Surname	Centre Number	Candidate Number
First name(s)		2

wjec cbac

GCE A LEVEL

A480U30-1

O20-A480U30-1

eduqas Part of WJEC

MONDAY, 19 OCTOBER 2020 – MORNING

GEOLOGY – A level component 3
Geological Applications

2 hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a calculator
- a ruler
- a protractor
- the Geological Map Extract (Wells)

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1.	15	
	2.	15	
Section B	3.	16	
	4.	6	
	5.	10	
	6.	13	
Section C	Option	30	
	Total	105	

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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 continuation pages at the back of the booklet, taking care to number the questions 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. **Figure 1** is an isoseismal map of an earthquake that occurred in 1979 showing the extent of the felt area using the European Macroseismic Scale (EMS).

Table 1 shows part of the European Macroseismic Scale.

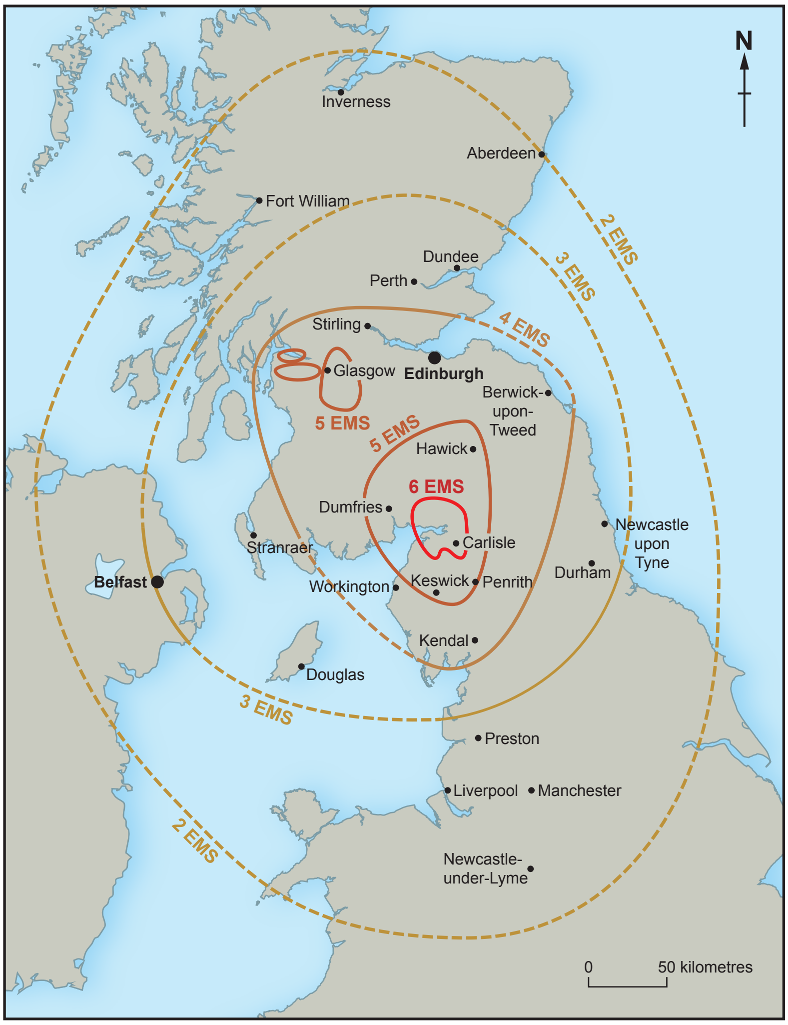

Figure 1

1. Not felt	Not felt, even under the most favourable circumstances.
2. Scarcely felt	Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.
3. Weak	The vibration is weak and is felt indoors by a few people. People at rest feel a swaying or light trembling.
4. Largely observed	The earthquake is felt indoors by many people, outdoors by very few. A few people are awakened. The level of vibration is not frightening. Windows, doors and dishes rattle. Hanging objects swing.
5. Strong	The earthquake is felt indoors by most, outdoors by few. Many sleeping people awake. A few run outdoors. Buildings tremble throughout. Hanging objects swing considerably. China and glasses clatter together. The vibration is strong. Top heavy objects topple over. Doors and windows swing open or shut.
6. Slightly damaging	Felt by most indoors and by many outdoors. Many people in buildings are frightened and run outdoors. Small objects fall. Slight damage to many ordinary buildings; for example, fine cracks in plaster and small pieces of plaster fall.
7. Damaging	Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many ordinary buildings suffer moderate damage: small cracks in walls; partial collapse of chimneys.

Table 1

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Refer to **Figure 1** and **Table 1**.

(a) Mark on **Figure 1** a likely location for the epicentre (E→) of this earthquake. [1]

(b) (i) Describe the pattern of intensity shown by the EMS isoseismal lines. [2]

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(ii) There was an anomalous earthquake intensity in the Glasgow area. Suggest **one** possible geological reason for this anomaly. Explain your answer. [2]

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(c) Using your knowledge, explain **two** ways in which earthquakes might be predicted by monitoring seismic activity. [4]

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(d) (i) The Seismic Moment (M_0) for the earthquake shown in **Figure 1** was 10^{23}.

Calculate the Moment Magnitude (M_W) of this earthquake using the equation below:

$$M_W = \frac{2}{3}\log_{10}\left(M_0\right) - 10.7$$

Show your working. [3]

M_W = ...

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(ii) Explain how the destructive effects of a British earthquake of **this** magnitude and intensity might be managed. [3]

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2. **Figure 2a** is a cross-section through the waste tip of Maerdy Colliery in South Wales before remediation. **Figure 2b** is a cross-section through part of the same waste tip after remediation work to permit a factory to be built.

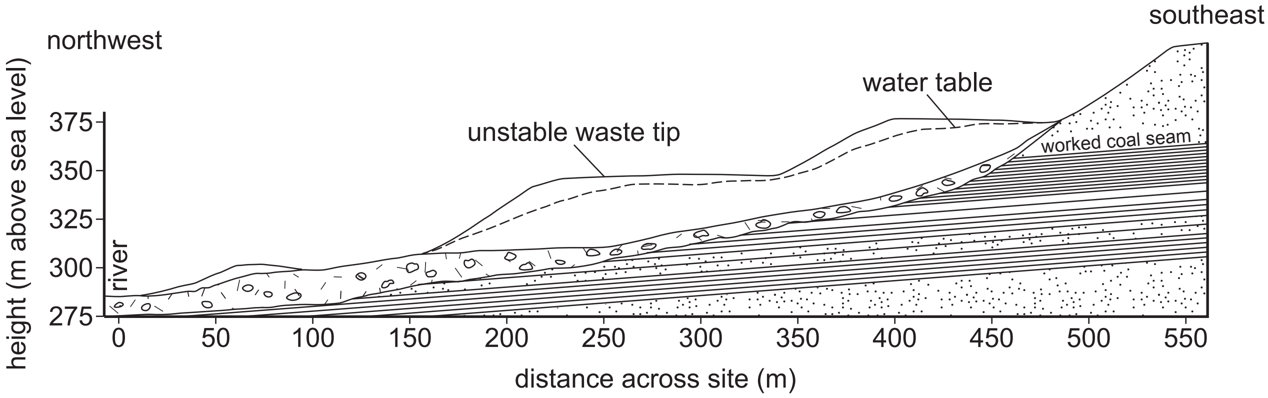

Figure 2a

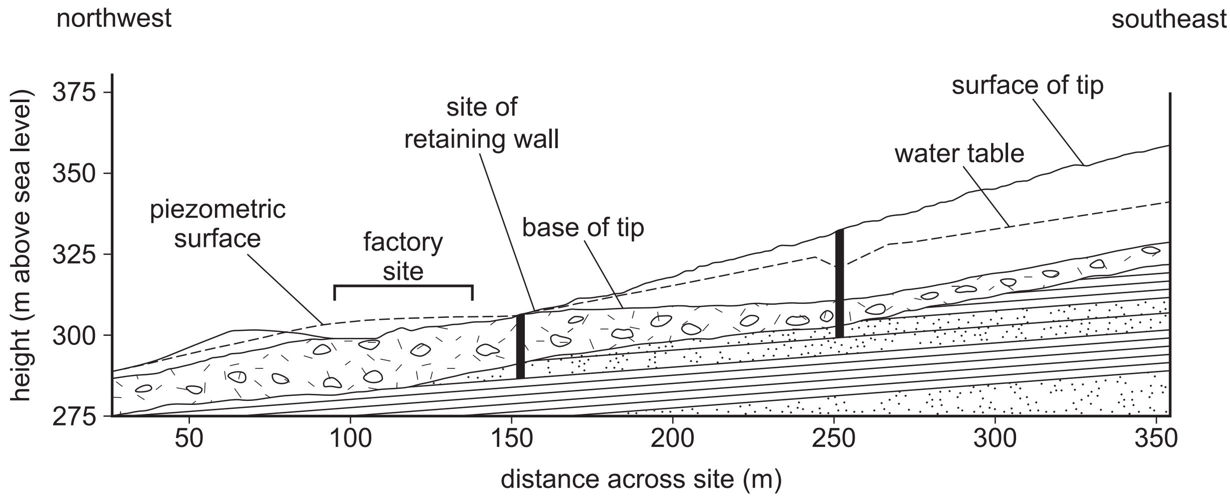

Figure 2b

Key
- mining waste
- superficial deposits
- sandstone
- mudstone
- coal seam
- borehole for extraction of groundwater

Refer to **Figure 2a**.

(a) (i) Describe the geological structure of this area. [2]

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(ii) State how the geology of this area contributed to the low stability of slopes in this valley prior to mining. [3]

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(b) Explain how human activities before remediation have further reduced the stability of this slope. [4]

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Refer to **Figure 2b**.

(c) State **two** remediation measures that have been used to stabilise this waste tip. Explain how each method has reduced the risk of mass movement in this location. [4]

Measure 1: ....

Explanation: ....

....

Measure 2: ....

Explanation: ....

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(d) Describe **one** geohazard indicated by the piezometric surface around the factory site on **Figure 2b**. [2]

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SECTION B

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

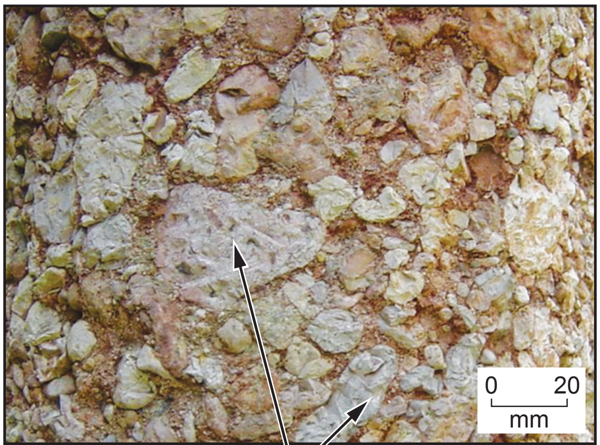
*Questions **3 – 6** relate to the **British Geological Survey 1:50 000 geological map** extract from the Wells Sheet (Solid and Drift).*

3. *(a)* The **generalised geological column** indicates an unconformity at the base of the Dolomitic Conglomerate (**DCg**). State **two** pieces of evidence from **box A** on the **geological map** for this unconformity. [2]

1. ....

2. ....

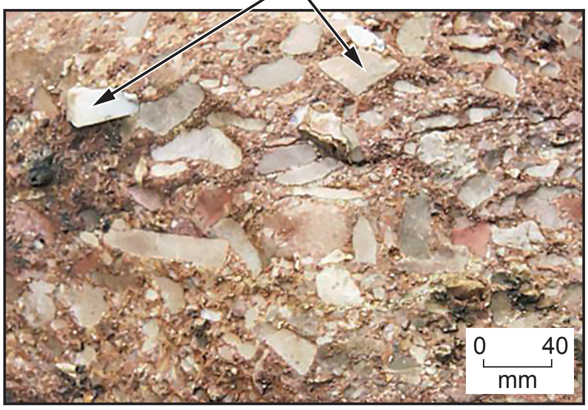
(b) During a field study of the area, a student identified two different facies (**X** and **Y**) within the Dolomitic Conglomerate (**DCg**) at localities close to each other. **Figure 3a** and **Figure 3b** are photographs and textural data representative of each of the facies.



Carboniferous Limestone clasts

Facies **X**	
Grain size	0.25 mm to 40 mm
Grain shape	subrounded – subangular
Sorting	poor

Figure 3a



Facies **Y**	
Grain size	3 mm to 60 mm
Grain shape	•
Sorting	•

Figure 3b

Examiner only

(i) Complete the table in **Figure 3b** to describe the texture of the Dolomitic Conglomerate (**DCg**) in facies **Y**. [2]

(ii) Explain the evidence from the **geological map** and **Figure 3a** that suggests the Dolomitic Conglomerate (**DCg**) was deposited
- rapidly
- in steep-sided valleys
- following the uplift and erosion of Carboniferous Limestone. [3]

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(c) A Mann-Whitney U-test was conducted using roundness index data for a random sample of 10 clasts from the Dolomitic Conglomerate (**DCg**) from each facies. This was to test the null hypothesis (H_0) that *there is no significant difference between the roundness of the clasts of the two facies*.

Dolomitic conglomerate clasts of facies **X**		Dolomitic conglomerate clasts of facies **Y**	
Roundness index	Rank (R_x)	Roundness index	Rank (R_y)
780	1	700	•
760	2	640	9
730	3	630	10
720	4	620	11
710	•	610	•
680	7	600	14
650	8	590	15
610	•	550	17
570	16	520	19
530	18	490	20
$\sum R_x = 76.5$		$\sum R_y = 133.5$	
• $U_x =$		$U_y = 21.5$	

The formula used for the Mann-Whitney U test is:

$$U_x = (n_x n_y) + \frac{n_x(n_x+1)}{2} - \sum R_x \quad \text{or} \quad U_y = (n_x n_y) + \frac{n_y(n_y+1)}{2} - \sum R_y$$

where
- U_x and U_y are the Mann Whitney scores for samples X and Y respectively
- n_x and n_y are the number in samples X and Y respectively
- ΣR_x and ΣR_y are the sums of the ranks for samples X and Y respectively

Table 2

(i) Complete **Table 2** by entering the missing ranks for the whole data set. [2]

(ii) Using the formula in **Table 2**, calculate the Mann-Whitney score (U_x) for facies **X**. Complete the 'U_x =' box in **Table 2** with your answer. Show your working below. [2]

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(iii) At a significance level of 0.05 (95% confidence level) the critical Mann-Whitney value for U is 23. Using the Mann Whitney value for U_y (21.5), assess the significance of this value in terms of the null hypothesis (H_0). [2]

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(d) Explain how the **two** facies (**X** and **Y**) within the Dolomitic Conglomerate (**DCg**) and the Mann-Whitney U test result, provide evidence of different surface processes operating in the same environment. [3]

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4. Refer to the **geological map** and **cross-section**.

(a) The Stock Hill Fault and Biddle Fault both cross the axis of the anticline at North Hill.

(i) *'The Stock Hill Fault is downthrown to the west.'*
State **two** pieces of evidence from the **geological map** to support this statement. [2]

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(ii) The **geological map** near grid reference **(GR) 570478** shows the base of the Black Rock Limestone **(BRL)** aligned with the top of the Portishead Beds **(PoB)** across the Biddle Fault. Using the **generalised geological column**, calculate the throw of the Biddle Fault at this location. Show your working. [2]

(b) The Stock Hill Fault and Biddle Fault both formed at the same time although the Biddle Fault was later reactivated. Explain the evidence from the **geological map** that shows the Biddle Fault was later reactivated. [2]

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5. **Table 3** is a partly completed tally of the mineral vein orientations on the **geological map**. **Figure 5** is a partly completed rose diagram of the mineral vein orientations.

Direction	N–S	NE–SW	E–W	SE–NW
Tally	~~////~~ ~~////~~ /	/	~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ ///	~~////~~ / ~~////~~ ~~////~~
Total	•	**1**	•	•

Key

/ = 1 mineral vein ~~////~~ = 5 mineral veins

Table 3

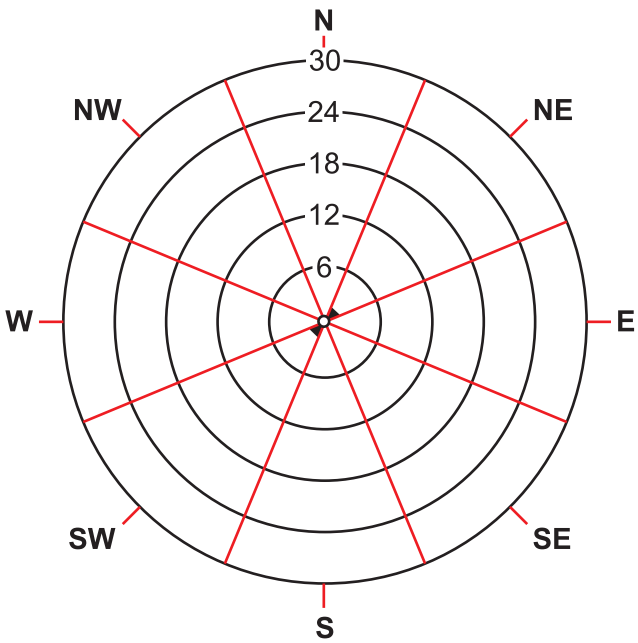

Figure 5

Refer to the **geological map**, **Table 3** and **Figure 5**.

(a) Name **one** metal found in mineral veins in this region. [1]

....

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(b) (i) The tally in **Table 3** does not include the orientations of **seven** mineral veins within **box B** on the **geological map**. Add these to the tally and complete the totals for the data set. [2]

(ii) Complete the rose diagram **(Figure 5)** to show the orientations of the mineral veins for the completed data set in **Table 3**. [3]

(iii) A student concluded that;
"Mineral veins are
- *only found in steeply dipping Carboniferous Limestone*
- *orientated parallel to the axis of the anticline at North Hill".*

Critically evaluate this statement using evidence from the **geological map** and **Figure 5**. [4]

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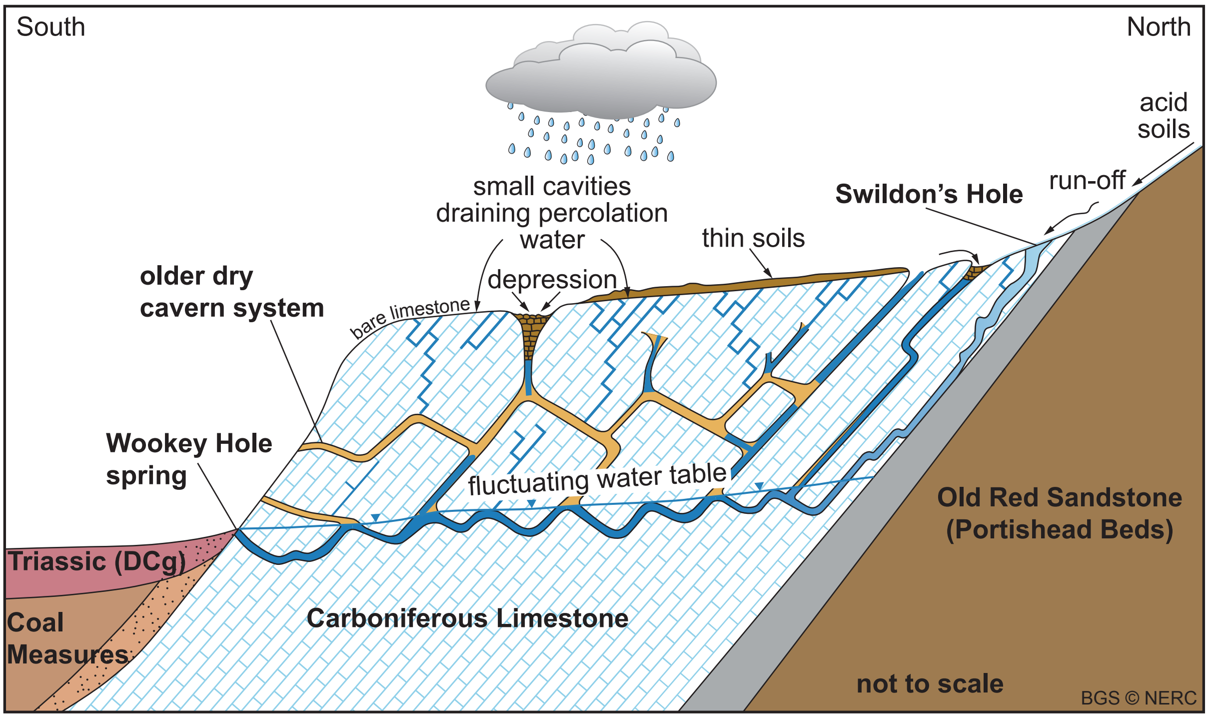
6. **Figure 6** is a simplified cross-section from North Hill, south to the spring at Wookey Hole, together with a table showing the primary porosity and relative permeability of the major rock formations.



Formation	Primary porosity %	Relative permeability
Old Red Sandstone	6.6%	low
Carboniferous Limestone	0.18%	very high
Dolomitic Conglomerate (DCg)	variable	high

Figure 6

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

(a) (i) Suggest how the texture of Carboniferous Limestone might result in a low primary porosity. [2]

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Examiner only

(ii) Suggest why the relative permeability of Carboniferous Limestone is very high. [3]

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(b) The velocity of water flow in the unsaturated zone above the water table of many aquifers is usually measured in metres per year. Tracer dyes, introduced into the entrance of Swildon's Hole (labelled **SH*** in **grid square 5351**), indicate a mean travel time of just 27 hours to the spring at Wookey Hole (labelled **WH*** in **grid square 5347**).

(i) With reference to the **geological map**, calculate the mean velocity of water flowing from the entrance of Swildon's Hole to the spring at Wookey Hole. Show your working. [2]

.... mh^{-1}

(ii) State **two** factors, other than permeability, that might affect the rate of water flow between the surface and the spring. [2]

Factor ....

Factor ....

(c) *"Most aquifers provide a degree of natural filtration through soil and pores in the rock which removes solid materials and produce a relatively pure water supply from springs."*

With reference to the **geological map** and **Figure 6**, assess the risk of contamination that the following potential sources of pollution may have on spring water at Wookey Hole;

- the slow chemical weathering of galena from mineral veins and associated ancient mine spoil tips
- the accidental spillage of industrial chemicals, such as oil or petrol, from waste dumping in limestone quarries near to Swildon's Hole. [4]

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SECTION C

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

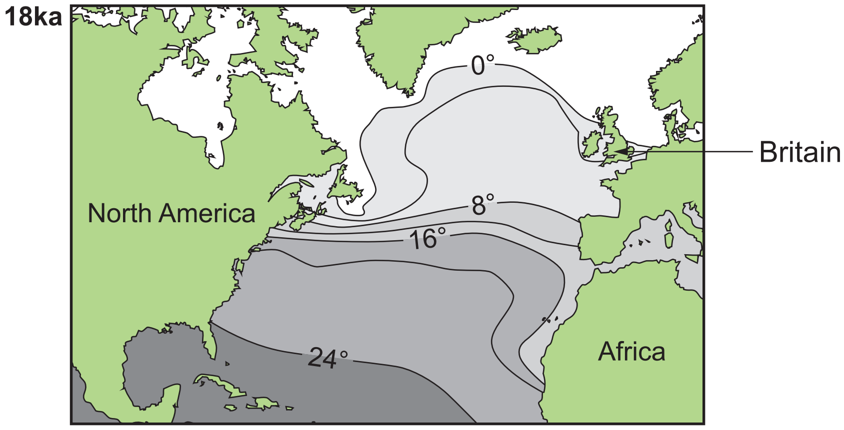
Tick (✓) ***one*** *of the boxes below to indicate which* ***one*** *option you have selected.*

☐ 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 the mean summer surface ocean temperatures (in °C) for the North Atlantic Ocean at the last glacial maximum 18,000 years ago (18ka). **Figure 7b** shows the present day mean summer surface ocean temperatures (in °C) for the North Atlantic Ocean.



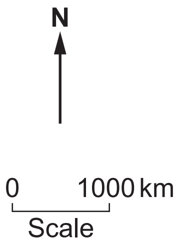


Figure 7a

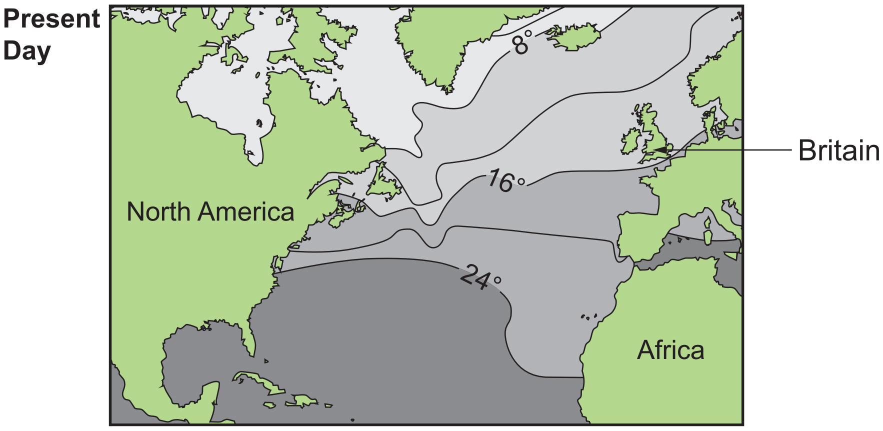


Figure 7b

(a) Refer to **Figures 7a** and **7b**.

(i) Describe **two** differences in the position of the 8°C isotherm between 18 ka and the present day. [2]

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(ii) Explain the effect of this change on the climate of Britain. [2]

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(b) **Figure 7c** shows a reconstruction of the temperature on the coasts of North America and Europe between 18ka and 9.5ka before present (BP).

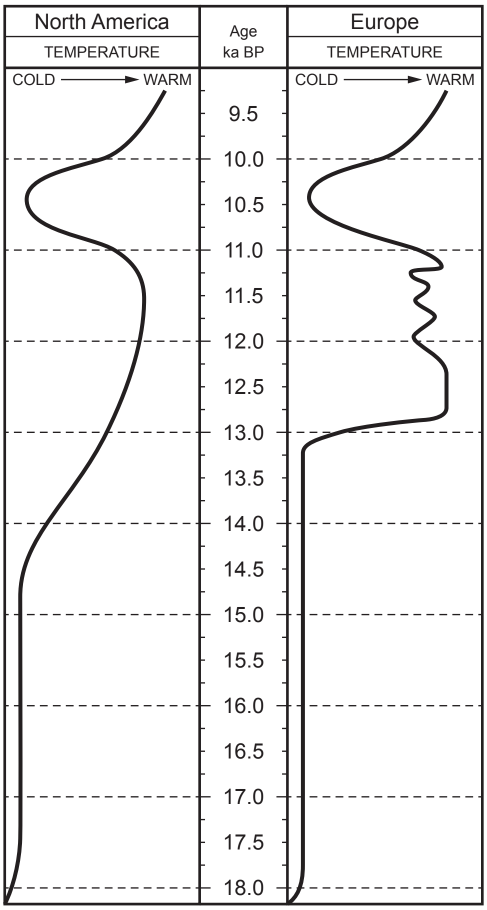

Figure 7c

Refer to **Figure 7c**.

(i) State **one** difference between the changes in temperature in North America and Europe between 18ka and 9.5ka. [1]

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(ii) State the age of a period of glacial readvance across the Northern Hemisphere. [1]

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(iii) Explain **two** glacial deposits that could indicate the occurrence of a glacial readvance. [4]

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8. **Figure 8a** is a sketch of a sequence of sediments from Olorgesailie, Kenya in which stone tools have been found. Interpretations of the environments of deposition are shown.
Figure 8b shows graphs of hominin brain size and climatic fluctuation over the last 3.5 Ma.

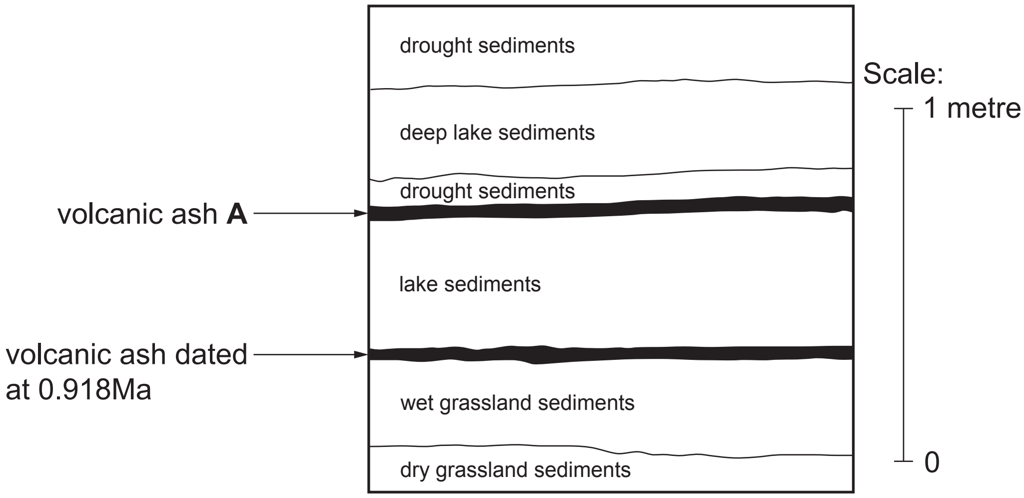

Figure 8a

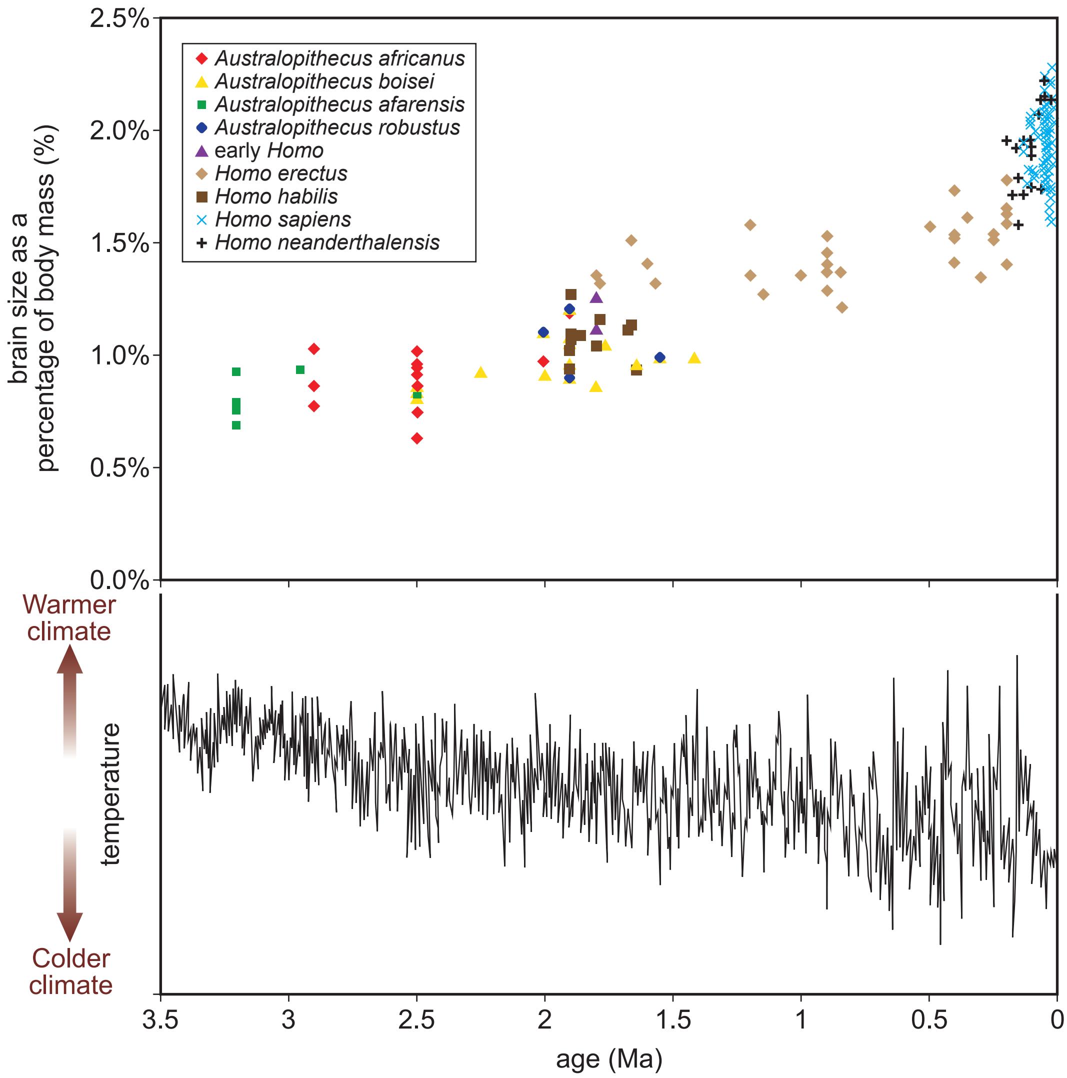

Figure 8b

Examiner only

Refer to **Figures 8a** and **8b**.

(a) (i) State the name of the hominin species that existed at the time the sediments in **Figure 8a** were depositied. [1]

....

(ii) Describe the environmental changes suggested by the sequence in **Figure 8a**. [2]

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(b) A sample of volcanic ash **A** shown in **Figure 8a** was tested and found to contain 90,000 isotopes of ^{40}K and 45 isotopes of ^{40}Ar.

(i) Calculate the radiometric age of volcanic ash **A**. Show your working. [3]

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

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

.... Ma

(ii) Evaluate the statement, *"dating a volcanic ash layer is more effective than radiocarbon dating in determining a timescale for hominin evolution".* [3]

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Examiner only

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

(i) Describe the change in hominin brain size as a percentage of body mass over the last 3.5 Ma. [2]

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(ii) Explain why human brain size has evolved in response to climatic change. [3]

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Examiner only

9. Explain why Milankovitch cycles are regarded as a contributory cause of climatic fluctuations during the Quaternary. [6 QER]

6

Option 2: Geological Evolution of Britain

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

10. **Figure 10a** is a sketch of the geology exposed at Caswell Bay, South Wales. **Table 4** shows dip and strike measurements from Locations **X** and **Y** on **Figure 10a**. **Figure 10b** is a simplified graphic log of some of the Carboniferous sedimentary sequence at Caswell Bay.

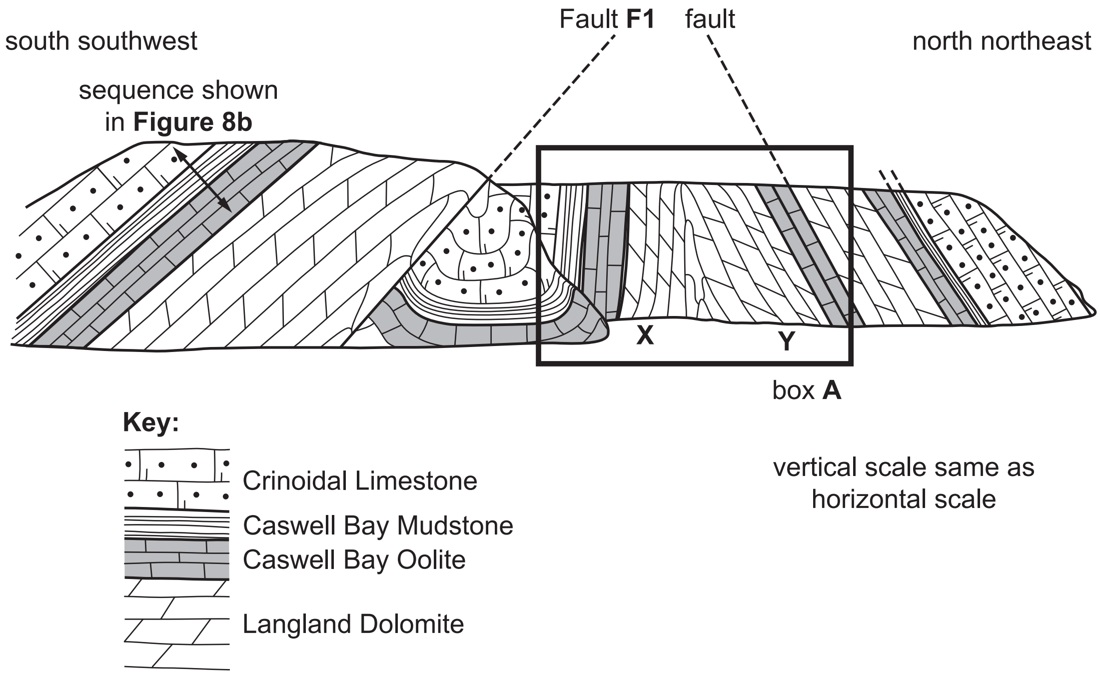

Figure 10a

Location	Strike orientation of beds	Dip of beds
X	110° – 290°	85° SSW
Y	110° – 290°	72° NNE

Table 4

Examiner only

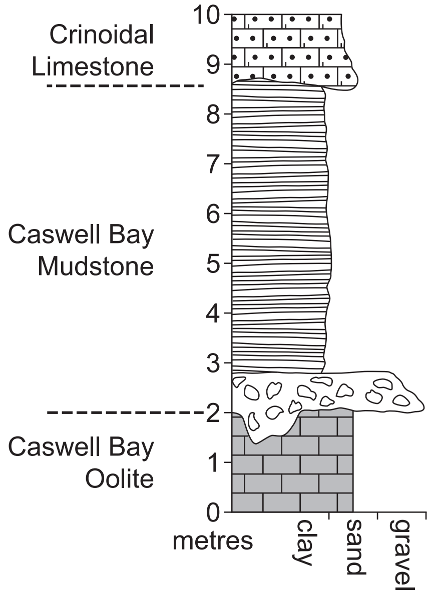

Figure 10b

Refer to **Figure 10a**.

(a) Describe Fault **F1** on **Figure 10a**. [2]

....

....

....

(b) (i) Calculate the interlimb angle of the fold shown in box **A** on **Figure 10a** using the data in **Table 4**. Show your working. [2]

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(ii) Explain why the data in **Table 4** provides evidence that the fold in box **A** on **Figure 10a** is not a plunging fold. [2]

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Examiner only

(iii) Suggest, giving your reasons, the orogenic event most likely to have caused the structures shown in **Figure 10a**. [3]

Orogenic event:

....

Reasons:

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

Explain the evidence that indicates South Wales underwent regression and transgression during the Carboniferous. [3]

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11. **Figure 11** is a simplified geological map of the Isle of Skye, Scotland.

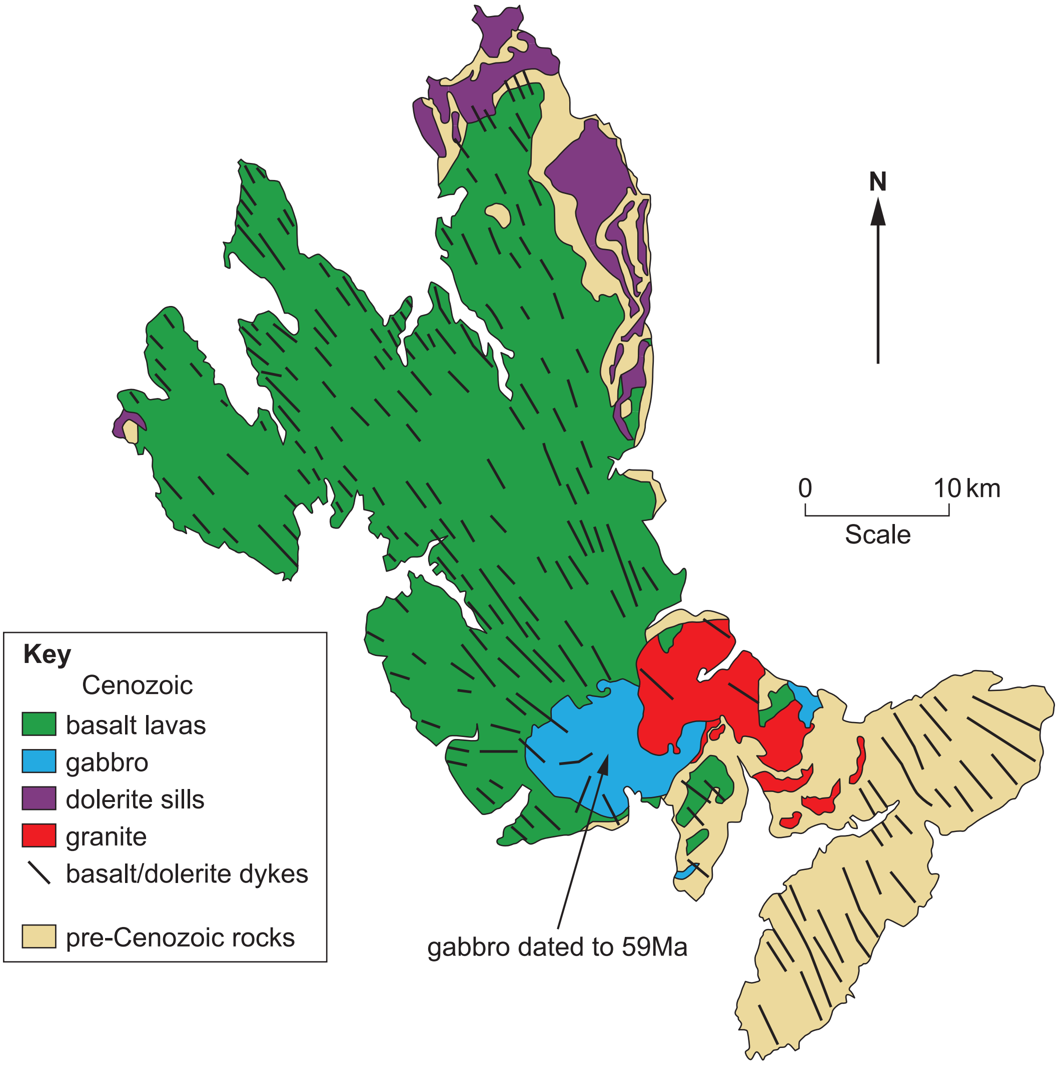

Figure 11

Refer to **Figure 11**.

(a) (i) Describe the relative age of the granite compared to the gabbro and basalt/dolerite dykes on Skye. [2]

....

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Examiner only

(ii) A sample of the granite shown in **Figure 11** was tested and found to contain 40,000 isotopes of ^{40}K and 1,200 isotopes of ^{40}Ar.

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

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

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

.... Ma

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

"Evidence from the geology of the Isle of Skye suggests that it was once located close to a divergent plate margin."

Explain **two** pieces of evidence that would support this interpretation. [4]

Explanation 1: ....

....

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Explanation 2: ....

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(c) The granite has a different composition from other igneous rocks on Skye. Suggest how this granitic magma may have formed. [3]

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Examiner only

12. Explain how the geological evidence from Britain and beyond suggests that there was a global glaciation in the Neoproterozoic. [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.

13. **Figure 13** is a graph showing the relationship between the relative depth to the ocean floor and the age of the oceanic crust for the Pacific, Indian and Atlantic oceans.

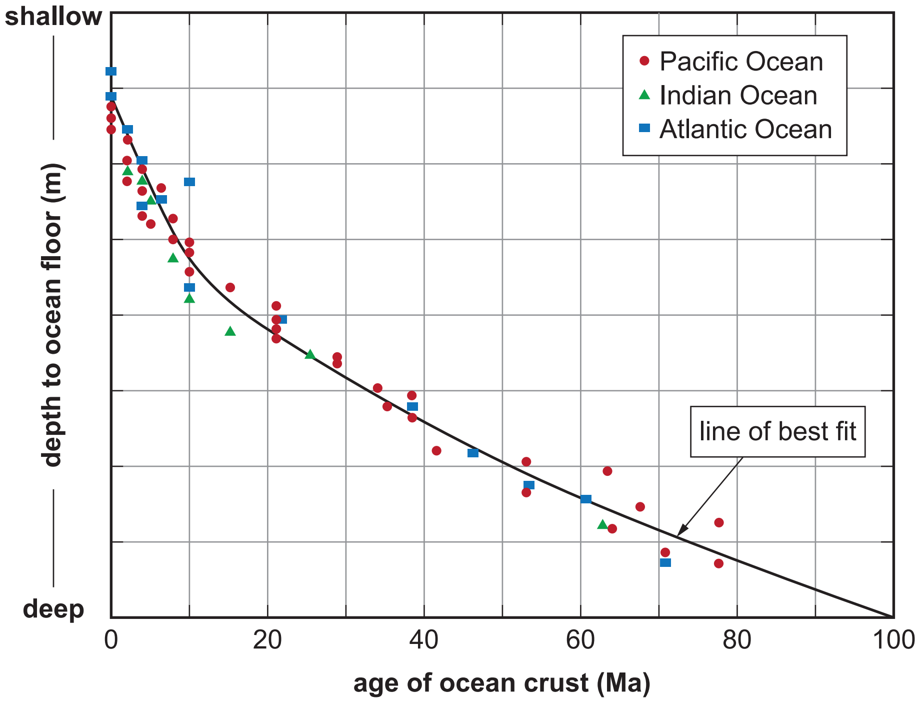

Figure 13

Refer to **Figure 13**.

(a) (i) Describe the relationship between relative depth to the ocean floor and age. [2]

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Examiner only

(ii) The age of the crust at a distance of 1600 km from the Mid-Atlantic Ridge is 40 Ma. Showing your working, calculate the depth to the ocean floor (m) at 1600 km from the Mid-Atlantic Ridge using the equation below: [3]

$$t = \left(\frac{d - 2500}{350}\right)^2 \text{ Ma}$$

where d = depth to the ocean floor (m)
t = age of the ocean crust (Ma)

.... m

(b) *"One of the more remarkable observations of ocean depth measurements is that any ocean floor of similar age always occurs at similar depths beneath sea level."*

(i) Explain how the data in **Figure 13** supports this statement. [2]

....

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(ii) Explain why the ocean floors of similar age in **Figure 13** might occur at the same depth. [3]

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(c) The depth to the ocean floor was obtained by remote sensing using sonar. Explain how the **age** of the ocean crust might have been determined remotely, without direct sampling of the ocean floor or the use of depth data. [2]

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Examiner only

14. **Figure 14a** shows the seismic layers through the oceanic lithosphere. **Figure 14b** shows two proposed models (**model 1** and **model 2**) used to explain the seismic wave velocities. **Table 5** is an explanation of the two models in **Figure 14b**.

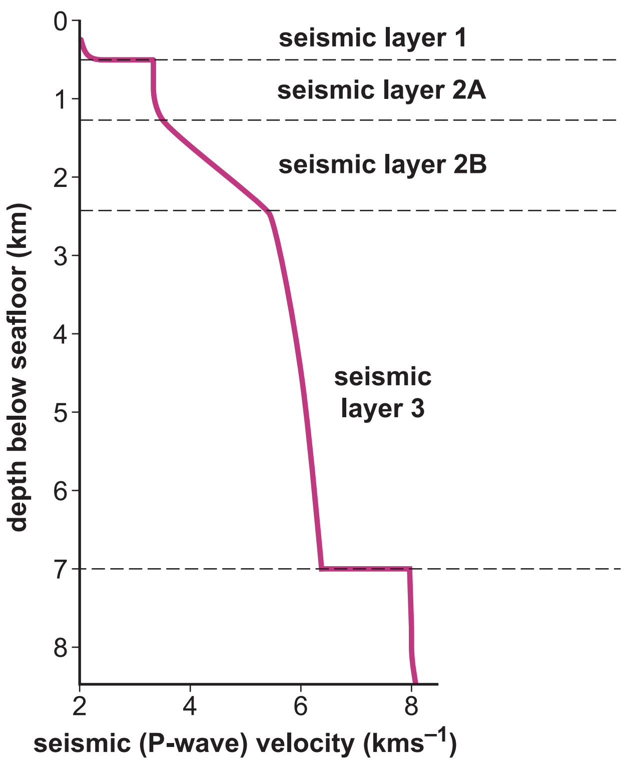

Figure 14a

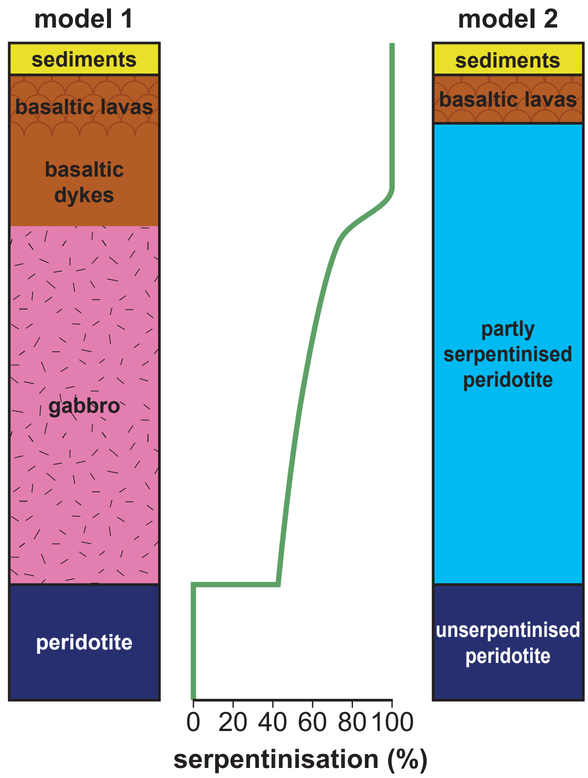

Figure 14b

Model 1 suggests that seismic wave velocities reflect the differences in composition and physical properties of a layered oceanic crust. An alternative model for slow-spreading ridges (**model 2**) suggests that seismic wave velocities depend upon the percentage the mantle has been altered from peridotite to serpentinite (serpentinisation).

Table 5

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

(i) The Mohorovičić discontinuity (Moho) is taken to be the boundary between the crust and the mantle. Mark the position of the Moho on **Figure 14a**, with an arrow labelled (→**M**). [1]

(ii) Explain why seismic layer **1** is thin or absent at the axis of an ocean ridge. [2]

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(iii) Explain the increase in p-wave velocities from seismic layer **1** to **3**.
You may wish to refer to the following formula; [3]

$$V_P = \sqrt{\frac{\left(k + \frac{4\mu}{3}\right)}{\rho}}$$

where V_P = velocity of p-waves
k = a measure of incompressibility
μ = a measure of rigidity
ρ = density

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(iv) State **one** piece of **field** evidence that supports the composition of seismic layer **3** in **model 1** (**Figure 14b**). [1]

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(b) Refer to **Figures 14a** and **Figure 14b**.

(i) Complete **Table 6** by stating
- the rock type in **model 1**
- the % serpentinisation in **model 2**

that the models predict will correspond to a p-wave velocity of 6.0 kms^{-1}. [2]

P-wave velocity (kms^{-1})	**Model 1** Rock type	**Model 2** % serpentinisation
6.0	•	•

Table 6

(ii) Explain how **model 2** in **Figure 14b** challenges our understanding of the nature of the Moho in **model 1**. [3]

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15. Explain the role of compressional tectonic stresses in the formation of large scale deformational structures in orogenic belts. [6 QER]

6

END OF PAPER

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For continuation only.

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For continuation only.

Acknowledgements

Figure 1	Stone, P. *et al* (2012) British regional geology: South of Scotland. BGS.
Table 1:	http://seismicscales.blogspot.com accessed 8/9/18
Figures 2a and 2b	Adapted from: Turner, M.D. (2004) Maerdy Tip, In: Nichol, D., Bassett, M.G. and Deisler, V.K. (eds) Urban Geology in Wales, 198-200 National Museum of Wales Geological Series No. 23, Cardiff
Figure 3a	https://upload.wikimedia.org/wikipedia/commons/8/8b/
Figure 3b	https://swaag.org/SWAAG-DATABASE/IMAGES/7141.jpg
Figure 6	http://learning.mendiphillsaonb.org.uk/resource/30
Figures 7a, 7b and 7c	Adapted from: Lowe, J. J. & Walker, M.J.C. (1997) Reconstructing Quaternary Environments, Prentice Hall, London
Figures 8a + 8b	Adapted from http://humanorigins.si.edu/research/climate-and-human-evolution/climate-effects-human-evolution accessed 2/7/18
Figure 10a	adapted from: https://www.geolsoc.org.uk/~/media/shared/documents/education%20and%20careers/Gower_Field_Guide/Fig14.pdf?la=en
Figure 11	Adapted from a map by Mikenorton [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons.
Figure 13	https://www.open.edu/openlearn/science-maths-technology/science/geology/plate-tectonics/content-section-3.2
Figure 14a and 14b	www.seafloorspreading.com