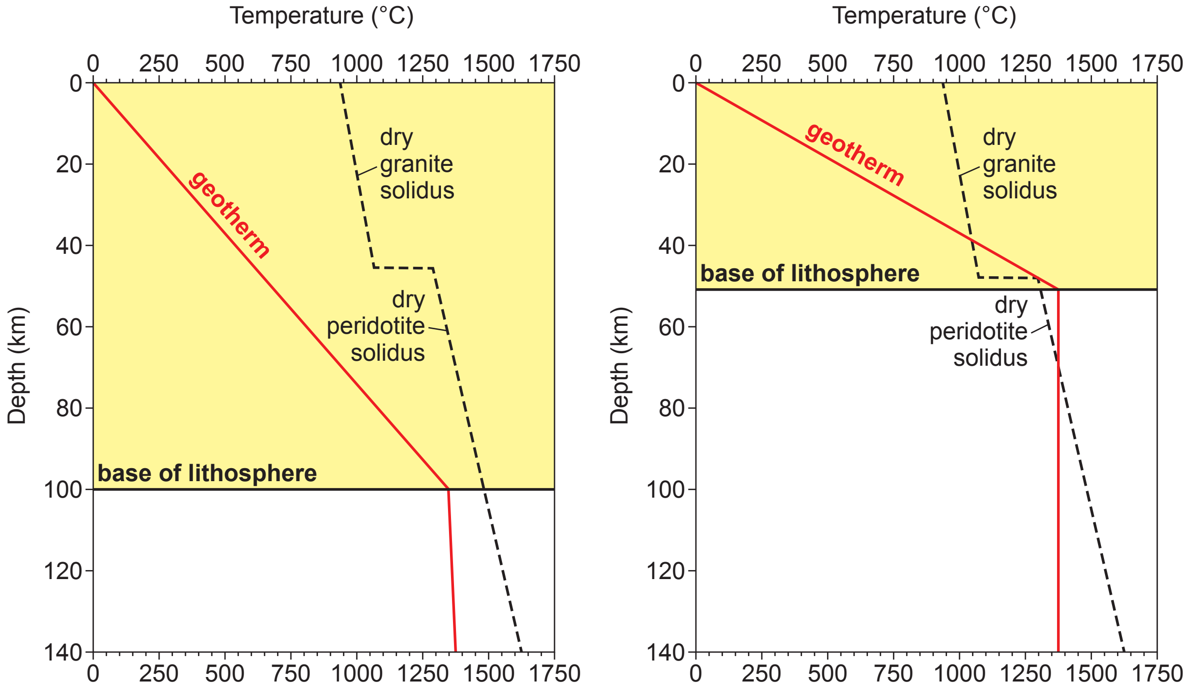

Figure 14a **Figure 14b**

(a) Refer to **Figure 14a**.

(i) State the approximate thickness of continental crust in **Figure 14a**. [1]

.... km

(ii) State **two** pieces of evidence in **Figure 14a** to confirm that the crust refers to **continental** crust and **not** oceanic crust. [2]

1. ....

....

2. ....

....

(b) (i) Explain why partial melting does **not** occur under the conditions shown in **Figure 14a**. [1]

....

....

(ii) Shade on **Figure 14b** where the model predicts that partially molten material will be generated. [2]

Examiner only

(c) The continental lithosphere in **Figure 14b** is half as thick as in **Figure 14a**. **Figure 14c** shows the process of delamination that has been proposed to account for thinning of the continental lithosphere beneath a thick orogenic belt.

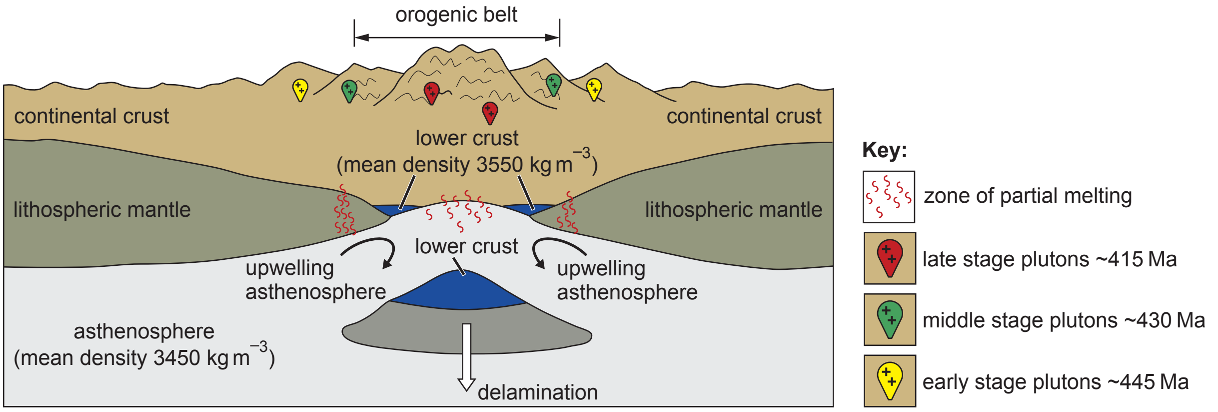

Figure 14c

Refer to **Figure 14c**.

Explain how it is proposed the continental lithosphere is thinned beneath the orogenic belt in **Figure 14c**. [3]

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(d) Describe the pattern of pluton ages in the orogenic belt in **Figure 14c**. Suggest an explanation for this pattern. [3]

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12

Turn over.

Examiner only

15. Explain how magnetic anomalies are used to calculate the direction and rate at which an ocean basin is widening. [6 QER]

6

END OF PAPER

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

Examiner only

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

Examiner only

Acknowledgements

Figures 1b and **1c:** Adapted from: Frampton, S. *et al* (2000) Natural Hazards: causes, consequences and management. *Hodder & Stoughton.*

Figure 8: Adapted from: Walker, M.J.C. Craig Cerrig-glesiad: pollen stratigraphy and dating. In Carr. S.J. *et al* (2007) *Quaternary of the Brecon Beacons; Field Guide.* Quaternary Research Association, London.

Figures 10a and **10b:** Charles, R. & Ryzhikov, K. (2015). Merganser Field; managing subsurface uncertainty in the UK Central North Sea. *Geol. Soc. Spec. Pub.* ***403****, 261-298.*

Figure 11a: Bevins, R.E & Metcalfe, R. (1993) Ordovician Igneous Rocks, Builth. In: Bassett, M.G. & Woodcock, N.H. (eds.) Geological Excursions in Powys. *University of Wales Press.*

Figure 11b: Photographs M. Walsh; specimens courtesy of the National Museum of Wales.

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