Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A480U20-1

S23-A480U20-1

Part of WJEC

TUESDAY, 13 JUNE 2023 – AFTERNOON

GEOLOGY – A level component 2

Geological Principles and Processes

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**17**	
3.	**15**	
4.	**15**	
5.	**13**	
6.	**15**	
Total	**90**	

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ADDITIONAL MATERIALS

In addition to this examination paper you will need:
- 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 **3** and **5**.

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

1. **Figure 1a** shows the changes in marine faunal diversity during the Phanerozoic (Sepkoski's curves) together with three fossils (**Fossil X**, a brachiopod and **Fossil Y**) which are characteristic of the Cambrian, Palaeozoic and Modern faunas.

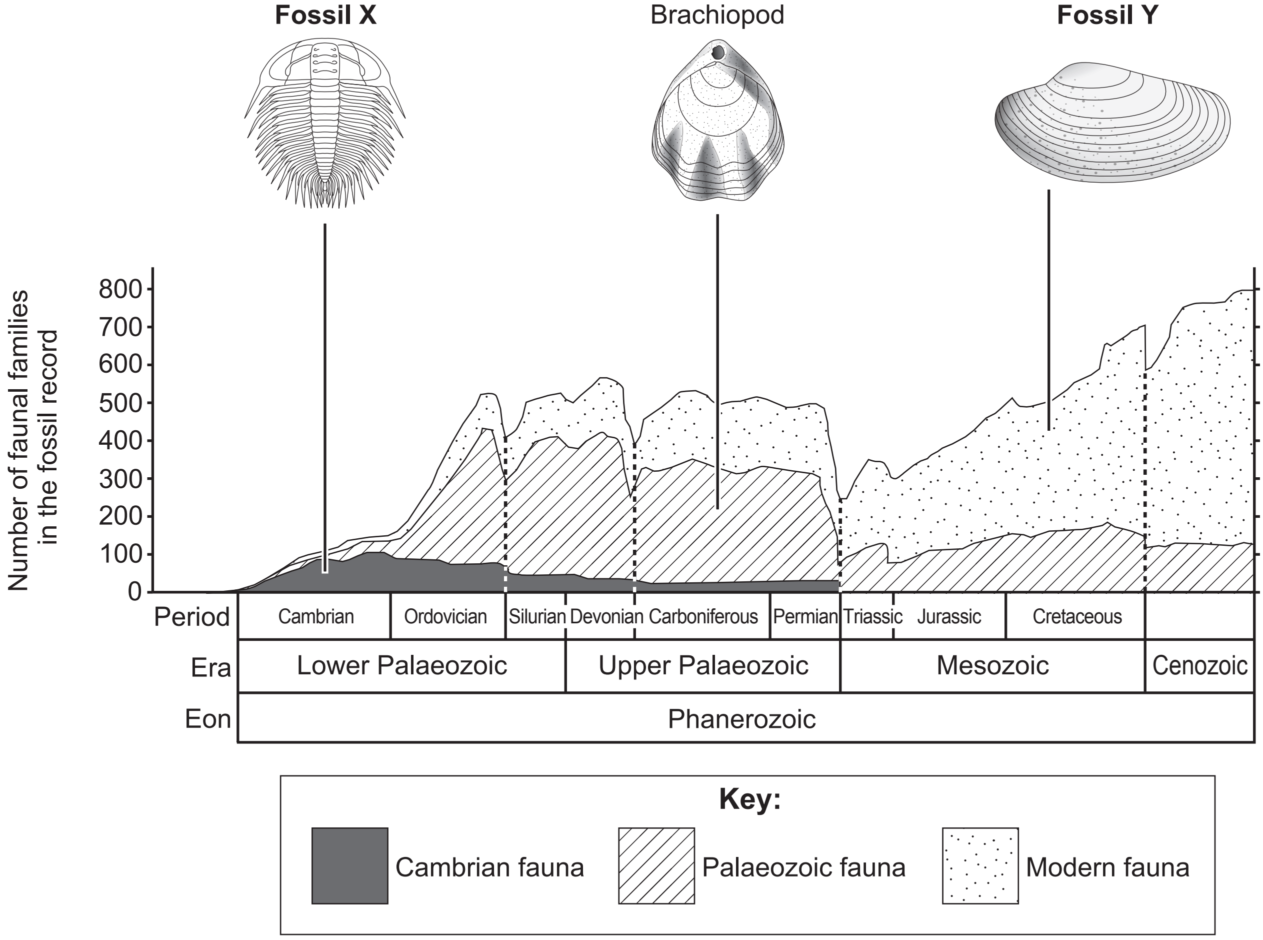

Figure 1a

Refer to **Figure 1a**.

(a) State the name of the fossil groups represented by **Fossil X** and **Fossil Y** on **Figure 1a**. [2]

Fossil X ....

Fossil Y ....

(b) (i) Describe the changes in the number of 'Cambrian' faunal families during the Lower Palaeozoic. [3]

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(ii) Calculate the percentage change in the number of 'Modern' faunal families from the start to the end of the Mesozoic. Show your working. [3]

.... %

(c) A student stated that 'every geological period during the Phanerozoic ends with a mass extinction event'. With reference to **Figure 1a**, evaluate the student's conclusion. [2]

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(d) **Figure 1b** shows two models used to interpret the way in which new species evolve.

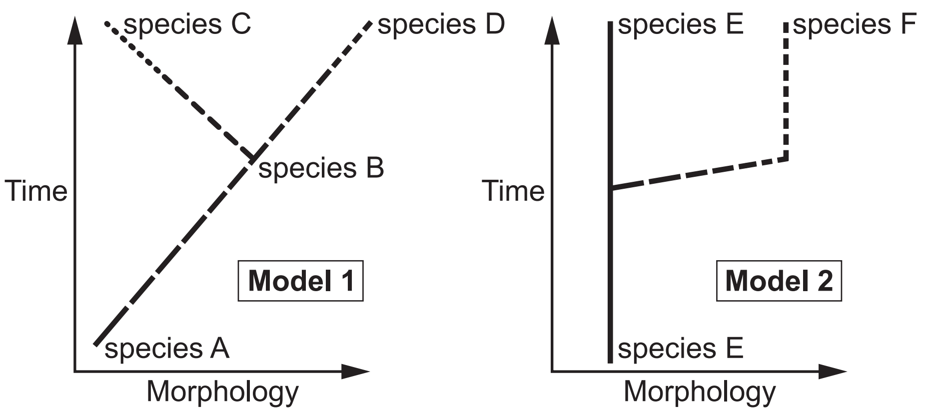

Figure 1b

(i) State which model, **Model 1** or **Model 2**, best illustrates 'punctuated equilibrium'. [1]

Model ....

(ii) Describe the differences between the **two** evolutionary models shown on **Figure 1b**. [4]

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2. **Figure 2a** shows a basalt from Hawaii which contains a fragment of peridotite. **Figure 2b** is an enlarged view of the peridotite fragment.

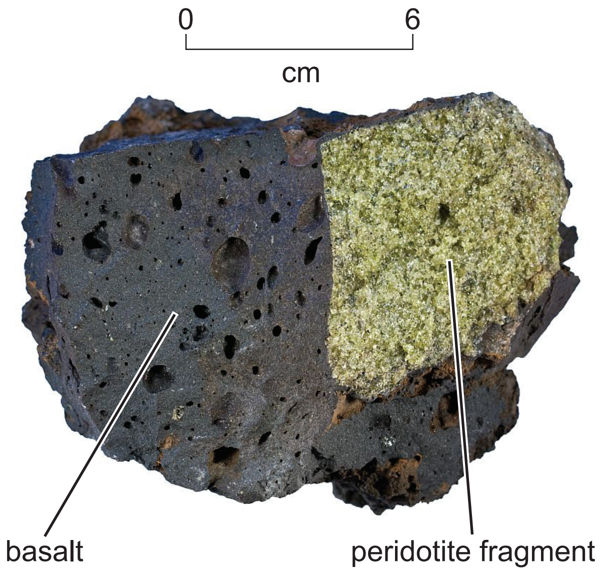

Figure 2a

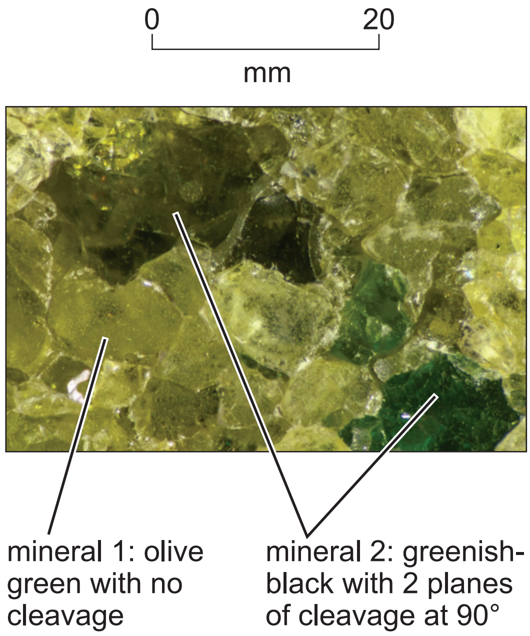

Figure 2b

(a) Explain why the rock in **Figure 2b** is correctly identified as peridotite. You may wish to refer to the Mineral Data Sheet. [3]

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(b) To calculate the density of peridotite, a student took a sample of the peridotite fragment and measured its mass and volume. **Table 1** shows the results of this experiment.

Mass (g)	Volume (cm^3)
34.0 ± 0.1	10 ± 0.5

Table 1

(i) Use the results in **Table 1** to calculate:

- the density of the peridotite sample
- the percentage uncertainty in the value of the density of the peridotite sample.

Show your working. [3]

Density = ... $g\,cm^{-3}$

Percentage uncertainty = ... %

(ii) State **two** ways by which the student could reduce the percentage uncertainty in their density calculation. [2]

1. ....

....

2. ....

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(c) **Figure 2c** shows how the density of rock in the mantle changes with depth down to 1800 km.

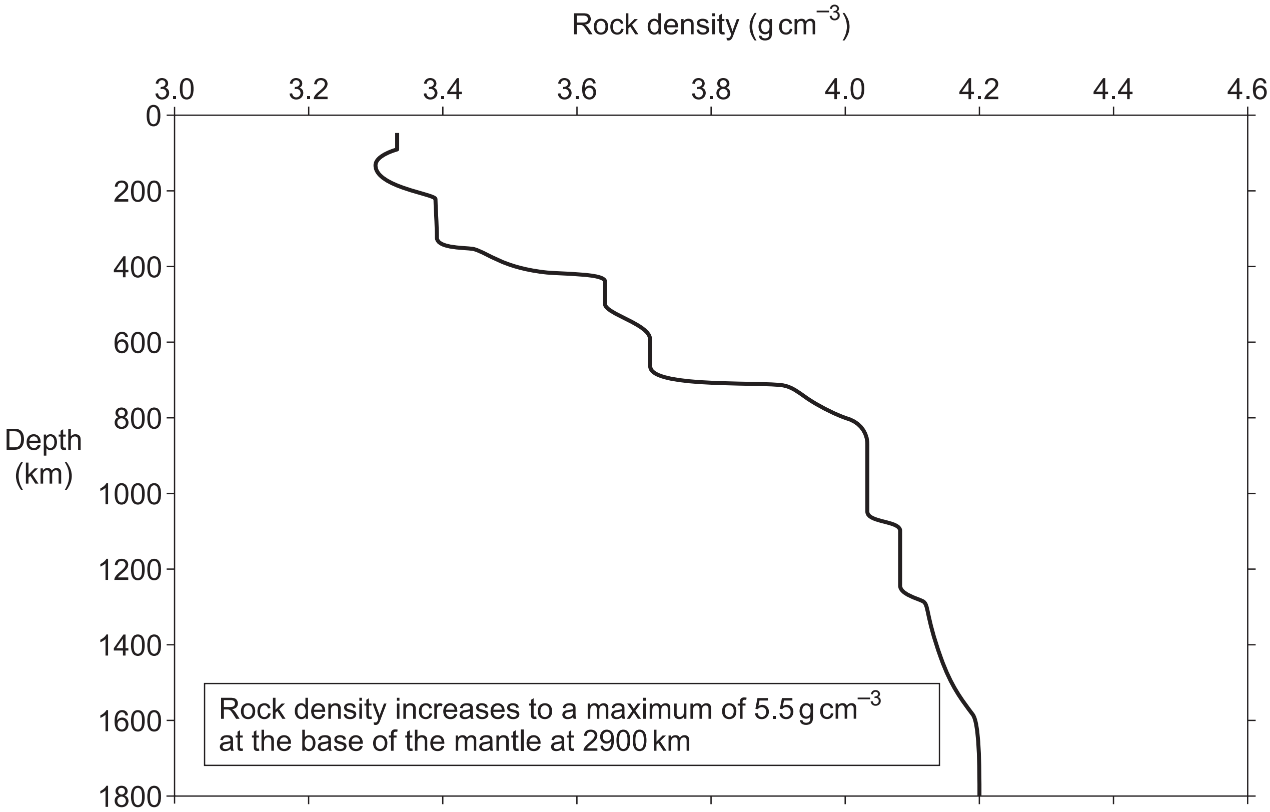

Figure 2c

(i) Describe how the density of rock in the mantle changes between the depths of 40 and 1800 km in **Figure 2c**. [2]

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(ii) Using your answer for density in question b(i), draw on **Figure 2c** a labelled arrow (←**P**) to mark the position where the peridotite fragment in **Figure 2a** may have formed. [1]

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(iii) Explain the geological processes by which the peridotite fragment in **Figure 2a** came to be found in the basalt on Hawaii. [3]

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(d) (i) Given that the mean density of the Earth is $5.5\,g\,cm^{-3}$, explain what the data on **Figure 2c** enables you to conclude about the density of the Earth's core. [1]

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(ii) Using your knowledge, describe what the Earth's magnetic field suggests about the composition of the Earth's core and its processes. [2]

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3. **Figure 3a** shows the pressure-temperature-time pathways followed by two metamorphic rocks together with the stability fields of three common metamorphic minerals.

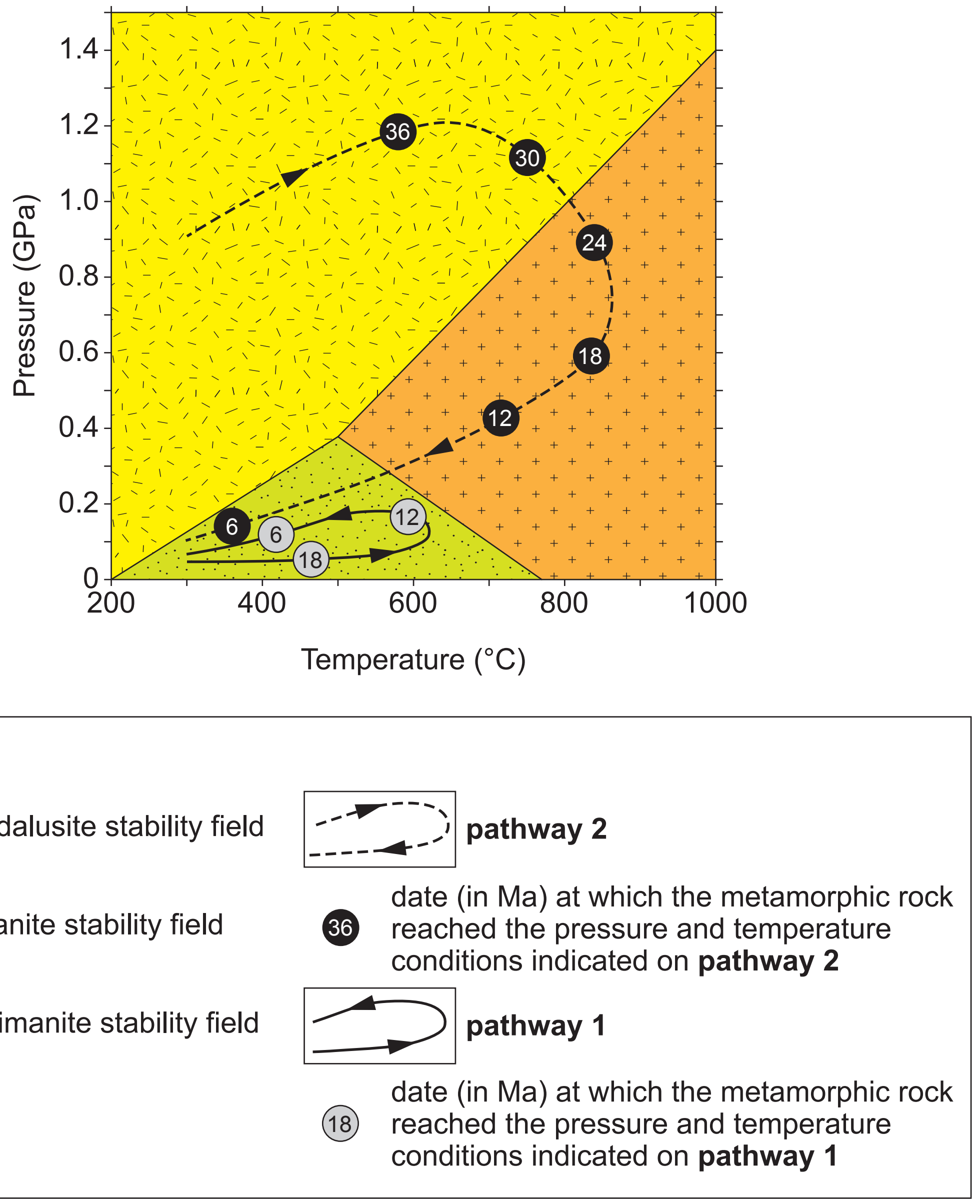

Figure 3a

(a) State the temperature and pressure experienced by the metamorphic rock following **pathway 2** at 36 million years ago (Ma) on **Figure 3a**. [2]

.... °C

.... GPa

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(b) Compare the metamorphic history of the rocks following **pathway 1** and **pathway 2** on **Figure 3a** in terms of:
- the relative timing and values of maximum temperature and pressure each rock underwent
- the sequence of mineral stability fields each rock passed through and the type and grade of metamorphism each rock underwent. [6 QER]

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(c) **Figure 3b** shows a photomicrograph of the metamorphic rock that formed under the conditions represented by **pathway 2** on **Figure 3a**.

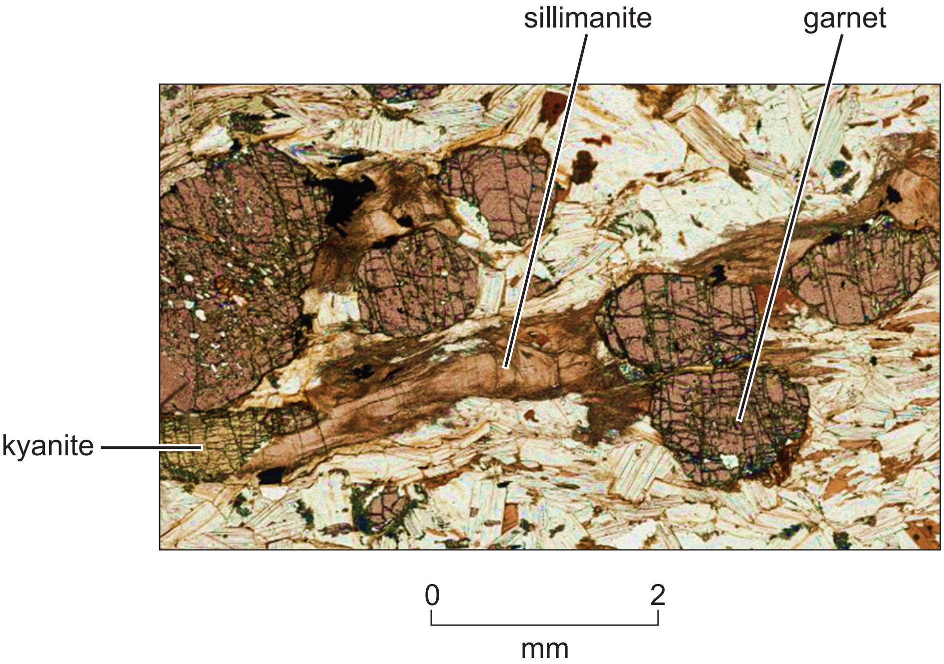

Figure 3b

(i) Explain how the texture and mineralogy of the metamorphic rock in **Figure 3b** support the conclusion that it formed under the conditions represented by **pathway 2** on **Figure 3a**. [4]

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(ii) Using information from **Figure 3a** only, explain why no andalusite is found in the metamorphic rock in **Figure 3b** despite **pathway 2** passing through the andalusite stability field. [3]

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4. **Figure 4a** shows the distribution and names of hot spots on the Earth's surface.

Figure 4b is a seismic tomography cross-section (**X–Y**) passing through the Yellowstone Hotspot.

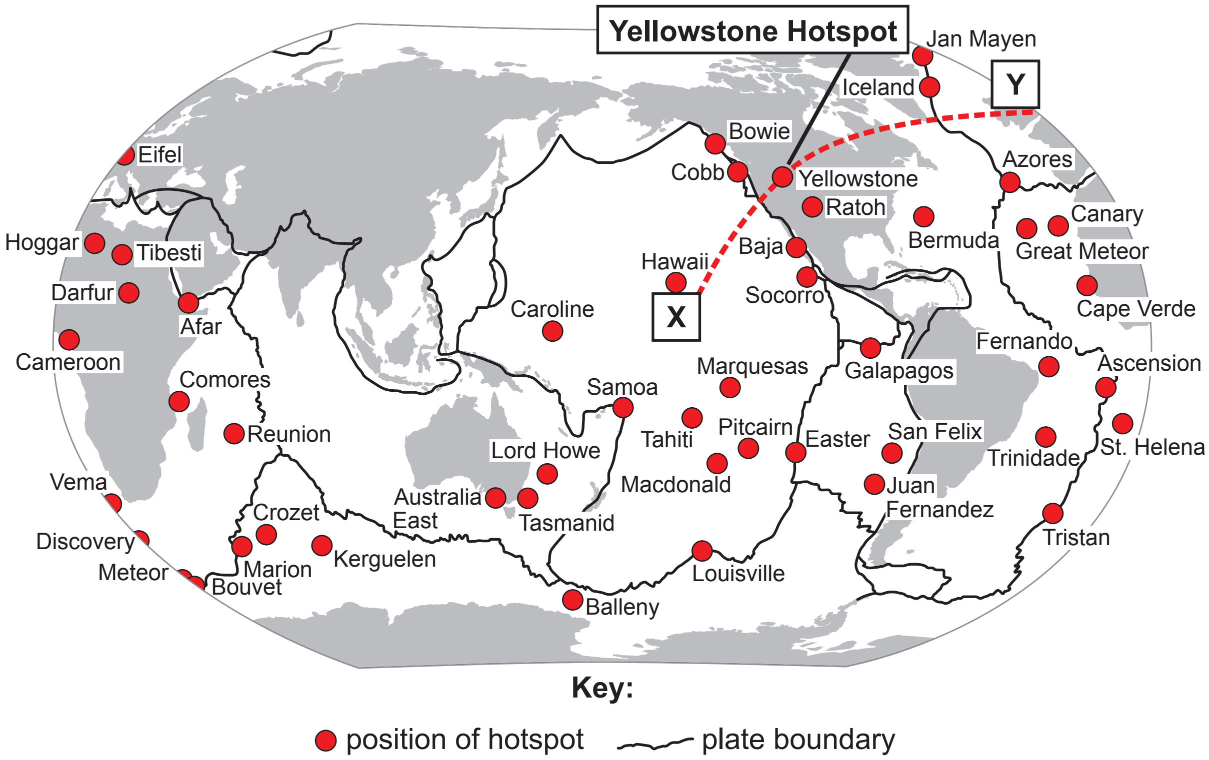

Figure 4a

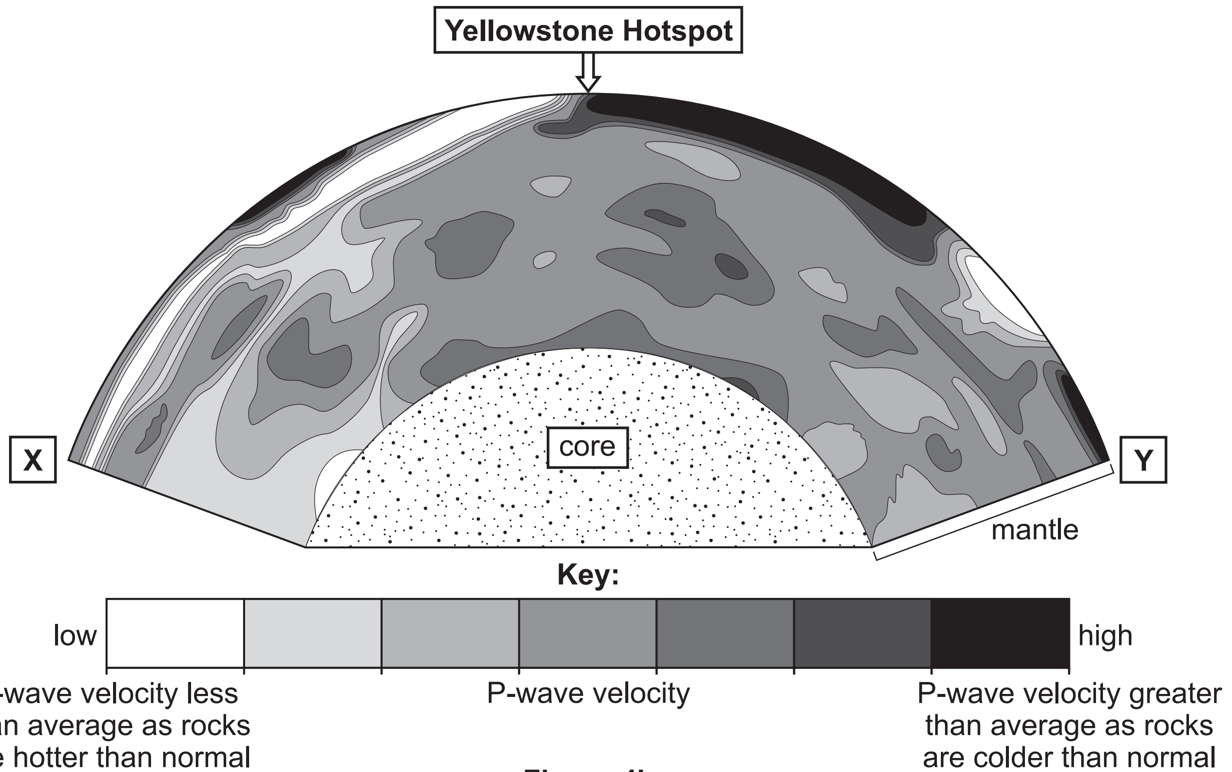

Figure 4b

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(a) Refer to **Figure 4a**. A student stated that 'the hot spots on the Earth's surface are regularly spaced and are only found along plate boundaries'. Evaluate the student's statement giving examples of named hot spots. [3]

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(b) Refer to **Figure 4a** and **Figure 4b**. In 1972 a geophysicist, William Morgan, suggested that hot spots, like that at Yellowstone, originate from plumes of hot rising rock from deep in the lower mantle. Explain whether or not the data in the seismic tomography cross-section supports Morgan's suggestion. [3]

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(c) **Figure 4c** shows graphs of depth and temperature data together with a geological cross-section. These have been used to explain the formation of magma at divergent plate boundaries and hot spots.

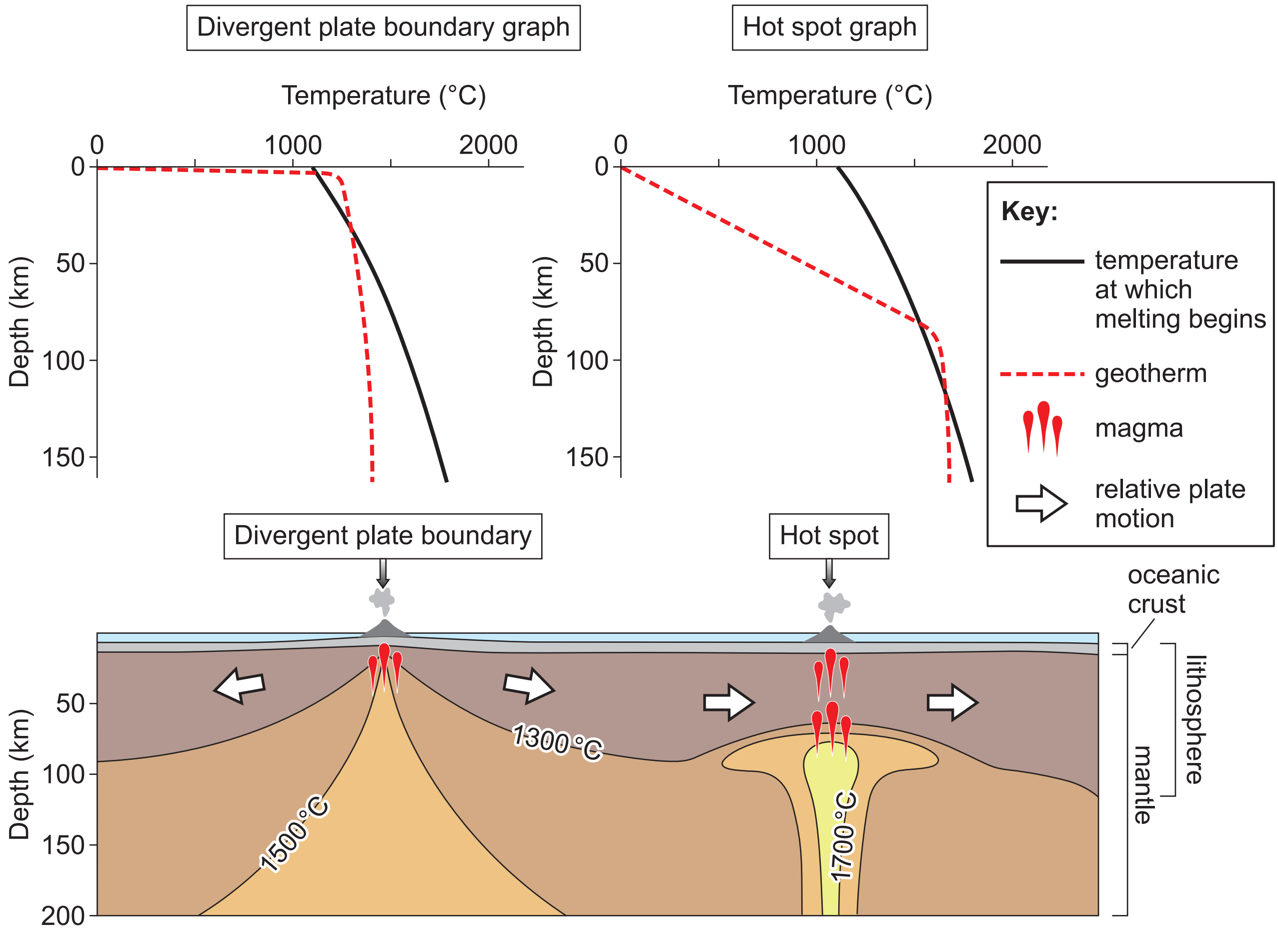

Figure 4c

(i) Shade in an area on both the divergent plate boundary graph and the hot spot graph on **Figure 4c** to show where the rocks are expected to be partially molten. Explain your answer. [3]

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(ii) Refer to **Figure 4c**. Describe the differences in the way magma is believed to form beneath divergent plate boundaries and hot spots. [4]

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(iii) Refer to **Figure 4c**. Explain why the lava erupted at divergent plate boundaries and hot spots may have a very similar composition despite being formed by different processes. [2]

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5. **Figure 5a** shows the current location of Neoproterozoic glacial deposits and an indication of the latitude at which they formed. It also shows the maximum limits of the recent Quaternary ice sheets.

Figure 5b is a partially completed bar chart showing some of the palaeolatitude data on **Figure 5a**.

Figure 5c is a photograph showing the texture of a Neoproterozoic deposit at the location shown on **Figure 5a**.

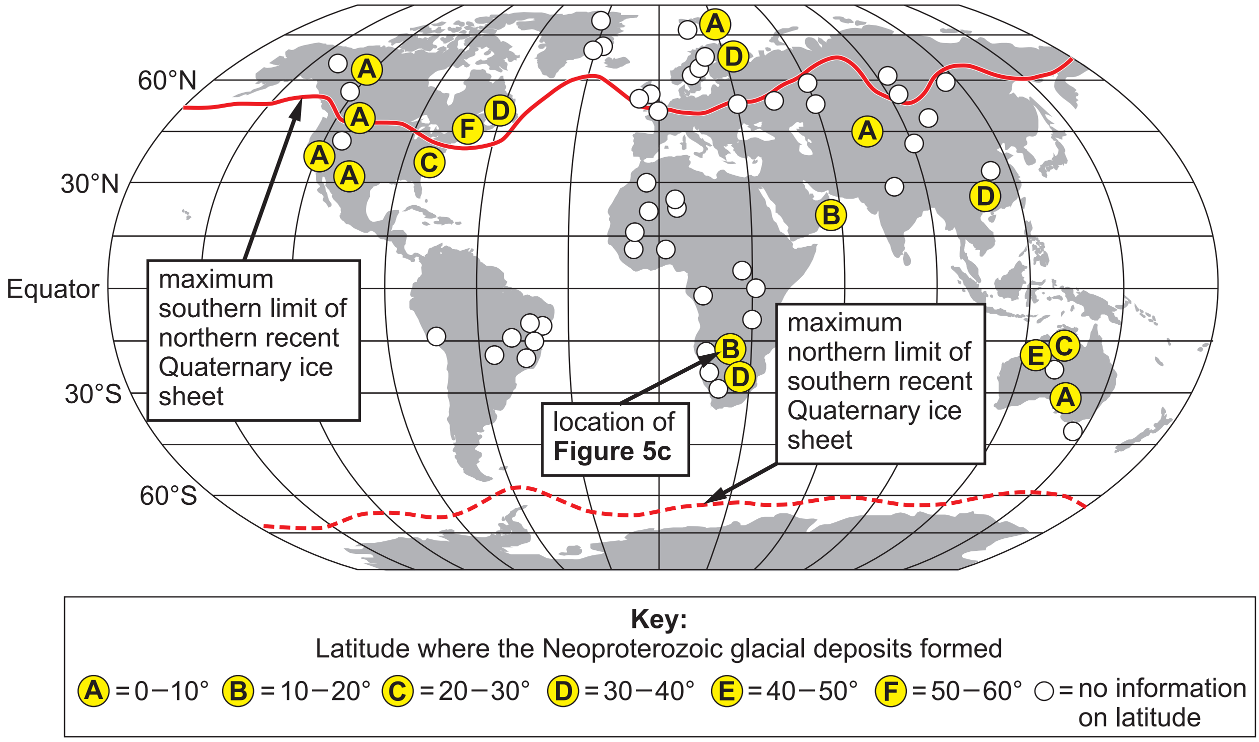

Figure 5a

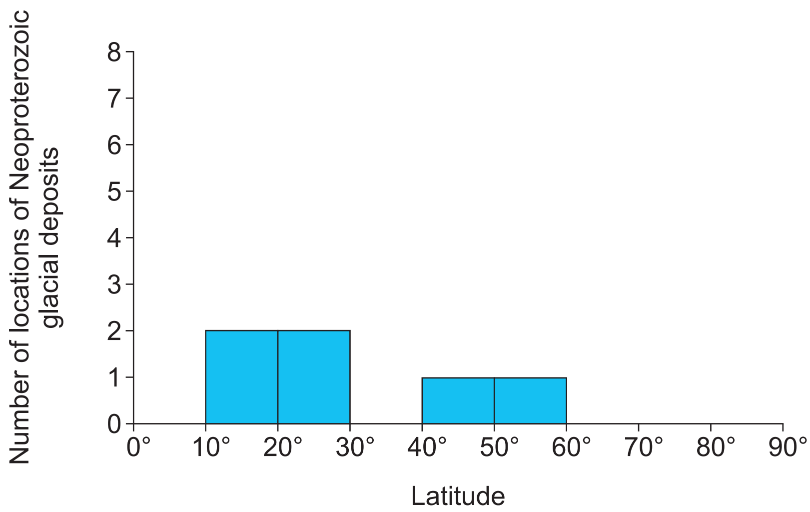

Figure 5b

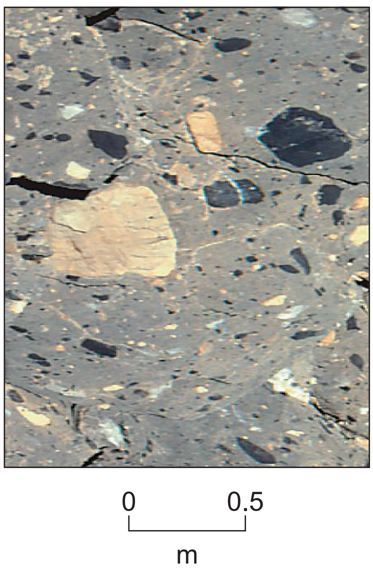

Figure 5c

Examiner only

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

(i) Complete **Figure 5b** to show the number of locations where Neoproterozoic glacial deposits formed between palaeolatitudes of:

- 0–10°
- 30–40° [2]

(ii) Using your knowledge, explain how the palaeolatitude of these Neoproterozoic glacial deposits can be determined. [3]

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(iii) Refer to **Figure 5a** and **Figure 5b**. Describe the differences in the distribution of ice sheets in recent Quaternary and Neoproterozoic times. [2]

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(b) The 'Snowball Earth' hypothesis proposes that during the Neoproterozoic the Earth's surface became completely covered by ice. Evaluate this hypothesis using the data on **Figure 5a**, **Figure 5b** and **Figure 5c**. [6 QER]

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6. **Figure 6a** shows the depth and temperature conditions under which oil and gas formed in part of the North Sea area.

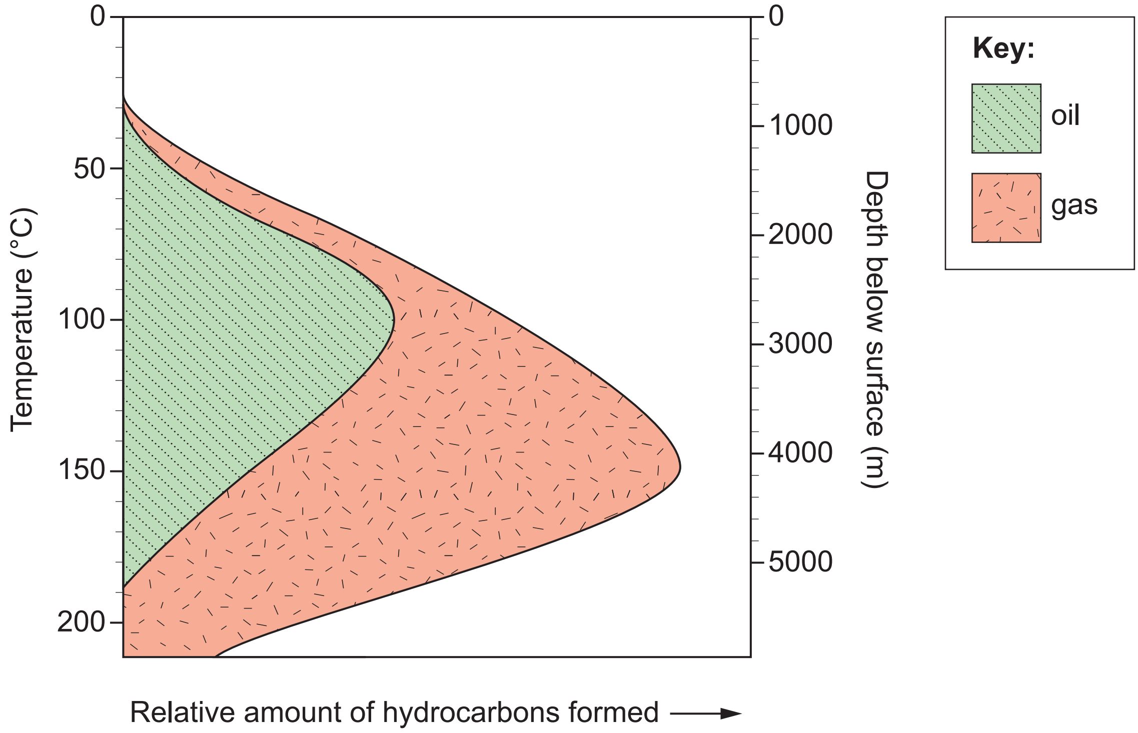

Figure 6a

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

(i) Complete **Table 2** to show the temperatures at which peak oil and peak gas formation take place. [2]

	Temperature (°C)
Peak oil formation	•
Peak gas formation	•

Table 2

(ii) Calculate the geothermal gradient of this area of the North Sea in $°C\,m^{-1}$. Express your answer to 2 significant figures. [2]

Geothermal gradient = ... $°C\,m^{-1}$

(iii) State what would happen to the depth of peak oil formation if the geothermal gradient was higher than that calculated in (a)(ii). Explain your answer. [2]

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(b) **Figure 6b** is a graphic log of a sedimentary sequence obtained from a borehole drilled in the North Sea area. **Figure 6c** is a chart to show the ammonite and microfossil zone fossils used to date this sequence.

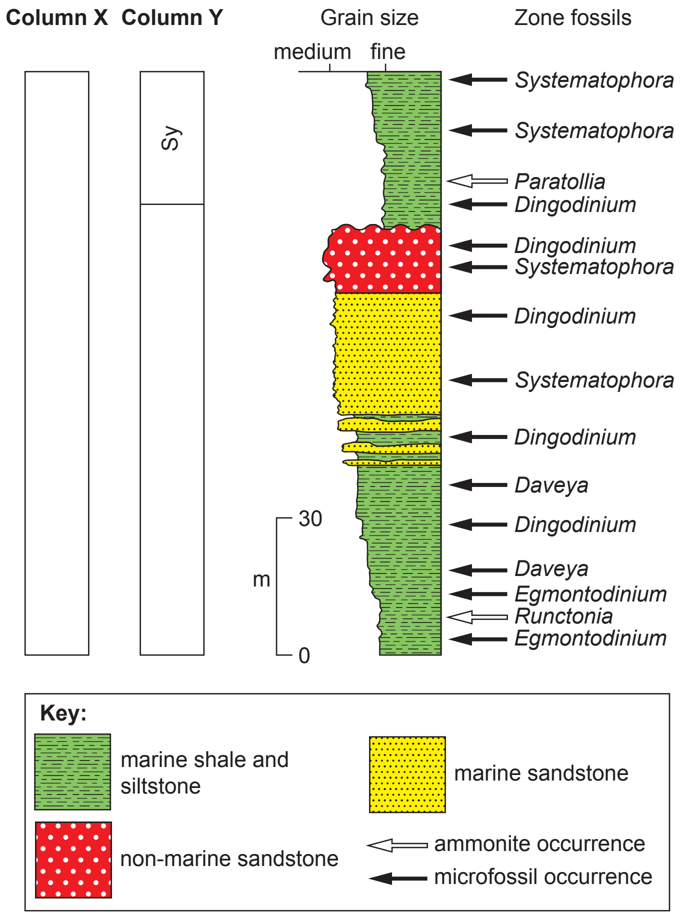

Figure 6b

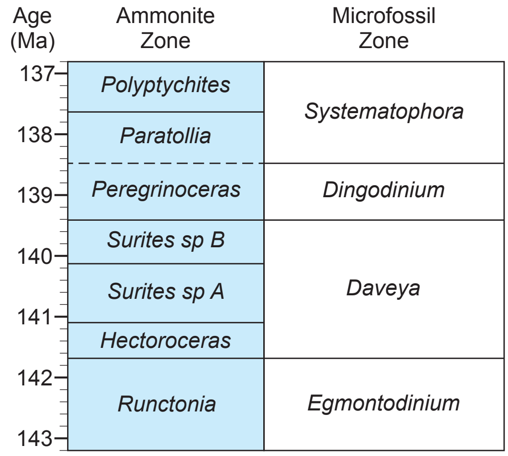

Figure 6c

(i) In this borehole a **20 m thick** section was discovered in which significant oil deposits have accumulated. In **Column X** on **Figure 6b** draw a horizontal line to show the position of the base of this oil-bearing section. [1]

(ii) Explain why you drew the base of this oil-bearing section at this position. [3]

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(c) To date the rocks shown in **Figure 6b** the microfossil zone chart shown in **Figure 6c** is used. The top of each zone is positioned at the first occurrence of that microfossil species working **down** through the sedimentary rock sequence.

(i) Complete **Column Y** on **Figure 6b** by drawing **two** horizontal lines to show the top of the following two microfossil zones:

- *Daveya* (**Da**)
- *Egmontodinium* (**Eg**)

Write the letters of the **three** microfossil zones *Dingodinium* (**Di**), *Daveya* (**Da**) and *Egmontodinium* (**Eg**) in **Column Y**. The position of the *Systematophora* (**Sy**) zone has been drawn to assist you. [2]

(ii) This sequence can also be relatively dated using ammonites. Use the data on **Figure 6b** and **Figure 6c** to evaluate the relative usefulness of ammonites and microfossils in dating this sequence of sedimentary rocks. [3]

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END OF PAPER

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

Acknowledgements

Figure 2a https://www.sandatlas.org/peridotite/.

Figure 2b http://peridotites.blogspot.com/2011/05/. Photograph by Daniel R. Snyder.

Figure 3b https://www.earth.ox.ac.uk.

Figure 5c Ch1–18.jpg (2200×1700) (snowballearth.org). Photograph by P Hoffman.

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