Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A480U20-1

O21-A480U20-1

TUESDAY, 12 OCTOBER 2021 – MORNING

GEOLOGY – A level component 2
Geological Principles and Processes

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**18**	
2.	**17**	
3.	**11**	
4.	**13**	
5.	**14**	
6.	**17**	
Total	**90**	

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ADDITIONAL MATERIALS

In addition to this examination paper you will need

- the Mineral Data Sheet;
- a calculator;
- a ruler.

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.

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

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 **1** and **6**.

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

1. **Figure 1a** shows three fossil cephalopods (**A**, **B** and **C**). **Figure 1b** is a map of the area from which the three fossils were collected.



A **B** **C**

Shells of fossils **A**, **B** and **C** are composed of mineral **Y**, a brass yellow mineral with a greenish-black streak.

Figure 1a

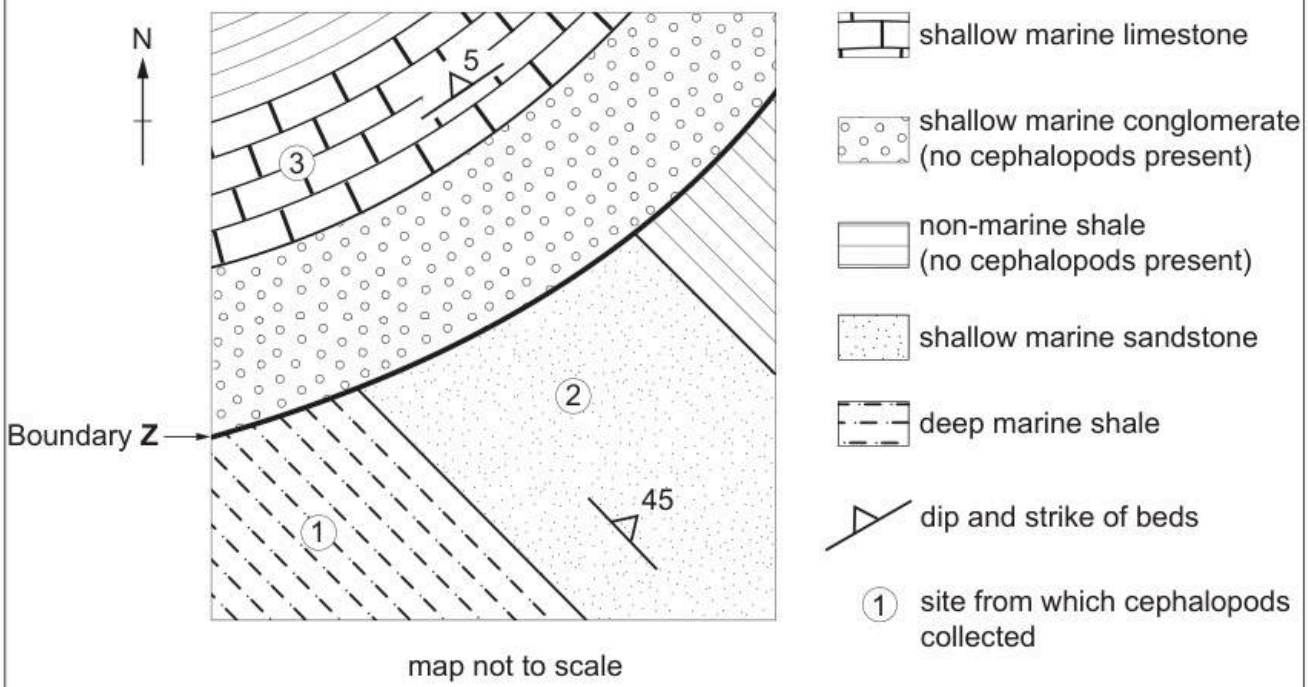


Figure 1b

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

(i) State the name of mineral **Y**. You may wish to refer to the Mineral Data Sheet. [1]

Name of mineral **Y**: .....

(ii) Describe the process by which the shells of fossils **A**, **B** and **C** have become composed of mineral **Y**. [3]

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

(i) The three fossil cephalopods (**A**, **B** and **C**) on **Figure 1a** were collected from three different sites labelled **1**, **2** and **3** on **Figure 1b**. State from which site (**1**, **2** or **3**) fossil **A** was most likely to have been collected. Explain your answer. [3]

Fossil **A** was collected from site .....

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(ii) Boundary **Z** has been interpreted as an unconformity. Explain the evidence on **Figure 1b** for this interpretation. [4]

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(c) The three fossil cephalopods (**A**, **B** and **C**) on **Figure 1a** are useful *'zone fossils'*.

(i) Explain what is meant by the term *'zone fossil'*. [1]

(ii) Evaluate the use of cephalopods as zone fossils. You should refer to **Figure 1a** and **Figure 1b** in your answer. [6 QER]

18

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2. **Figure 2** shows a simplified pattern of magnetic stripes across a section of oceanic lithosphere.

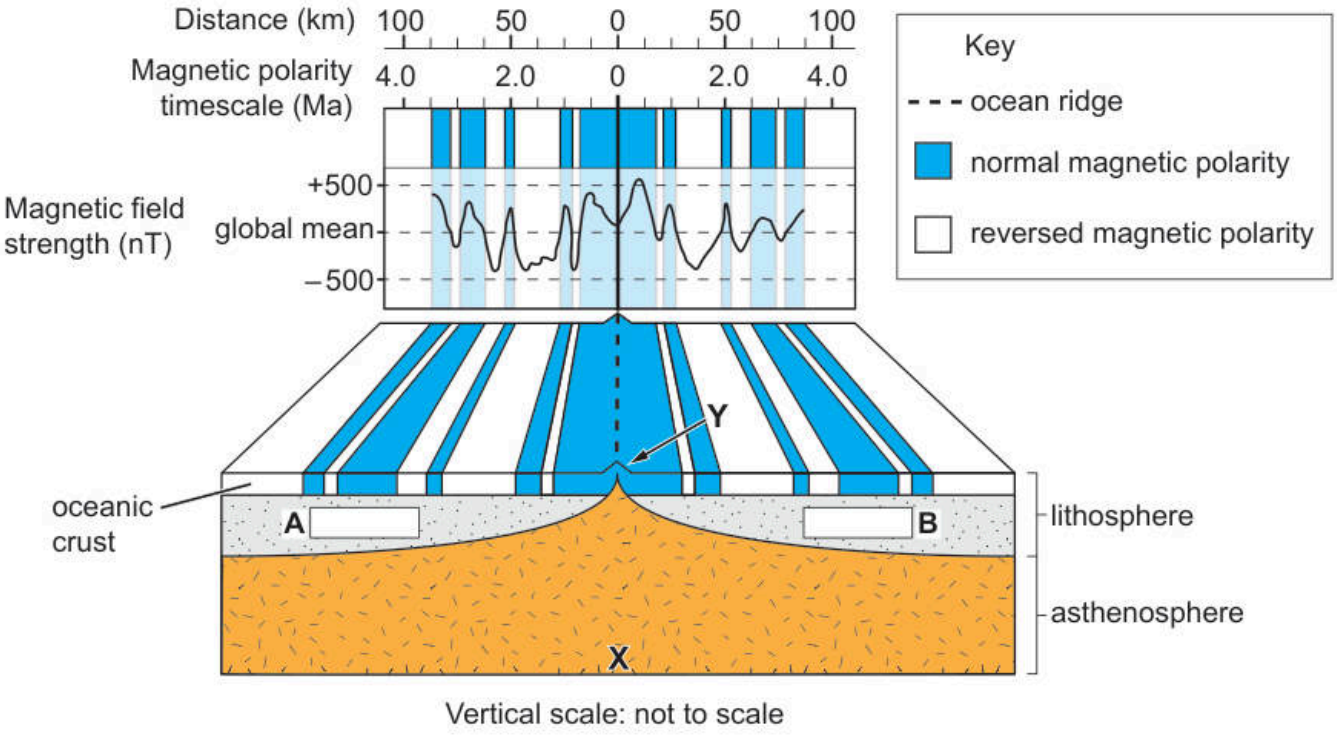


Figure 2

Refer to **Figure 2**.

(a) (i) Draw an arrow in each of the boxes marked **A** and **B** on **Figure 2** to show the relative direction of plate motion at each location. [1]

(ii) Using **Figure 2**, calculate the mean rate at which the ocean has opened during the past 4.0 Ma. Show your working and give your answer in cm yr^{-1}. [3]

..... cm yr^{-1}

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(b) (i) State what is meant by 'reversed magnetic polarity'. [1]

(ii) Using your knowledge, explain how rocks of the oceanic crust contain a record of the Earth's magnetic polarity. [3]

(iii) Explain **two** possible reasons for the variation in the width of the magnetic stripes in **Figure 2**. [4]

(c) (i) Describe the processes by which solid mantle from location **X** forms new oceanic crust at location **Y**. [3]

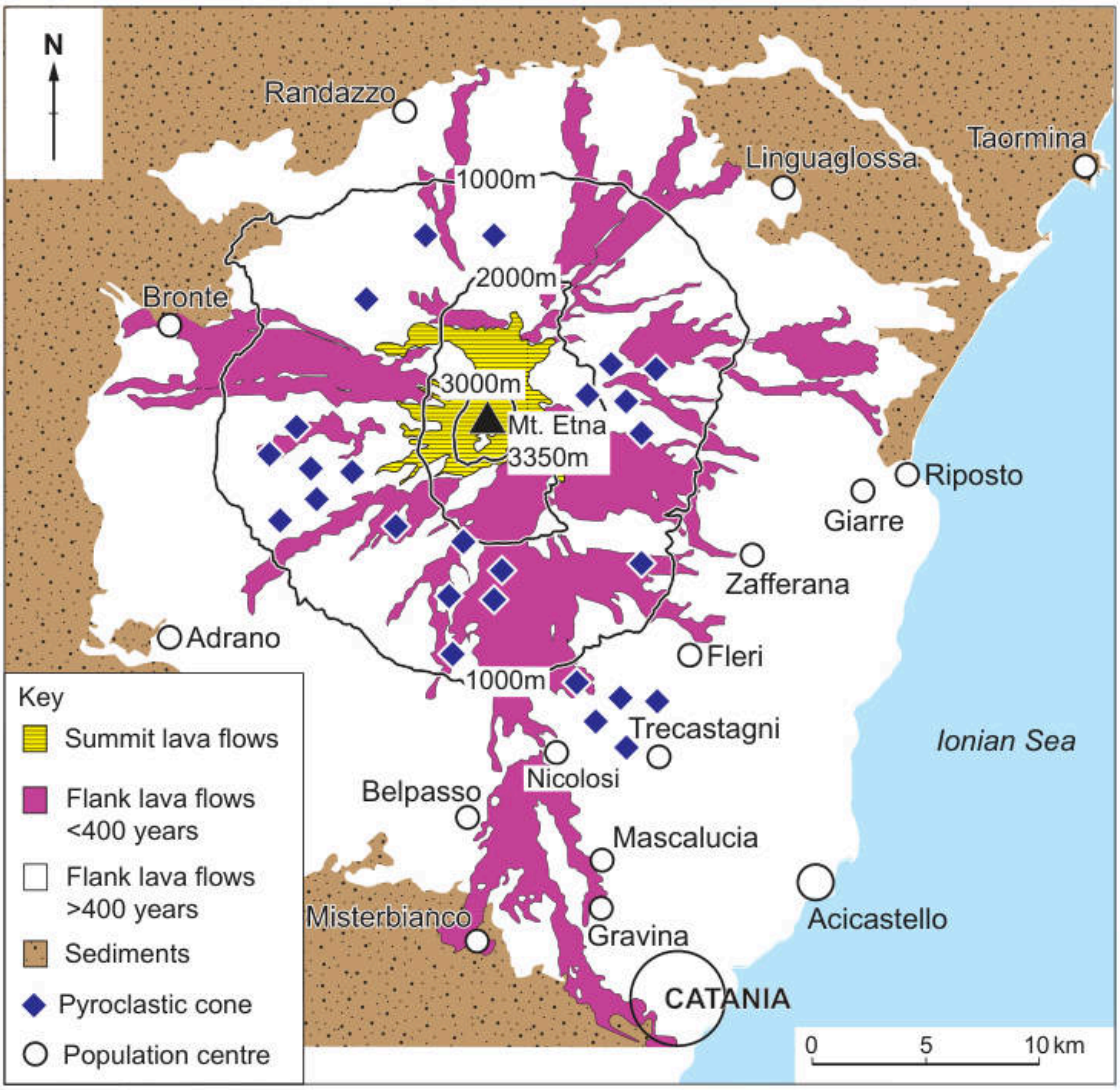
(ii) Explain how the formation of new oceanic crust at location **Y** may produce a driving force for lithospheric plate motion. [2]

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3. **Figure 3a** shows the main volcanic features of Mt. Etna, Italy.



Lava flows are the main volcanic hazard on Mt. Etna. Two types of lava flow are distinguished; **summit lava flows** which originate from the summit of Mt. Etna and **flank lava flows** which originate from off-summit fissures.

Figure 3a

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(a) Refer to **Figure 3a**.

(i) State which **one** of the two types of lava flow (summit or flank) on **Figure 3a** presents the greatest risk to the local population. Explain your answer. [1]

- Lava flow type: .....
- Explanation: .....

.....

(ii) Describe the features of **one** type of volcanic hazard, other than lava flows, that may present a risk to the local population around Etna. [3]

- Volcanic hazard: .....
- Hazardous features: .....

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(b) **Figure 3b** shows the gas emissions (CO_2:SO_2 ratio) for the summit eruptions of Mt. Etna during 2006.

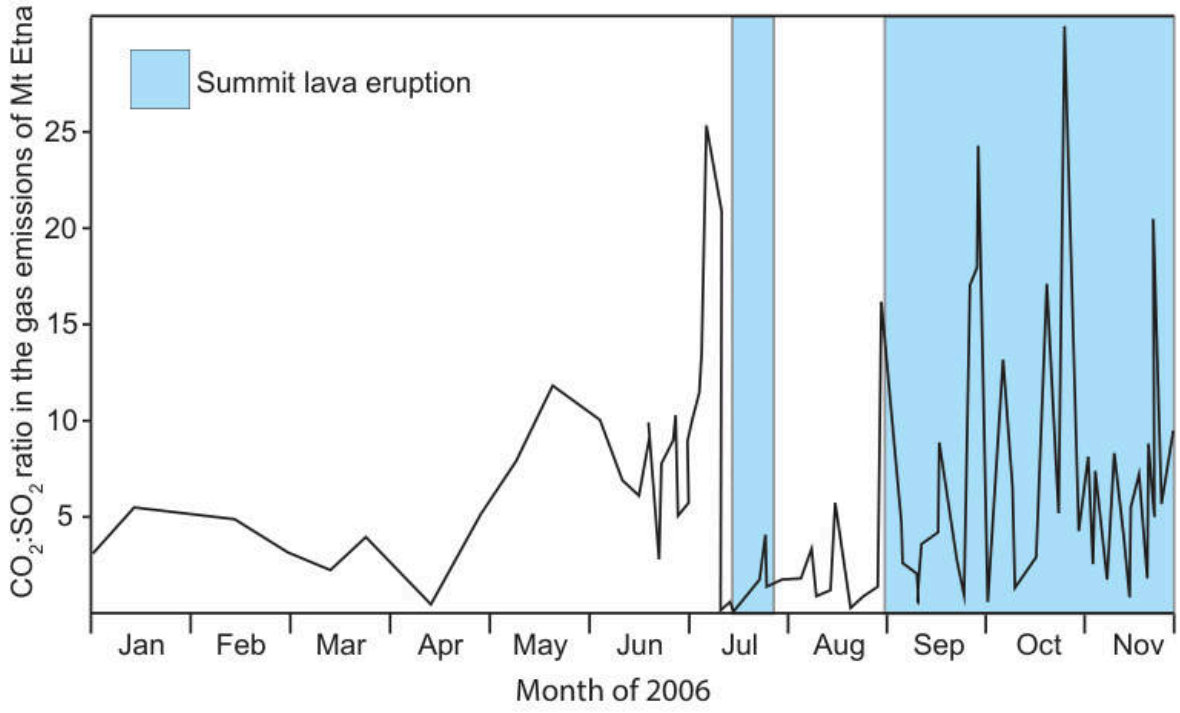


Figure 3b

Refer to **Figure 3b**.

(i) Describe the change in the CO_2:SO_2 ratio from January to the end of May 2006. [3]

(ii) A student stated that *'the CO_2:SO_2 ratio can be used to predict a summit volcanic eruption at Mt. Etna'*. Evaluate the student's statement. [4]

11

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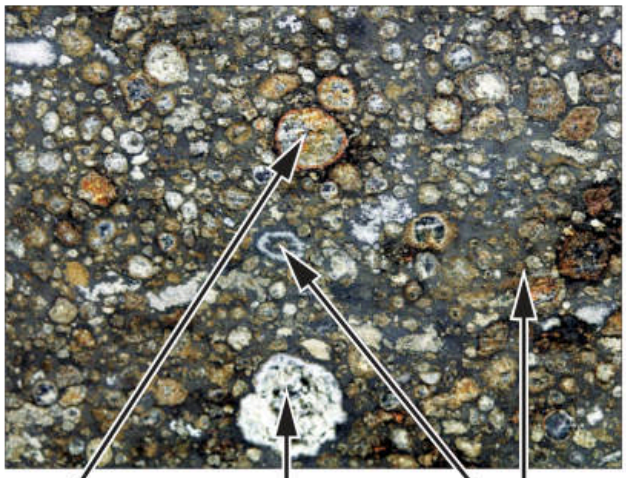
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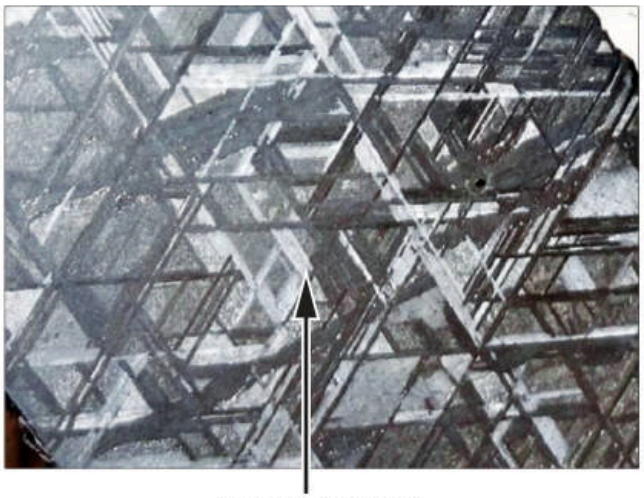
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4. **Figure 4** shows photographs of the polished surfaces of two meteorites; a stony (chondrite) meteorite and an iron meteorite.

Stony (chondrite) meteorite



Iron meteorite



Mineral **A** is green in colour, has no cleavage and is not scratched by a steel blade.
Mineral **B** is grey in colour, has 2 cleavage planes and is not scratched by a steel blade.

Figure 4

(a) Refer to **Figure 4**.

(i) State the names of minerals **A** and **B** in the stony (chondrite) meteorite. You may wish to refer to the Mineral Data Sheet. [2]

- Mineral **A** .....
- Mineral **B** .....

(ii) Describe **three** differences in texture between the two types of meteorite. [3]

1. .....

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2. .....

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3. .....

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(b) **Table 1** shows the abundance of elements in the Earth's crust, whole Earth and the two types of meteorite in **Figure 4**.

Element	Abundance in the Earth's crust (%)	Abundance in the whole Earth (%)	Abundance in stony (chondrite) meteorite (%)	Abundance in iron meteorite (%)
Oxygen	46	30	32	
Silicon	27	15	14	
•	8.1	1.4	0.90	
Iron	6.3	32	30	88
•	5.0	1.5	1.1	
Magnesium	2.9	14	12	
Sodium	2.3	0.40	0.55	
Potassium	1.5	0.20	0.10	
Others	0.9	5.5	9.35	12

Table 1

Refer to **Table 1**.

(i) Using your knowledge, complete **Table 1** by stating the name of the two missing elements. [2]

(ii) Compare the relative abundance of iron in the Earth's crust, whole Earth, stony (chondrite) meteorites and iron meteorites. [2]

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(iii) *'The data in **Table 1** provides evidence for the origin of the layered structure of the Earth.'* Explain this statement with reference to the variation in the abundance of iron in the Earth and meteorites. [4]

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5. **Figure 5a** shows a sedimentary log with an interpretation of depth of seawater, from a borehole in the North Sea area.

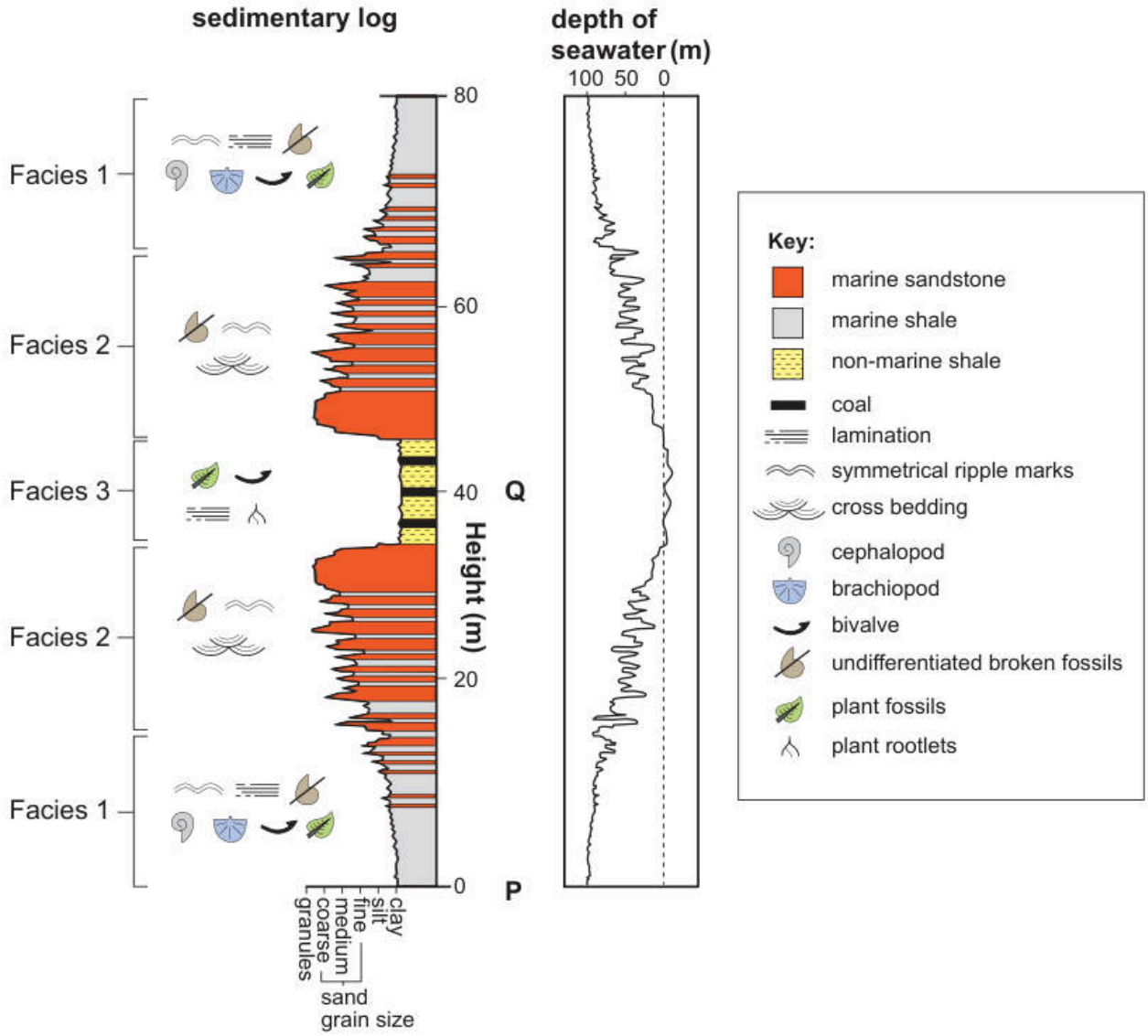


Figure 5a

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Refer to **Figure 5a**.

(a) Describe the changes in the depth of seawater which occurred during the deposition of the sedimentary sequence from **P** to **Q** in **Figure 5a**. [2]

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(b) The sedimentary sequence in **Figure 5a** has been sub-divided into three facies (**1**, **2** and **3**) which have been interpreted as having been deposited in different marine and non-marine environments.

Using the information on **Figure 5a** only, evaluate the conclusion that *'**facies 1** was deposited in a low energy, marine environment'*. [4]

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(c) **Figure 5b** is a model cross-section from part of the North Sea area where the borehole in **Figure 5a** was drilled.

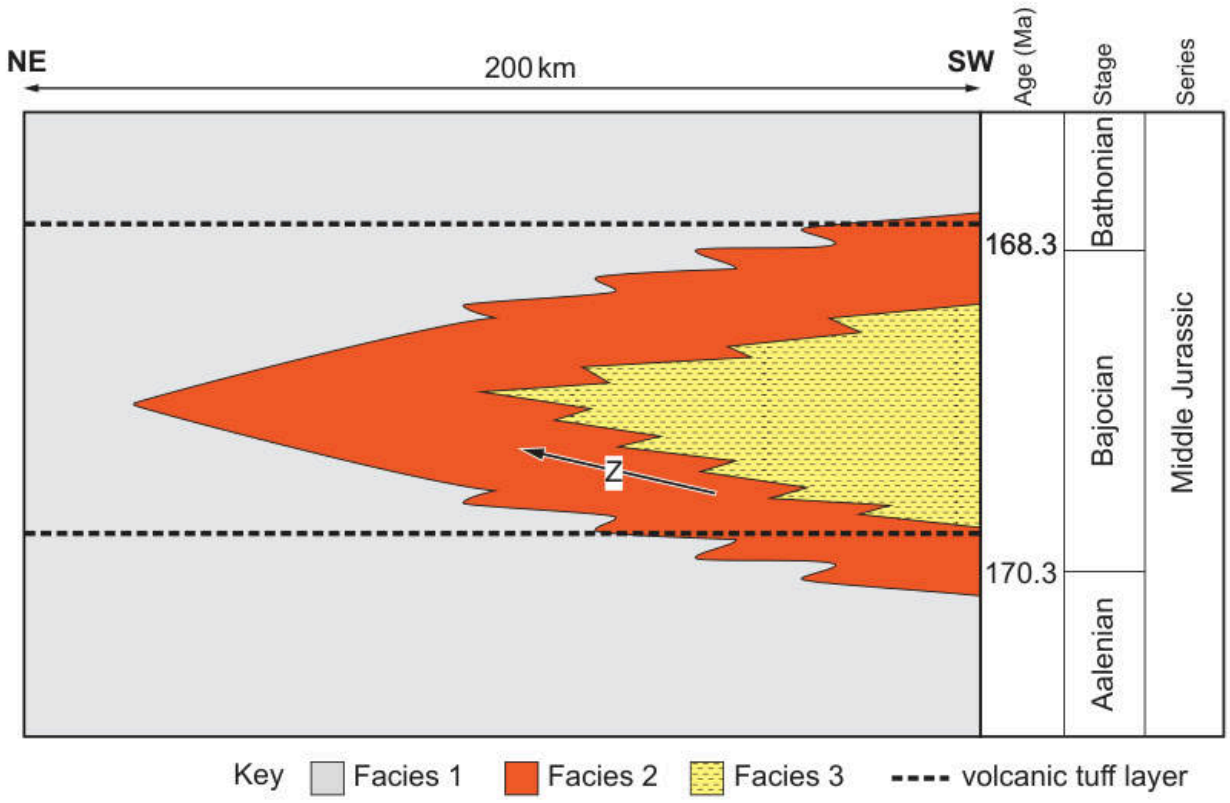


Figure 5b

Refer to **Figure 5b**.

(i) State whether the arrow **Z** on **Figure 5b** demonstrates an episode of:

- marine transgression
- marine regression
- constant sea level

Give a reason for your answer. [2]

Arrow **Z** demonstrates an episode of .....

Reason .....

.....

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(ii) A student stated that *'volcanic tuff layers and boundaries between facies types are both diachronous'*. Evaluate the student's statement with reference to **Figure 5b**. [2]

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(d) Refer to **Figure 5a** and **Figure 5b**.

(i) Draw on **Figure 5b** a vertical line to represent the position where a borehole would record the sedimentary sequence in **Figure 5a**. [1]

(ii) Explain how the data on **Figure 5a** and **Figure 5b** can be used to illustrate Walther's Law. [3]

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14

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6. **Figure 6a** shows the apparatus for deforming a cylinder of sandstone by applying a compressive stress.

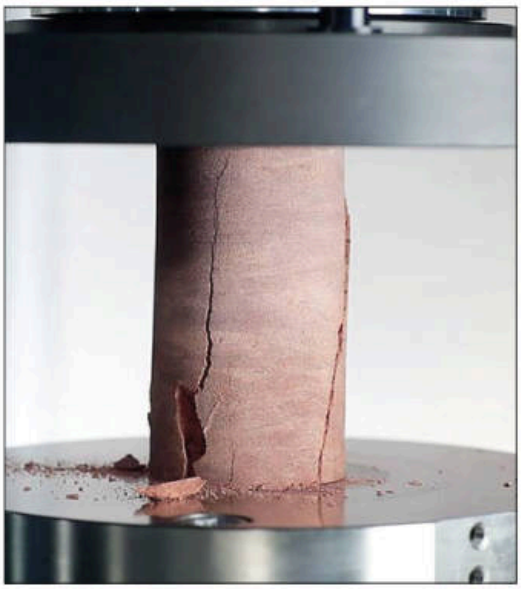


Figure 6a

Refer to **Figure 6a**.

(a) (i) Draw a circle around the box below that represents the orientation of the principal stress component (σ_{max}) associated with the formation of the structures in **Figure 6a**. [1]



(ii) Explain why the sandstone has deformed in the way shown in **Figure 6a**. [3]

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(b) **Figure 6b** is a graph of stress against strain showing the results of the experiment performed in **Figure 6a**.

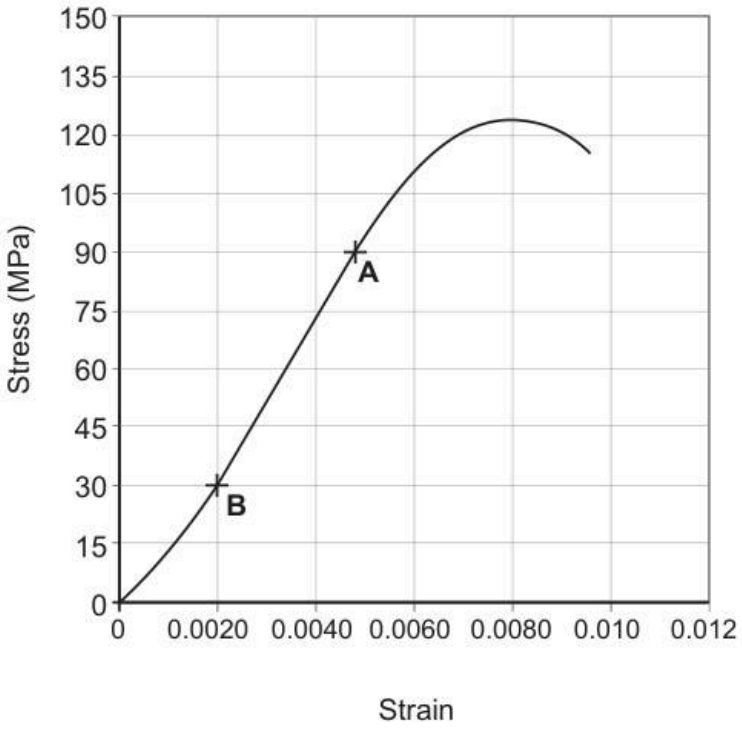


Figure 6b

Refer to **Figure 6b**.

(i) Mark on **Figure 6b** with an arrow labelled **F** (→**F**) the position of the fracture point of the sandstone shown in **Figure 6a**. [1]

(ii) The gradient of the line between points **A** and **B** on **Figure 6b** represents the stiffness of the sandstone. Calculate the gradient of the line between points **A** and **B**. Show your working and give your answer to the correct number of significant figures. [3]

..... MPa

(iii) When deformed under the same conditions another sandstone is found to be **less stiff**, with a **lower yield strength** and a **greater region of plastic strain**. Draw on **Figure 6b** a line to show the stress-strain graph for this sandstone. [3]

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(c) **Figure 6c** shows how the deformation a rock undergoes changes with depth.

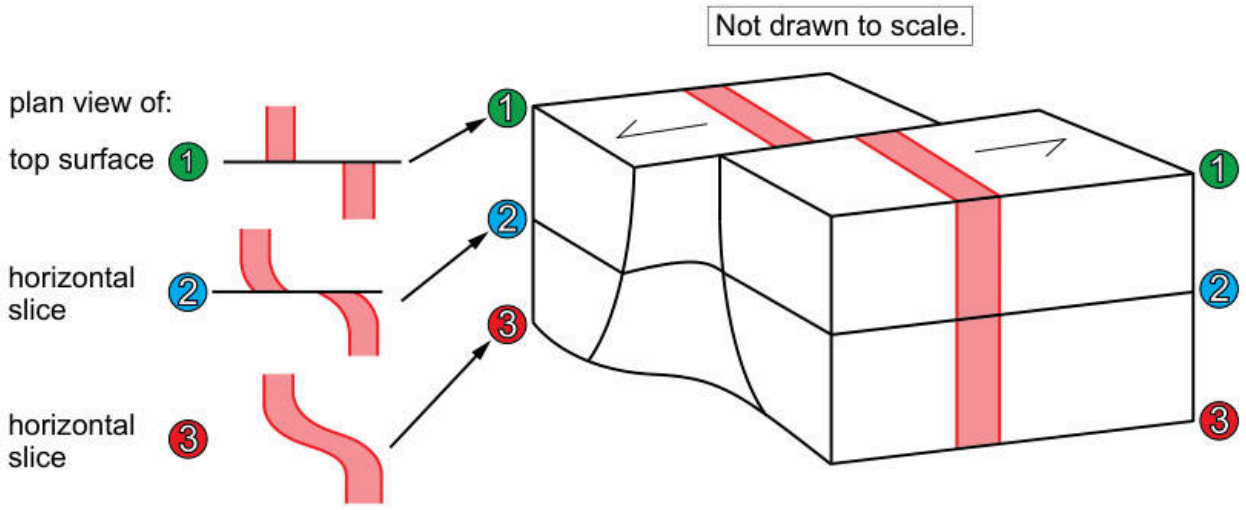


Figure 6c

Describe how and explain why the type of deformation the rocks in **Figure 6c** have experienced changes with depth. [6 QER]

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17

END OF PAPER

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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 1a	Understanding Geology. Webster, D. 1987. Oliver and Boyd, Harlow, 197pp.
Figures 2	https://earthref.org/drupal/content/magnetic-anomaly-mapping
Figure 3a	https://www.wired.com/2010/08/etna-week-part-2-the-current-dynamics-and-activity-of-etna/
Figure 3b	https://www.nap.edu/read/24650/chapter/6
Figure 4	Stony meteorite. https://www.crystalclassics.co.uk/product/ Iron meteorite. http://www.meteorite-list-archives.com/2015/oct/0087.html
Table 1	Meteorites. https://www.permanent.com/meteorite-compositions.html Earth. http://periodictable.com/Properties/A/CrustAbundance.html
Figure 5b	Analysis of floodplain sedimentation, avulsion style and channelized fluvial sandbody distribution in an upper coastal plain reservoir: Middle Jurassic Ness Formation, Brent Field, UK North Sea. Y. S. Flood and G.J. Hampson. 2016. Geological Society, London, Special Publications, 444, 109-140, 29
Figure 6b	https://www.chegg.com/homework-help/questions-and-answers/problem-1-stress-strain-curve-berea-sandstone-sample-uniaxial-compression-test-given-figur-q26685241
Figure 6c	Foundations of structural geology. Park, R.G. 1989. Blackie, London, 148pp.

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