Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL – NEW

A480U30-1

S19-A480U30-1-R1

TUESDAY, 11 JUNE 2019 – 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.	12	
	4.	8	
	5.	15	
	6.	10	
Section C option		12	
		12	
		6	
	Total	105	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a calculator
- the Geological Map Extract (Ross-on-Wye)

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 additional 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**.

© WJEC CBAC Ltd.

Examiner only

SECTION A

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

1. **Figure 1** shows a schematic cross-section of the Ferry Road Landfill on a brownfield site in Cardiff Bay following the remediation of the site.

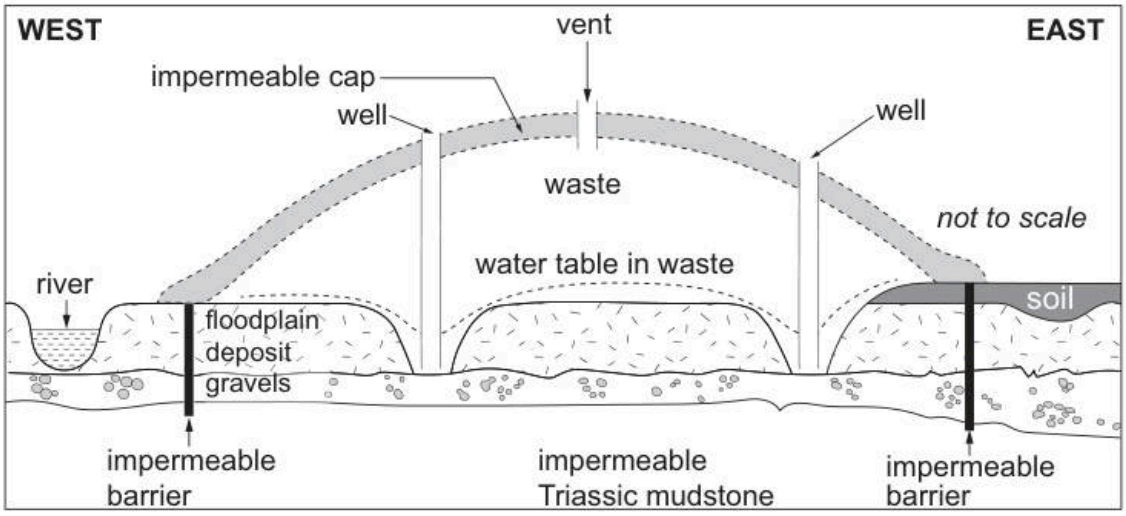


Figure 1

Refer to **Figure 1**.

(a) (i) From your knowledge, state and explain **one** reason for the difference between the grain size of the gravels compared to Triassic mudstone. [2]

.....

.....

.....

(ii) Explain **one** feature of the geology of this site that created an environmental risk when developing this site for domestic waste disposal. [2]

.....

.....

.....

(b) When Cardiff Bay was flooded during a major engineering project, the natural groundwater table in the underlying sediments was raised above the gravels. Suggest the possible impact this may have had on the stability of the gravels in this area. [2]

.....

.....

.....

Examiner only

(c) (i) The height of the water table in the waste in **Figure 1** has been lowered and its shape modified to reduce the risk of contaminating the raised groundwater in the gravels. Explain how the change in height and shape of the water table in the waste in **Figure 1** has been achieved. [3]

.....

.....

.....

.....

(ii) Explain how **two** other environmental controls shown in **Figure 1** have ameliorated the environmental risks of this landfill. [4]

1. Environmental Control:

.....

Explanation:

.....

.....

.....

2. Environmental Control:

.....

Explanation:

.....

.....

.....

(d) Describe **two** environmental problems that might arise with the future use of industrial brownfield sites for housing developments. [2]

.....

.....

.....

15

© WJEC CBAC Ltd.

2. **Figure 2a** is a map showing the North Anatolian Fault in Turkey and the major displacements from 1939 to 1999. **Figure 2b** is a map of the horizontal ground movement (in metres) recorded at the locations indicated along the North Anatolian Fault during the 1999 earthquake.

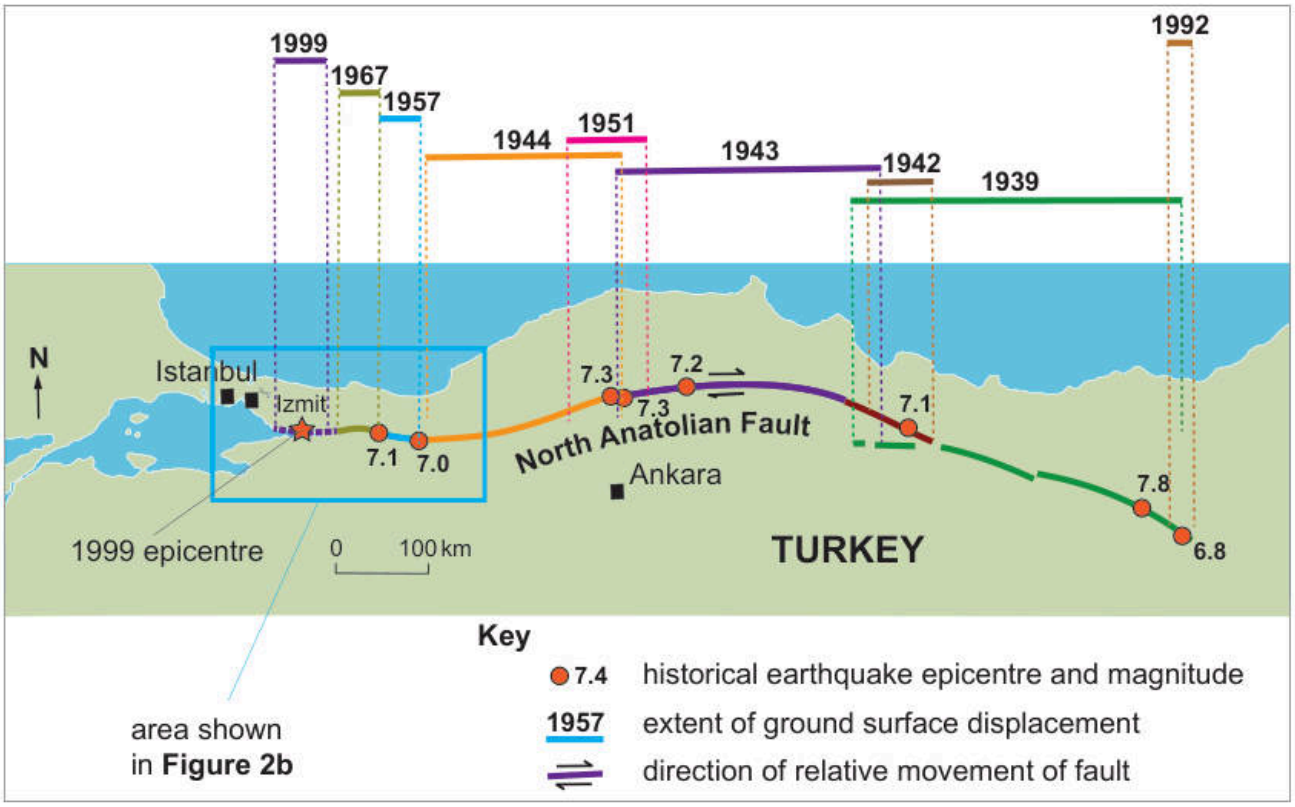


Figure 2a

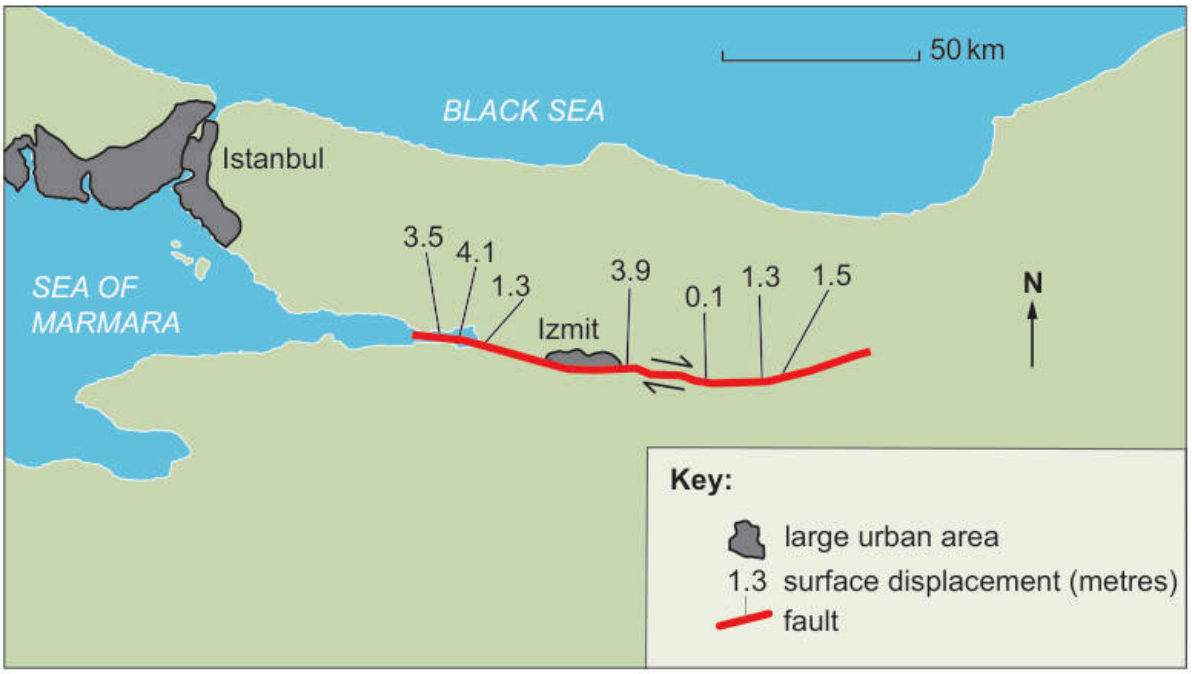


Figure 2b

© WJEC CBAC Ltd.

Examiner only

(a) Describe the type of fault represented by the North Anatolian Fault. [2]

.....

.....

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

(i) Calculate the return period of major earthquakes along the North Anatolian Fault between 1939 and 1999. Show your working. [2]

..... years

(ii) Describe the pattern of ground surface displacements over time along the North Anatolian Fault. [2]

.....

.....

.....

(iii) Explain the pattern of ground surface displacements over time along the North Anatolian Fault. [2]

.....

.....

.....

(c) Refer to **Figure 2b**.

(i) State the range of horizontal ground movement for the 1999 earthquake. [1]

..... m

(ii) Suggest and explain **one** geological factor that might explain the variation in the amount of horizontal ground movement for the 1999 earthquake. [2]

.....

.....

.....

© WJEC CBAC Ltd.

Examiner only

(d) In 2000 the United States Geological Survey predicted there was a 62% probability of a major earthquake in Istanbul before 2030.
Critically evaluate the information in **Figures 2a** and **2b** in relation to this prediction. [4]

15

BLANK PAGE

© WJEC CBAC Ltd.

Examiner only

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 Ross on Wye Sheet (215).*

3. *(a)* (i) Describe the outcrop pattern of the Aymestry Limestone **(AL)** on the **geological map**. [3]

(ii) Explain why the Aymestry Limestone **(AL)** appears as a wedge-shaped unit on the **generalised geological column**. [2]

(b) The Aymestry Limestone **(AL)** crops out in **box X** on the **geological map**.

(i) Using the scale of the **geological map** complete **Table 1** by calculating the maximum width of outcrop of the Aymestry Limestone in **box X**.
Show your working. [2]

Aymestry Limestone **(AL)**	
Width of outcrop (m) in **box X**	The **true thickness** in **box X**
Show your working. Answer ..... (m)	**30 m**

Table 1

© WJEC CBAC Ltd.

Examiner only

(ii) Refer to the data in **Table 1**. The Aymestry Limestone **(AL)** dips to the NE in **box X**. Assuming the land surface is horizontal, use trigonometry to calculate the angle of dip of the Aymestry Limestone in **box X**.
Show your working. [3]

..... °

(c) The true thickness of the Aymestry Limestone **(AL)** in **box Y** on the **geological map** is only 5 metres whereas in **box X** it is 30 metres. Using your knowledge and/or evidence from the **geological map**, suggest **two** possible reasons why the **width of outcrop** is wider in **box Y** than in **box X**. [2]

1. .....

.....

2. .....

.....

12

A480U301
09

Examiner only

4. **Figure 3** is a bedding surface of the Aymestry Limestone **(AL)** showing a typical assemblage of specimens from one fossil group. The fossils have been interpreted as living in a shallow sea environment.



Figure 3

Refer to **Figure 3**.

(a) State the fossil group to which the specimens in **Figure 3** belong.
Give **one** diagnostic reason for your choice. [2]

Fossil group .....

Reason .....

.....

(b) (i) Explain why the assemblage in **Figure 3** might correctly be interpreted as a *'life assemblage'*. [3]

.....

.....

.....

.....

© WJEC CBAC Ltd.

Examiner only

(ii) Explain why this fossil assemblage does not necessarily reflect the original living community of organisms that existed in this environment during the Silurian. [3]

.....

.....

.....

.....

8

© WJEC CBAC Ltd.

Examiner only

5. A student sampled data of both the dip angle and dip direction (azimuth) for the Woolhope Anticline; a major fold structure on the **geological map**. **Figure 4** is a partly completed polar equal area 'stereonet' of these data.

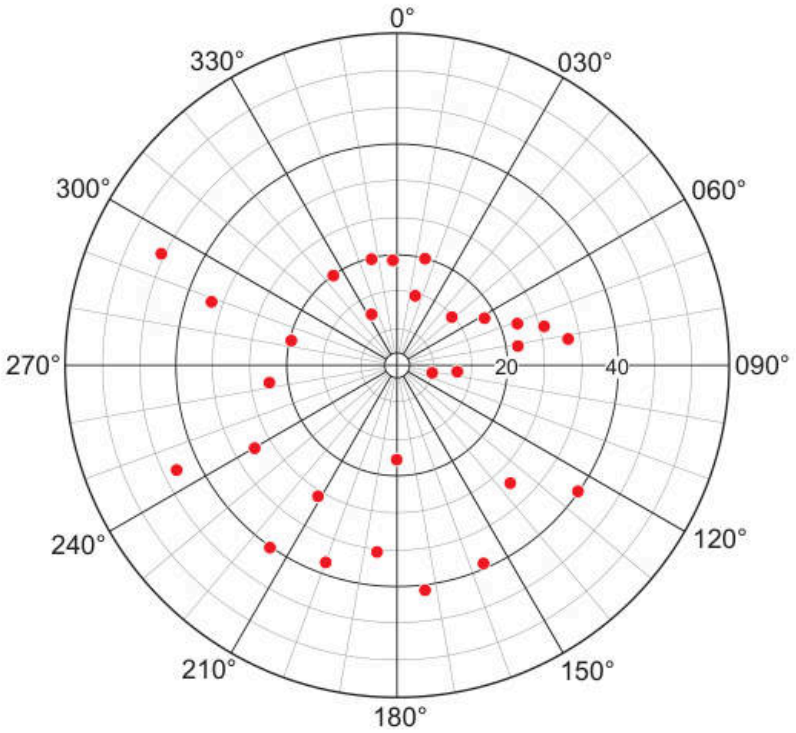


Figure 4

(a) (i) State the dip angle and dip direction (azimuth) for the data in **box Z** on the **geological map**. [1]

dip angle (degrees)	dip direction (azimuth) (degrees)
•	•

(ii) Complete **Figure 4** by plotting the data from **box Z**. [2]

(iii) State **one** limitation of plotting data on a polar equal area 'stereonet' (as in **Figure 4**) to interpret fold structures. [1]

.....

.....

© WJEC CBAC Ltd.

Examiner only

(b) In analysing the data the student concluded that the Woolhope Anticline is an *".. upright, open anticline with a NW – SE axis that plunges to the SW."*

Evaluate this statement with reference to the evidence from the **geological map**, **cross-section** and **Figure 4**. [4]

(c) The faults associated with the Woolhope Anticline to the east of the Woolhope Fault are normal faults.

(i) Describe the pattern of the normal faults to the east of the Woolhope Fault on the **geological map**. [2]

(ii) The Woolhope Fault has been described as a *thrust* fault.
With reference to the **cross-section alone**, explain **one** piece of evidence for, and **one** piece of evidence against, this statement. [2]

For .....

Against .....

(d) *"The geological structures result from NE-SW crustal shortening."*

Critically evaluate this statement with reference to the fold and faults identified on the **geological map**. [3]

© WJEC CBAC Ltd.

Examiner only

6. *(a)* The Fownhope Borehole **(GR 593356)** is a vertical borehole drilled to a depth of 2000 metres, reaching Precambrian rock at its base.

(i) With reference to the **geological map** and **generalised geological column**, name the formation that crops out at the surface at the top of the Fownhope Borehole. [1]

.....

(ii) Using the **generalised geological column**, identify the formation that was encountered in the borehole at a depth of **1500 m** from the surface.
Show your working. [3]

Formation .....

(b) *"The Woolhope Anticline has been revealed as a potential site for hydrocarbon exploitation, including shale gas obtained by hydraulic fracking. Further exploration shows this potential to be **low**."*

- Explain the geological reasons why this region was considered as a potential site for hydrocarbon exploration.
- Suggest possible reasons why this potential turned out to be so low. [6]

.....

.....

.....

.....

.....

.....

.....

.....

10

© WJEC CBAC Ltd.

BLANK PAGE

Examiner only

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 5** is an isoline map of Scandinavia showing the isostatic uplift of the area in metres from the end of the last glacial period to present day.

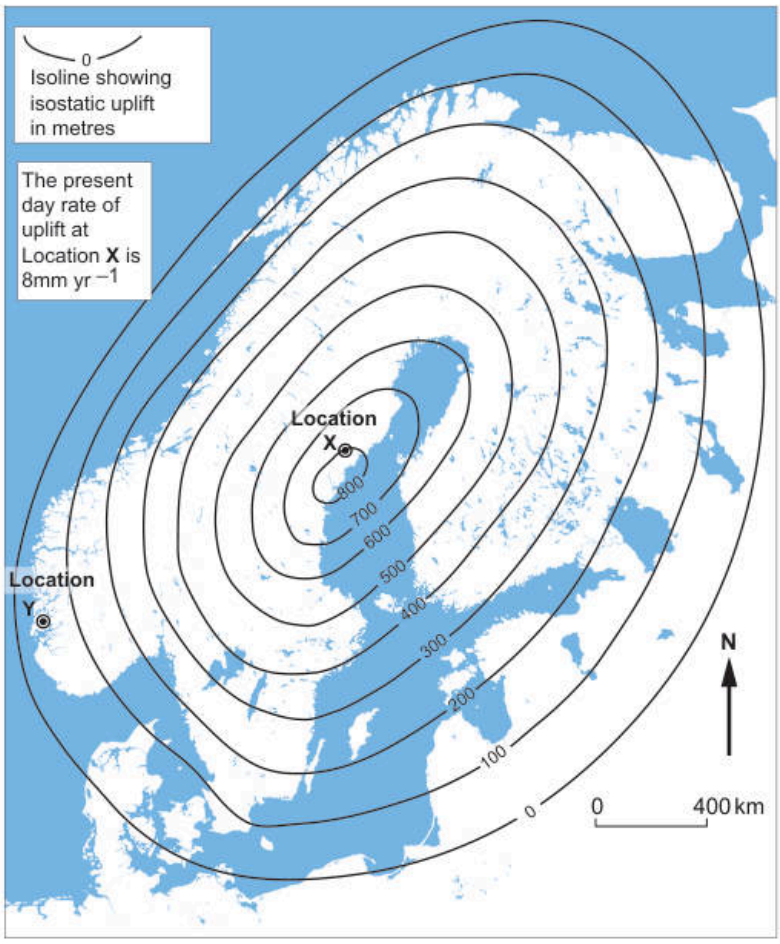


Figure 5

(a) Using your knowledge:

(i) State **one** piece of geological evidence that could be used to create a map of isostatic uplift such as **Figure 5**. [1]

.....

.....

Examiner only

(ii) Describe **one** method for establishing the timescale for the uplift of Scandinavia. [2]

.....

.....

.....

Refer to **Figure 5**.

(b) (i) Using the equation below, calculate the ice thickness that existed during the last glacial period at location **X**.
Give your answer in kilometres. Show your working. [3]

$$\text{density of ice} = \frac{\text{(isostatic uplift x density of asthenosphere)}}{\text{thickness of ice}}$$

where: density of ice = 917 kgm^{-3}
density of asthenosphere = 3300 kgm^{-3}

..... km

(ii) Explain why this calculation is likely to **underestimate** the actual thickness of the ice that existed during the last glacial period. [2]

.....

.....

.....

(c) Despite the isostatic uplift of the crust in Scandinavia there are drowned valleys at Location **Y** on **Figure 5**. Explain the presence of drowned valleys at Location **Y**. [4]

.....

.....

.....

.....

.....

A480U301
17

Examiner only

8. **Figure 6** is a graph showing the records of CO_2, estimated temperature and oxygen isotopes from the **Vostok ice core**, Antarctica.

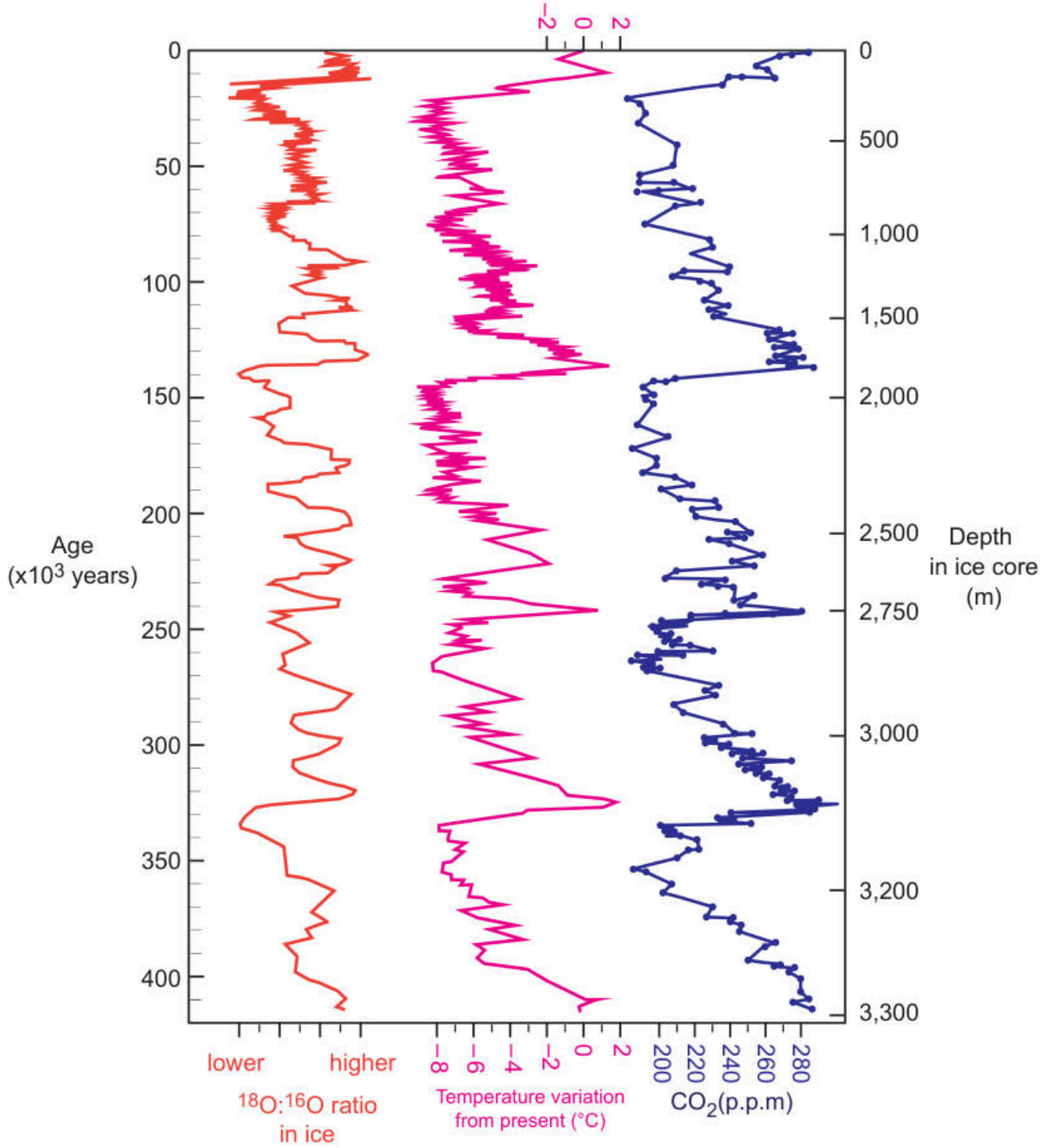


Figure 6

Refer to **Figure 6**.

(a) (i) State how many times in the last 420,000 years Antarctica has experienced a temperature greater than the present. [1]

© WJEC CBAC Ltd.

Examiner only

(ii) Quaternary temperature change has been interpreted as being cyclic. Using **Figure 6**, determine the duration of the most recent climatic cycle from the peak temperature of the previous interglacial to the peak temperature of the current interglacial. [1]

(iii) Explain a possible cause of cyclic climatic changes during the Quaternary. [3]

(b) Describe the relationship between temperature and CO_2. [2]

(c) Explain why the ratio of ^{18}O:^{16}O in the ice varies with time. [3]

(d) Suggest **two** reasons to account for the non-linear scale for depth in the ice core. [2]

12

Examiner only

9. Explain, giving examples, how the distribution of continents and mountain belts affects oceanic and atmospheric circulation to influence past and present climate. [6 QER]

6

© WJEC CBAC Ltd.

BLANK PAGE

Option 2: Geological Evolution of Britain

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

10. **Figure 7a** is a geological map of southwest England showing the Bouguer gravity field with isolines at 10 mGal intervals. **Figure 7b** is a gravity profile and partly completed cross-section of the Bodmin Granite along the transect labelled **A-B** on **Figure 7a**.

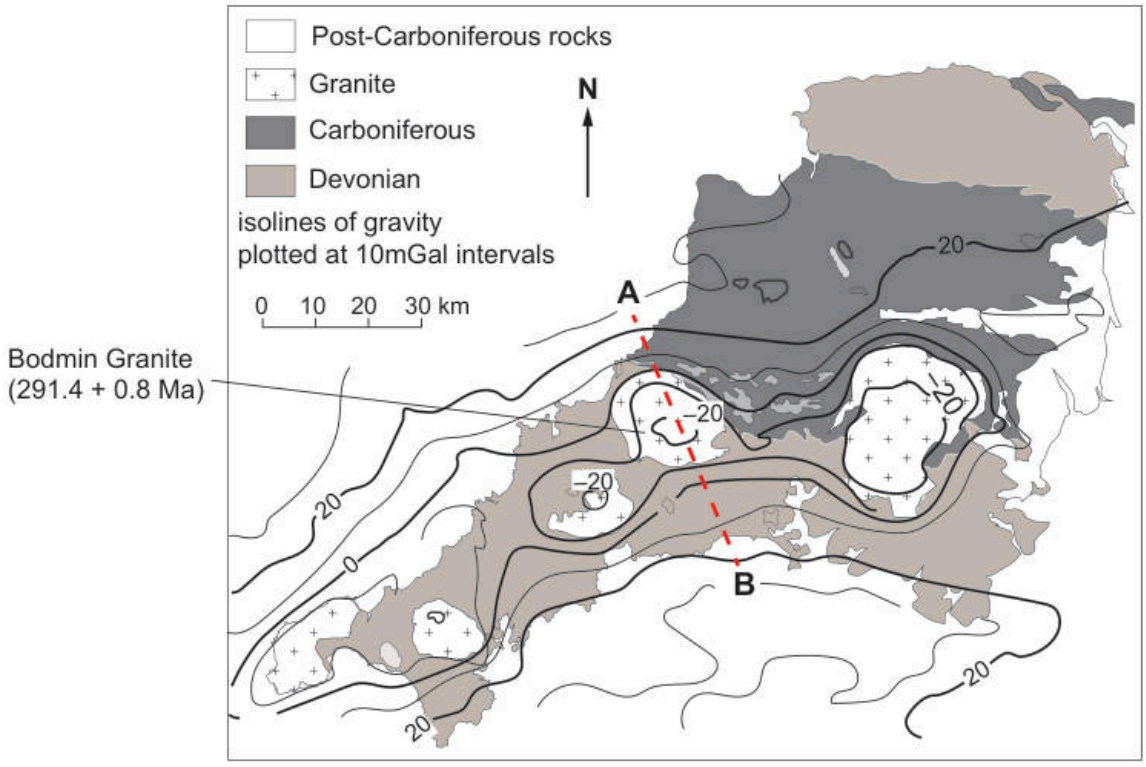


Figure 7a

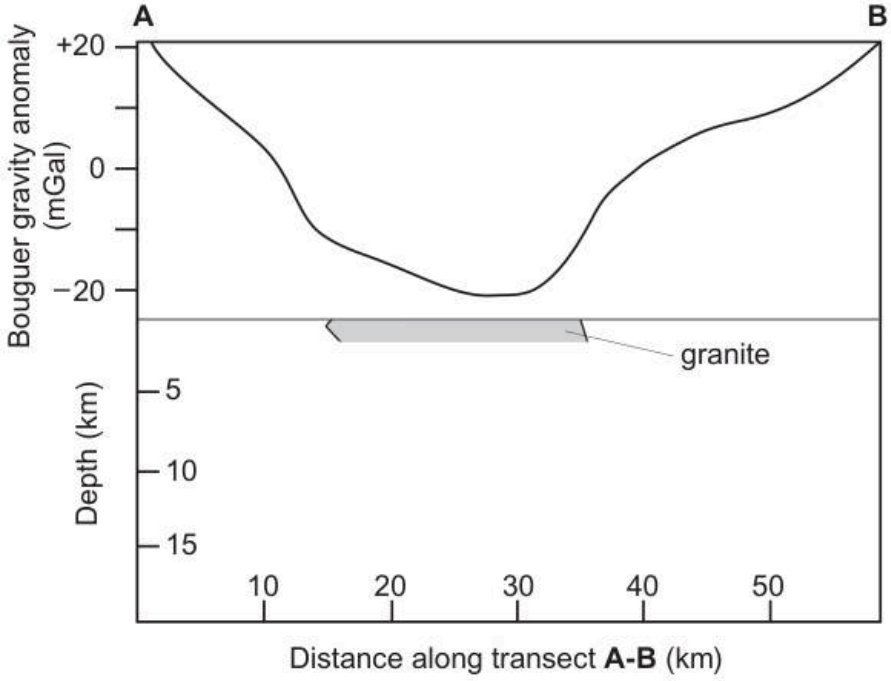


Figure 7b

© WJEC CBAC Ltd.

Examiner only

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

(i) Describe the size and shape of the **negative** Bouguer gravity anomaly in southwest England. [2]

(ii) Explain why there is a **negative** Bouguer gravity anomaly in southwest England. [2]

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

(i) Calculate the maximum thickness of the Bodmin Granite along the transect **A-B** using the equation:

$$T = bL^a$$

Where: T = maximum thickness of granite (km)
L = width of outcrop (km)
a = 0.70
b = 0.75

Show your working. [3]

..... km

(ii) Complete the cross-section of the granite on **Figure 7b**. [2]

(c) A student suggested that the granites in southwest England were intruded during the later stages of the Variscan Orogeny. Evaluate this statement with reference to **Figure 7a**. [3]

12

11. **Figure 8a** is a palaeogeographic map of the British area during the Permian. **Figure 8b** is a photograph of sedimentary rock **A**, deposited during the Permian at location **A** on **Figure 8a**. **Figure 8c** is a graphic log of a sequence of Permian sedimentary rocks found in northern England.

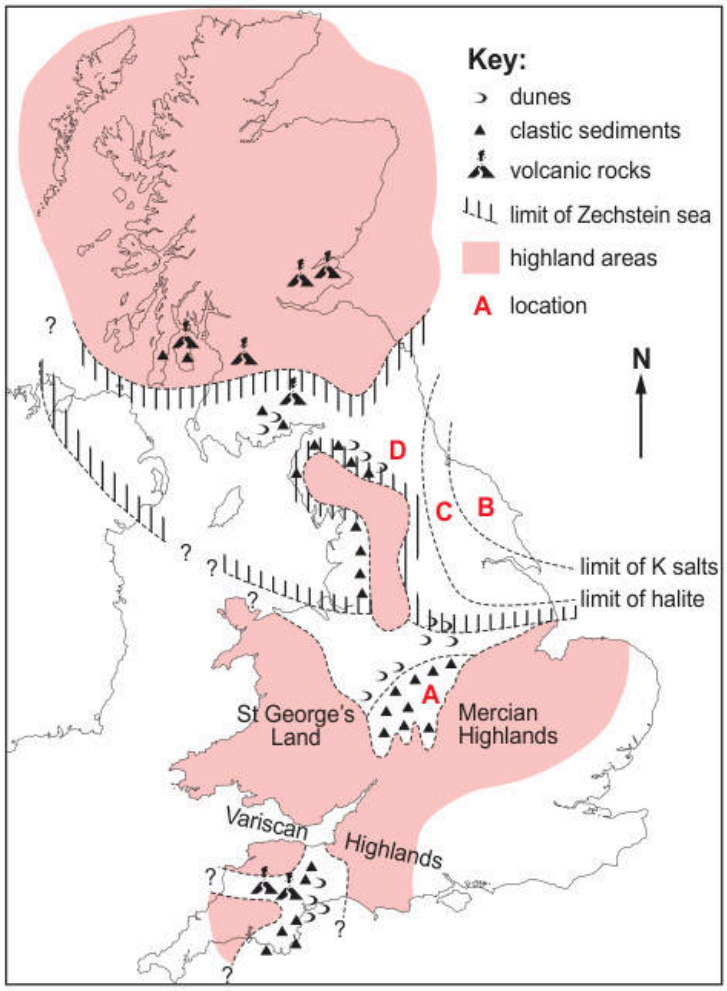


Figure 8a



Figure 8b

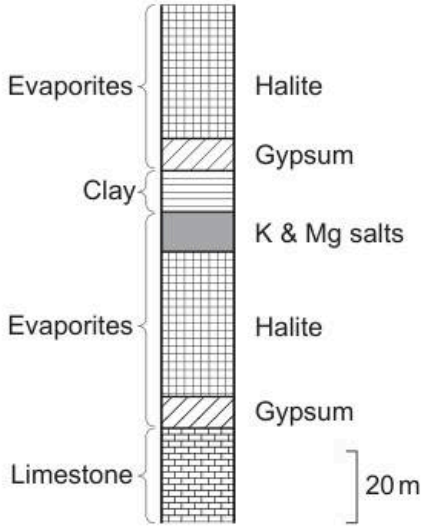


Figure 8c

© WJEC CBAC Ltd.

Examiner only

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

(i) Describe the texture of rock **A**. [2]

.....

.....

.....

(ii) Suggest why sediment with this texture might have been deposited at location **A**. [2]

.....

.....

.....

(b) Refer to **Figures 8a** and **8c**.

Identify the most likely location (**B**, **C** or **D**) on **Figure 8a** where the sequence of sediments shown in **Figure 8c** was deposited. Give a reason for your answer. [2]

Location (tick **one** box only):

☐ **B** ☐ **C** ☐ **D**

Reason .....

.....

.....

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

It has been suggested that British rocks of Permian age were deposited between latitudes of 15°N and 20°N in an arid climate.

(i) Explain how the evidence from Permian sedimentary rocks would support this conclusion. [3]

.....

.....

.....

.....

© WJEC CBAC Ltd.

Examiner only

(ii) Explain how volcanic rocks could be used to determine the palaeolatitude of the British area during the Permian. [3]

.....

.....

.....

.....

12

Examiner only

12. Explain how the mafic igneous rocks of the Palaeogene Igneous Province in NW Britain provide evidence for the early history of the opening of the North Atlantic Ocean. [6 QER]

6

© WJEC CBAC Ltd.

Examiner only

Option 3: Geology of the Lithosphere

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

13. **Figure 9a** shows a model of a stage in the evolution of a foreland basin system associated with crustal shortening and lithospheric loading.
Figure 9b is a model of how the lithosphere flexes with time as a result of the lithospheric loading caused by an advancing orogenic belt.

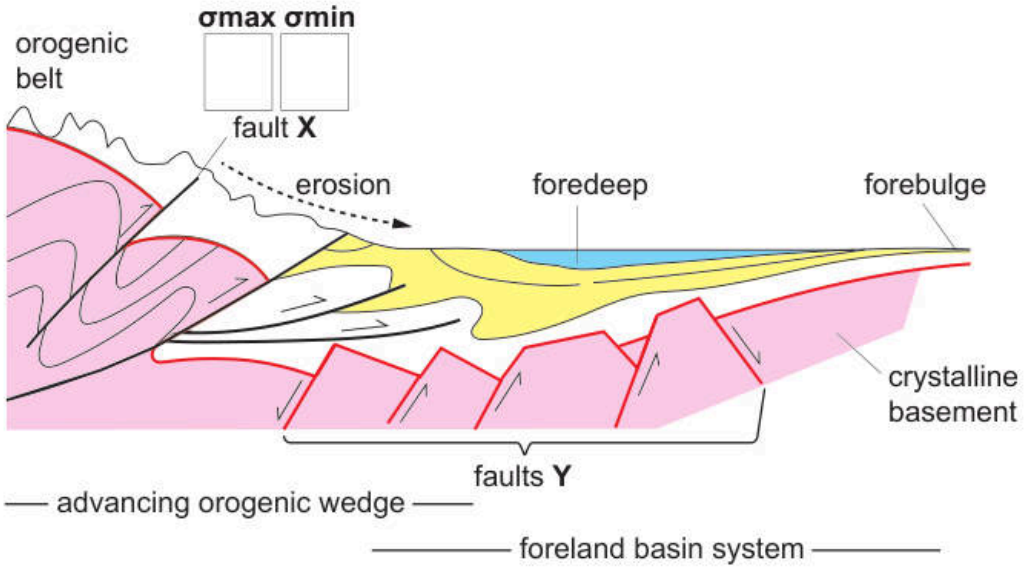


Figure 9a

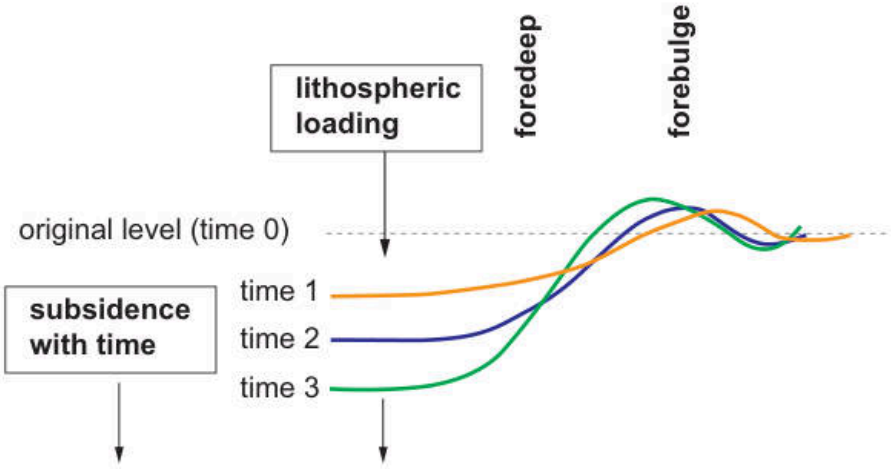


Figure 9b

Refer to **Figure 9a**.

(a) Label a *nappe* structure with an arrow labelled **N (N →)** on **Figure 9a**. Explain your choice of location. [3]

Examiner only

(b) Refer to **Figure 9b**. Describe the effect of an advancing orogenic belt on the cross sectional **shape** of the following elements of a foreland basin system over time:

- the foredeep
- the forebulge [3]

foredeep .....

.....

forebulge .....

.....

(c) (i) Insert **one** pair of arrows (→←) in each of the boxes labelled **σ max**, **σ min** on **Figure 9a** to show the principal stress directions that produced fault **X**. [1]

(ii) Explain how the faults labelled **Y** were formed by crustal extension when the regional tectonic setting is dominated by crustal shortening. [2]

.....

.....

.....

(d) Describe and explain the effect that erosion of the orogenic belt might have on the depth of the Mohorovičić discontinuity (Moho) beneath:

- the orogenic belt and
- the foreland basin system. [3]

.....

.....

.....

.....

12

© WJEC CBAC Ltd.

Examiner only

14. **Figure 10a** shows the surface of the ocean floor across an oceanic ridge system. **Figure 10b** and **Figure 10c** show the velocity of S-waves recorded at separate locations on the ocean floor on **Figure 10a**.

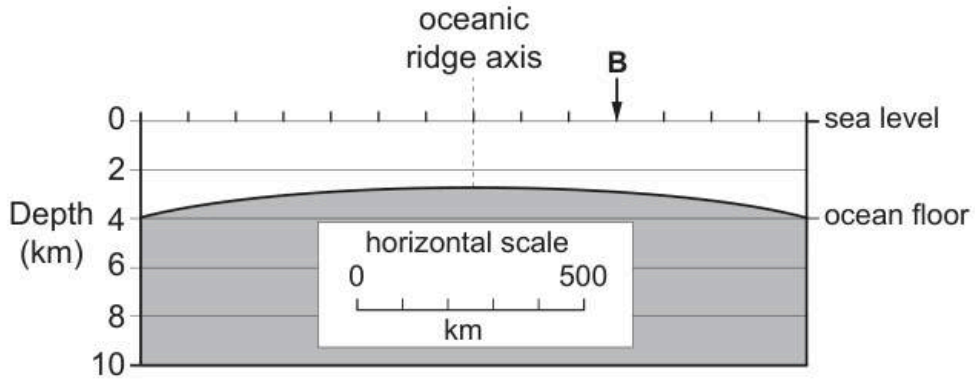


Figure 10a

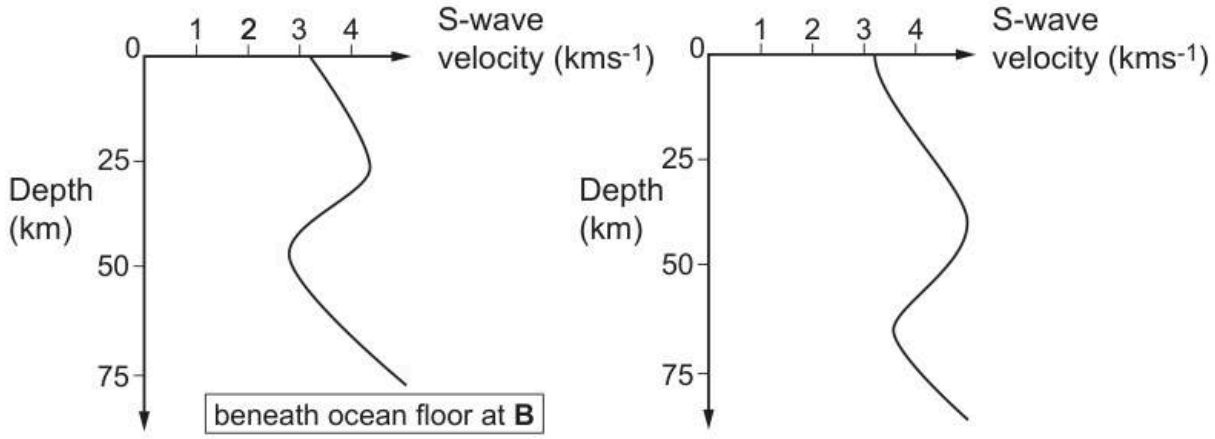


Figure 10b **Figure 10c**

Refer to **Figure 10a**.

(a) Seafloor spreading on each side of the ridge axis has been calculated as 7.5 cmyr^{-1}.

(i) Calculate the distance from the ridge axis where the ocean lithosphere is 5 Ma. Show your working. [2]

..... km

(ii) Show with an arrow labelled **A (↓A)** on **Figure 10a** wherever the ocean lithosphere is 5 Ma. [1]

© WJEC CBAC Ltd.

Examiner only

(b) Refer to **Figure 10b**. **Figure 10b** shows how the velocity of S-waves varies beneath the ocean floor at **B** on **Figure 10a**.

(i) Describe how the velocity of S-waves changes with depth. [2]

.....

.....

.....

(ii) Explain why there are changes in S-wave velocity with depth. [2]

.....

.....

.....

(iii) On **Figure 10b** draw a line labelled **L** to mark the base of the lithosphere. [1]

(c) **Figure 10c** is another seismic profile recorded on the ocean floor.
Draw an arrow labelled **C (↓C)** on **Figure 10a** to show a possible location on the ocean floor beneath which this seismic profile might have been recorded. Explain the reasons for your answer. [4]

.....

.....

.....

.....

.....

12

© WJEC CBAC Ltd.

Examiner only

15. Explain why the oceanic crust is rarely older than 200 Ma when the age of the continental crust can exceed 4000 million years. [6 QER]

6

END OF PAPER

© WJEC CBAC Ltd.

Examiner only

For continuation only.

Examiner only

For continuation only.

Examiner only

For continuation only.

Acknowledgements

Figure 1	Adapted from Cherrill, H. + Phillips, A. (2004) Remediation of landfill.
Figure 2a	Adapted from Aydin, Ferhat (2003) Investigation of Concrete Quality of Collapsed-Heavily Damaged Structures During Marmara Earthquake.
Figure 2b	Adapted from https://apps.peer.berkley.edu/news/1999october/turkey.html
Figure 3	http://geopark.org.uk/pub/2009/07/geology-and-landscape-image-gallery/
Figure 5	Adapted from: Lowe, J. J. + Walker M. J. C. (1997) Reconstructing Quaternary Environments, Pentice Hall, London.
Figure 6	Adapted from: http://www.antarcticglaciers.org/glaciers-and-climate/ice-cores/ice-core-basics/
Figures 7a + 7b	Taylor, G. K. (2007) Pluton Shapes in the Cornubian batholith: new perspectives from gravity modelling. Journal of the Geological Society 164, 525-528.
Figure 8a	S23 – Block 6 Historical Geology, The Open University.
Figure 9a	http://www.crpg.cnrs_nancy.fr/spip.php?article 1425.
Figure 9b	https://uploadwikimedia.org/wikipedia/en/0/00/viscoelastic_lithosphere_flexure.png

GCE A LEVEL – NEW

A480U30-1A

S19-A480U30-1A

TUESDAY, 11 JUNE 2019 – MORNING

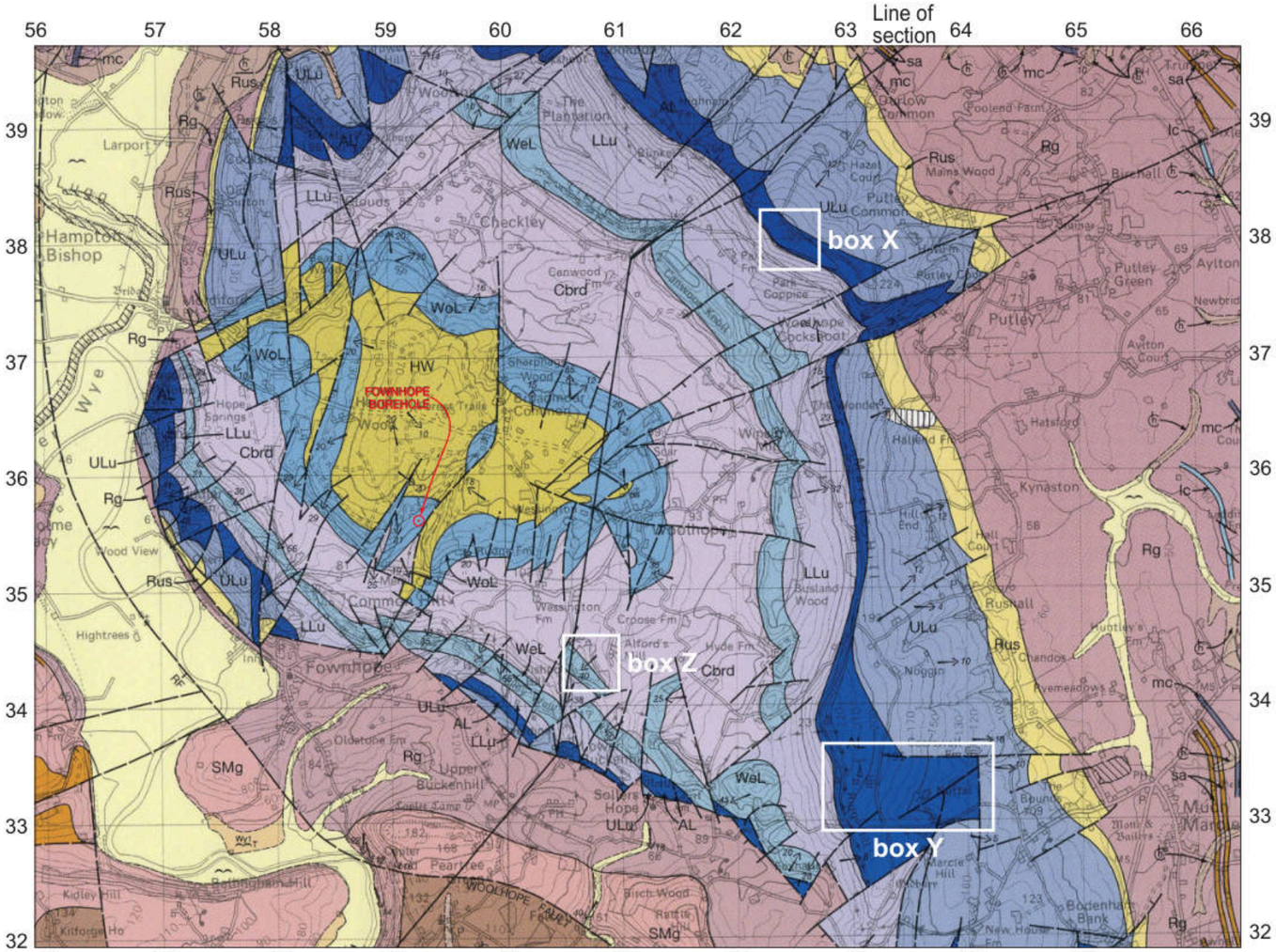
GEOLOGY – A level component 3
Geological Applications

RESOURCE SHEET

© WJEC CBAC Ltd.

WJEC - EDUQAS A480U30-1A
ADVANCED GEOLOGY COMPONENT 3
JUNE 2019

Extract from Ross-on-Wye (Solid and Drift)
1:50 000 (1 cm to 500 m)



DRIFT

- Landslip
- Head Deposits: sandy, pebbly clay
- Alluvium: mainly clay

KEY

- Geological boundary, Drift
- Geological boundary, Solid
- Fault at rockhead, crossmark on downthrow side RF denotes reverse fault
- Borehole
- Horizontal strata

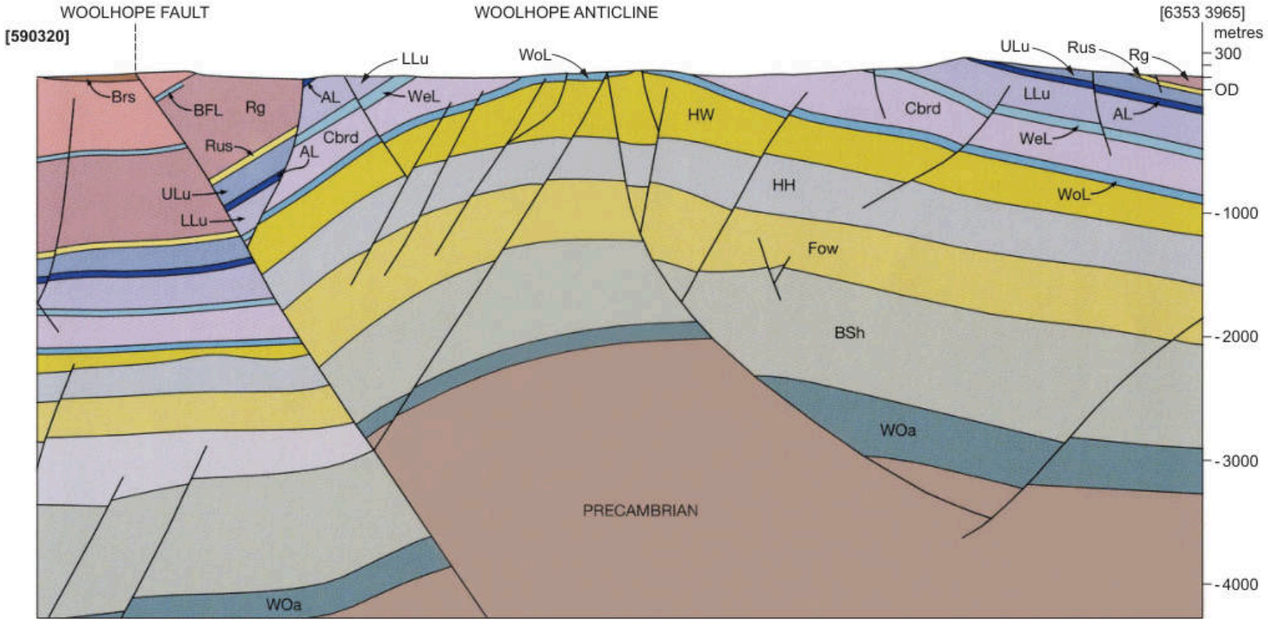
GENERALISED GEOLOGICAL COLUMN

Scale 1:20 000 (1cm to 200 m)

DEVONIAN	Brs	Sandstone, drab red-brown, pebbly	BROWNSTONES FORMATION (Brs)
	SMg	Mudstone and sandstone	ST. MAUGHANS FORMATION (SMg)
	Rg	Mudstone and siltstone	RAGLAN MUDSTONE FORMATION (Rg)
	Rus		RUSHALL FORMATION (Rus)
	ULu	Mudstone siltstone	UPPER LUDLOW SHALES (ULu)
SILURIAN	AL	Siltstone, calcareous Limestone, nodular, impure	**AYMESTRY LIMESTONE (AL) (0-30m)**
	LLu	Siltstone and silty mudstone	LOWER LUDLOW SHALES (LLu)
	WeL	Limestone	MUCH WENLOCK LIMESTONE FORMATION (WeL)
	Cbrd	Siltstone	COALBROOKDALE FORMATION (Cbrd)
	WoL	Limestone, nodular, impure and siltstone	WOOLHOPE LIMESTONE FORMATION (WoL)
	HW	Sandstone and siltstone	HAUGH WOOD FORMATION (HW)
	HH	Sandstone and siltstone	HUNTLEY FORMATION (HH)
	Fow	Sandstone and siltstone	FOWNHOPE FORMATION (Fow)
	Unconformity		
ORDOVICIAN	BSh	Siltstone and mudstone	BRONSIL SHALE FORMATION (BSh)
PRECAMBRIAN CAMBRIAN	WOa	Mudstone, minor sandstones	WHITE-LEAVED OAK SHALE FORMATION (WOa)
	Unconformity		
		Sandstone and igneous rocks	

CROSS-SECTION SHOWING THE GENERAL RELATIONS OF THE ROCKS ALONG THE LINE DRAWN ON THE MAP

Horizontal and Vertical scales 1:50 000



Scale 1:50 000

0 1 2 miles

0 1 2 3 kilometres 4

Contours are at 10 m vertical intervals

Heights are to the nearest metre above mean sea level

© WJEC CBAC Ltd.

(A480U30-1A)

Reproduced by permission of the Director British Geological Survey
© NERC All rights reserved