Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B480U20-1

S23-B480U20-1

MONDAY, 22 MAY 2023 – MORNING

GEOLOGY – AS component 2
Foundation Geology

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**17**	
3.	**15**	
4.	**13**	
5.	**19**	
6.	**16**	
Total	**90**	

B480U201
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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 **2** and **6**.

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Answer **all** questions.

1. The Earth is composed of a variety of different elements which can be classified using the Goldschmidt classification system.

Lithophile	•
Siderophile	•
Atmophile	•

Table 1

(a) Complete **Table 1** by matching **three** of the following Earth layers to their most likely corresponding Goldschmidt classifications. [2]

core **hydrosphere** **crust** **mantle** **atmosphere**

(b) (i) Using the following information, calculate the volume of the whole Earth assuming that it is a sphere. Show your working and write your answer in standard form. [3]

r = Earth radius = 6371 km

$\pi = 3.14$

Volume of a sphere $= \frac{4}{3}\pi r^3$

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(ii) Using your answer to question (b)(i) and the information below, calculate the mean density of the whole Earth. Show your working. [2]

Earth mass $= 5.972 \times 10^{24}$ kg

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(c) **Table 2** shows the density of the Earth's crust and mantle.

Earth layer	Density ($g\,cm^{-3}$)
Continental crust	2.7
Oceanic crust	3.0
Mantle	4.5

Table 2

The whole Earth has a density greater than $4.5\,g\,cm^{-3}$. With reference to the data in **Table 2** only, explain how this can be used to support the theory that the Earth has an iron/nickel core. [3]

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2. **Figure 2a** is a graph showing a number of different rock forming conditions.

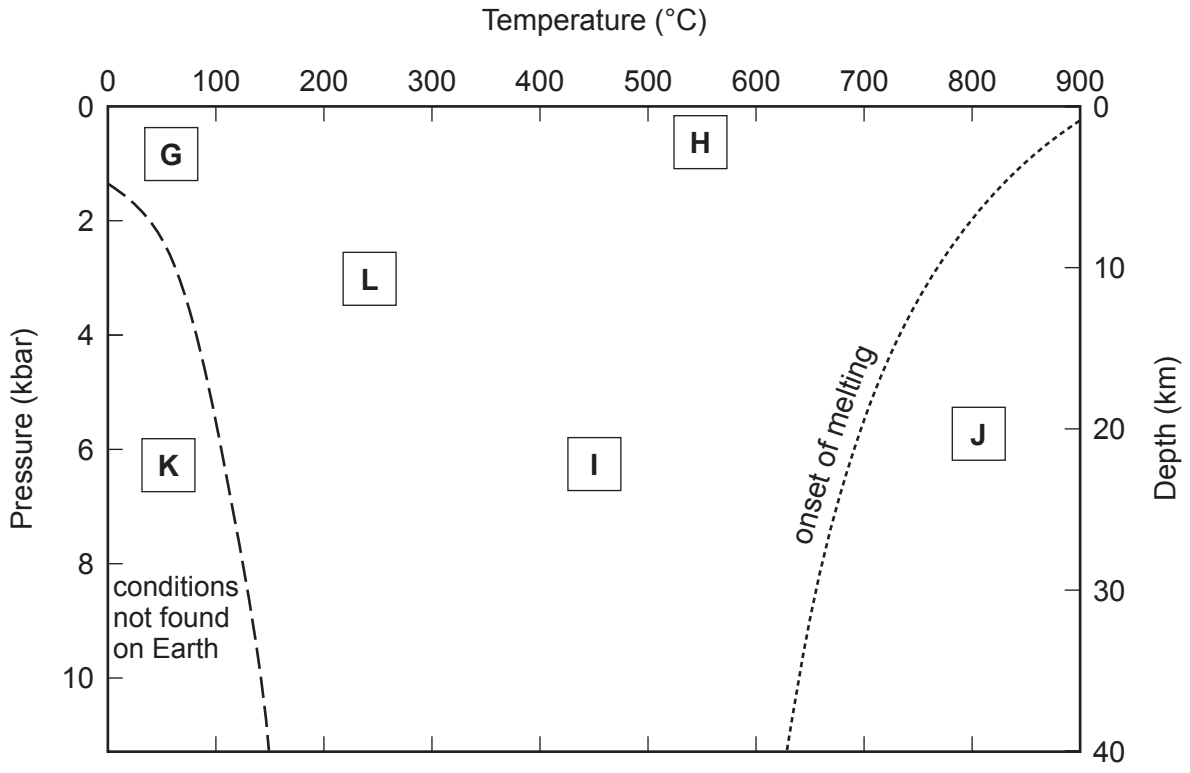

Figure 2a

(a) State the rock type (igneous, sedimentary, metamorphic) forming at location **G** on **Figure 2a**. [1]

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(b) **Figure 2b** shows sedimentary rock **S**. In **Figure 2c** draw the texture of the rock that would be formed if sedimentary rock **S** is exposed to the conditions at location **H** on **Figure 2a**. [3]

sediment **S**

Figure 2b

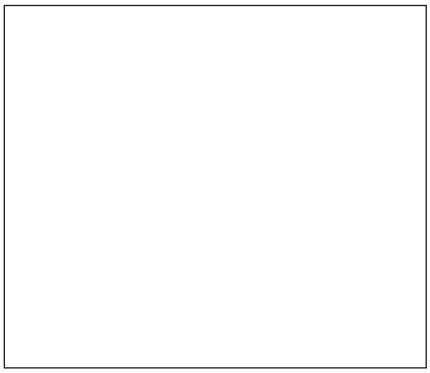

Figure 2c

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(c) The rock shown in **Figure 2d** formed at a location on **Figure 2a**.

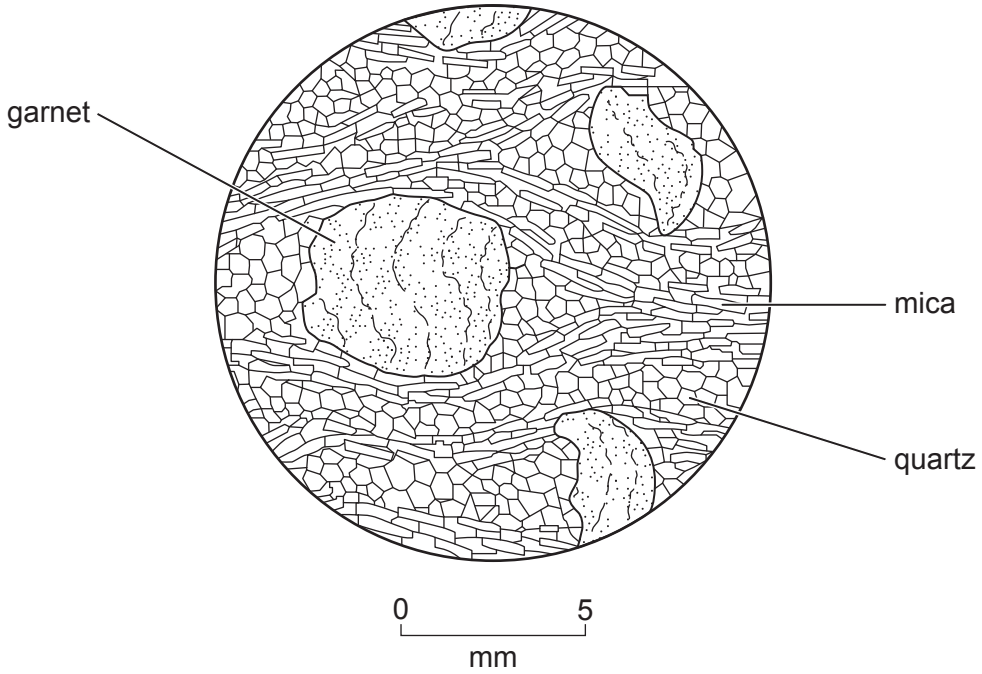

Figure 2d

State the location (**G**, **H**, **I**, **J**, **K**, **L**) at which the rock shown in **Figure 2d** is likely to have been formed. Give reasons for your answer. [4]

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(d) (i) James Hutton was the first to develop the principle of uniformitarianism. State what is meant by uniformitarianism. [1]

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(ii) James Hutton also developed the concept of the rock cycle which involves the transfer of energy. State the internal and external energy sources which drive the rock cycle. [2]

Internal: .....

External: .....

(iii) **Figure 2e** shows three rocks **A**, **B**, and **C**.

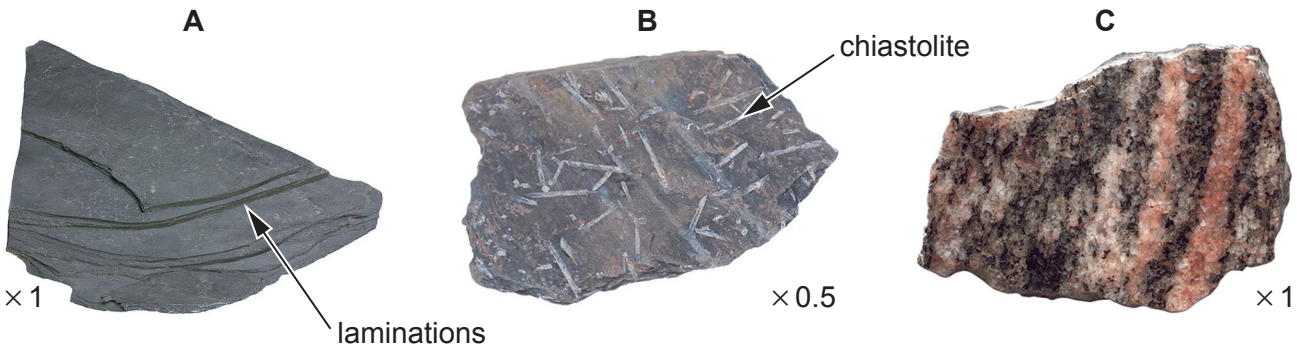

Figure 2e

The three rocks shown in **Figure 2e** (**A**, **B**, **C**) can be linked through the rock cycle. Explain how the rocks can be linked, describing the conditions and geological settings for the formation of each rock. [6 QER]

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3. **Figure 3a** shows different settings for the generation of magma. **Figure 3b** shows the geotherm and melting point temperatures for peridotite, obtained by laboratory experiments.

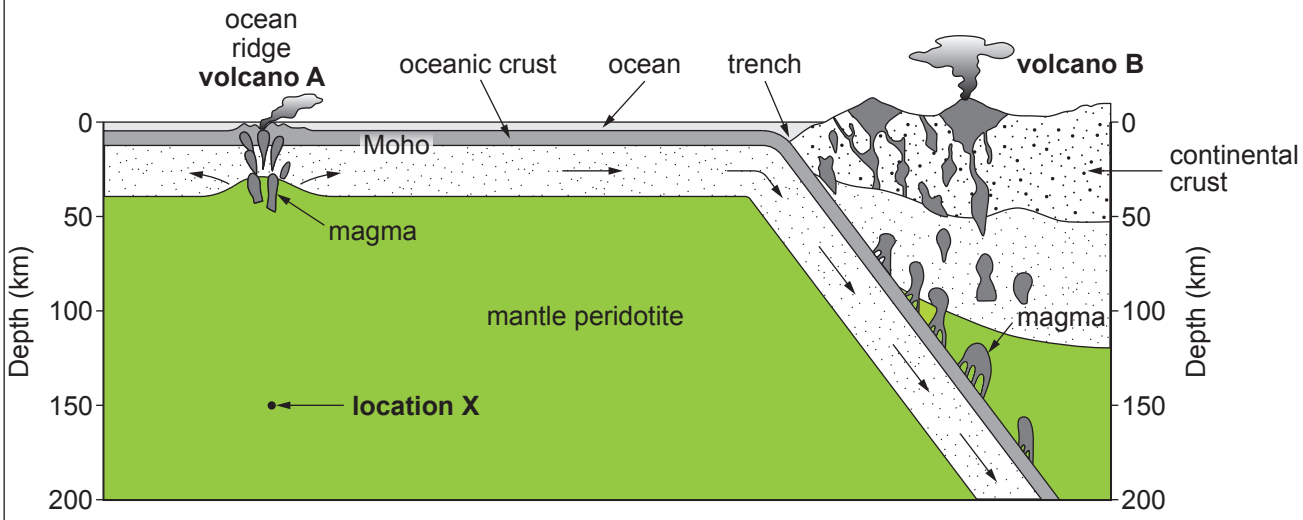

Figure 3a

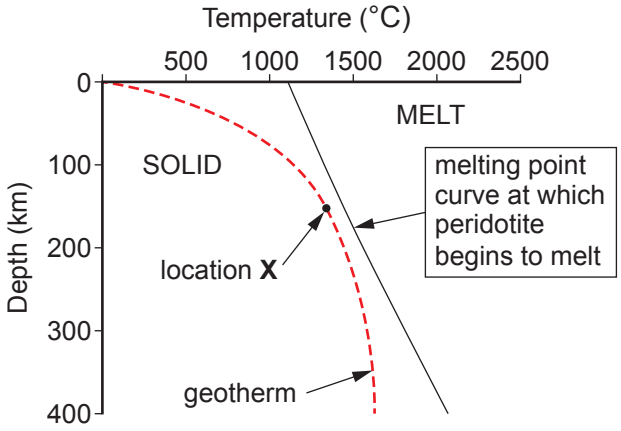

Figure 3b

(a) State the type of plate boundaries where volcano **A** and volcano **B** are formed on **Figure 3a**. [2]

Volcano **A** .....

Volcano **B** .....

(b) Location **X** is in the asthenosphere. Using **Figure 3b** state the physical state (solid, liquid, gas) of the asthenosphere at location **X**. [1]

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(c) (i) Explain the process that enables magma to be generated beneath volcano **A**. [3]

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(ii) State the composition of lava most commonly erupted from volcano **A** and volcano **B**. [2]

Volcano **A** .....

Volcano **B** .....

(d) **Figure 3c** shows a volcanic rock.

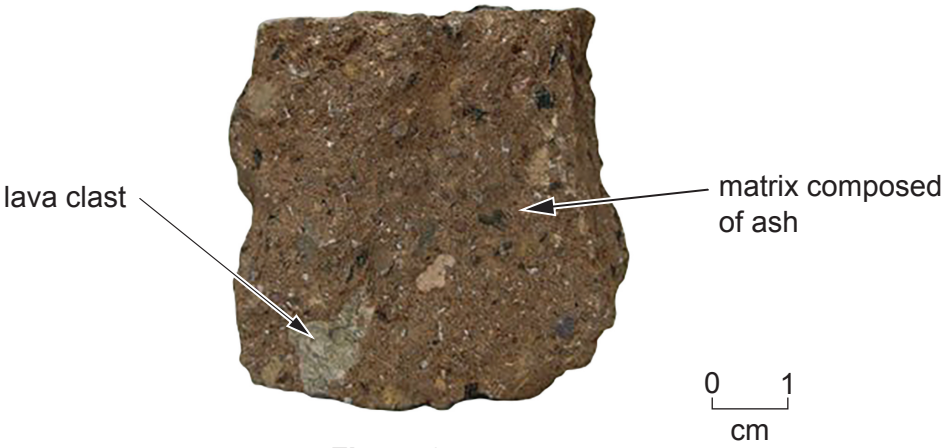

Figure 3c

(i) Describe the texture of the rock shown in **Figure 3c**. [3]

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(ii) State which volcano, volcano **A** or volcano **B** in **Figure 3a**, is most likely to have produced the rock shown in **Figure 3c**. Give reasons for your answer. [4]

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4. **Figure 4a** shows fossil **L** and **Figure 4b** shows fossil **M** (an ammonite).

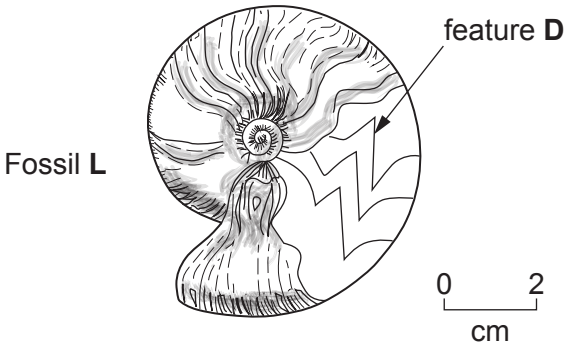

Figure 4a

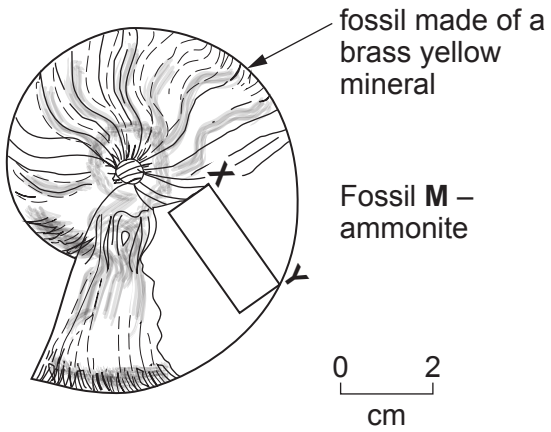

Figure 4b

Refer to **Figure 4a** and **Figure 4b**.

(a) (i) State the name of feature **D** in **Figure 4a**. [1]

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(ii) State the type of fossil cephalopod shown in **Figure 4a**. Give a reason for your answer. [2]

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(iii) Draw, in the box below, a diagram to show how feature **D** would appear between points **X** and **Y** in fossil **M** (an ammonite) in **Figure 4b**. [2]

X **Y**

(iv) Explain how fossil **M** has been preserved. Give a reason for your answer. You may wish to refer to the Mineral Data Sheet. [3]

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(b) Fossils **L** and **M** were observed at two of three locations shown on the geological map in **Figure 4c**.

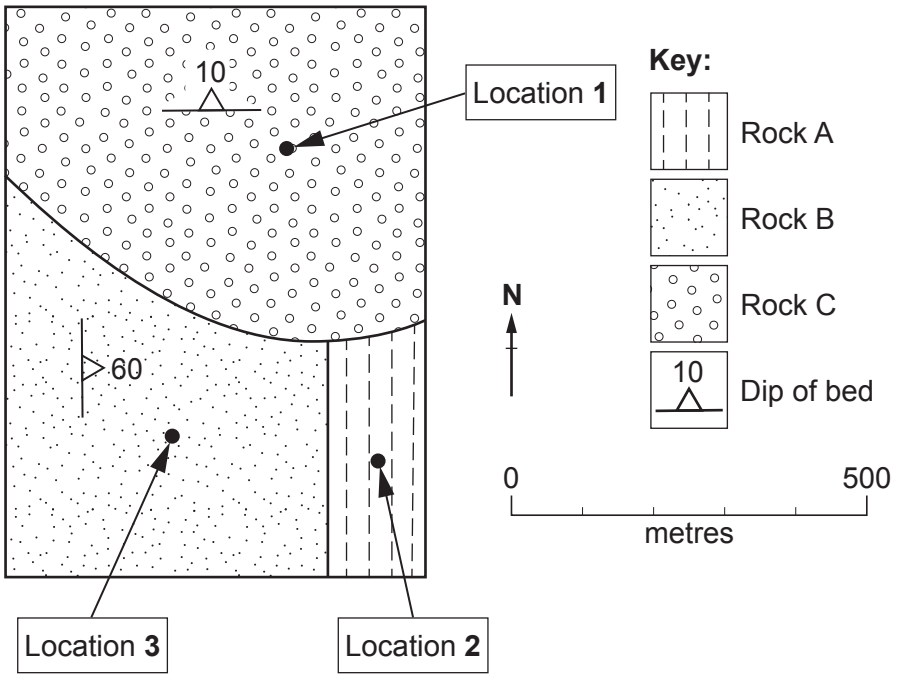

Figure 4c

(i) Fossils **L** and **M** can be used as zone fossils. Explain what is meant by the term zone fossil. [1]

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(ii) Fossil **L** was observed at location **2** on **Figure 4c**. State at which location fossil **M** is most likely to have been observed. Give reasons for your answer. [4]

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5. **Figure 5** is a partially completed diagram showing variations of magnetic inclination at different latitudes around the Earth.

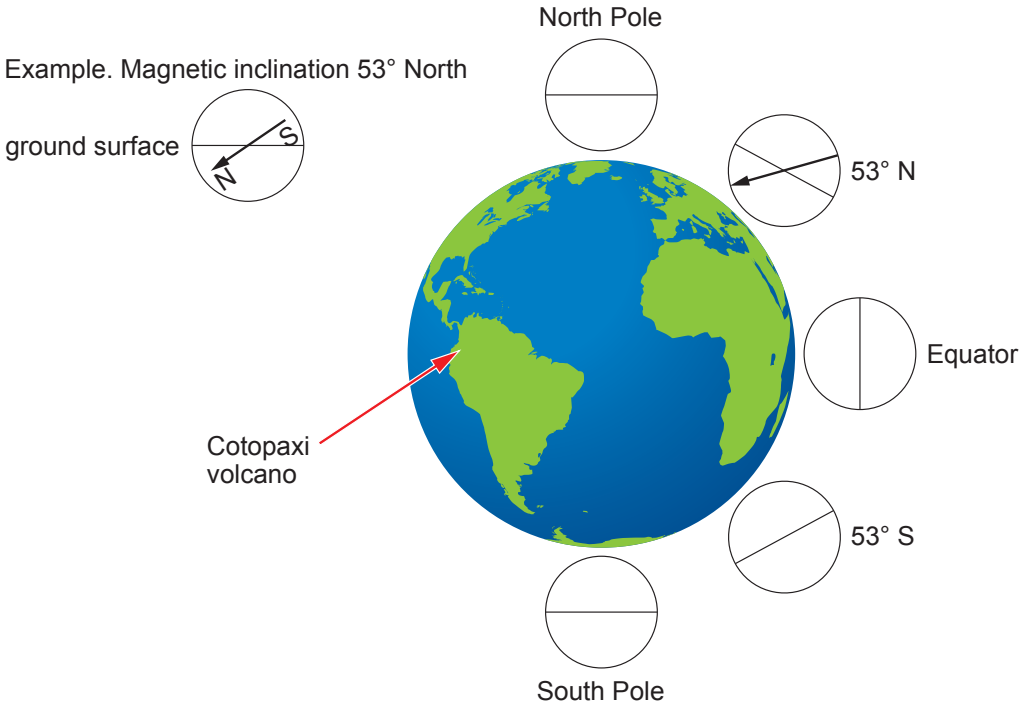

Figure 5

(a) Complete **Figure 5** by drawing an arrow in **four** circles to show the variation in magnetic inclination from the North Pole to the South Pole. [3]

(b) **Table 3** shows magnetic inclination data of lavas erupted during the 2016 Cotopaxi volcanic eruption in Ecuador and of lavas erupted in India over time.

Sample Number	Cotopaxi magnetic inclination (°)	India magnetic inclination (°)
1	1	–20
2	2	–30
3	1	10
4	–1	20
5	1.5	15
6	–0.5	12
7	1.5	1.5
8	2	2
9	–0.5	1
10	1.5	–15
11	1	19
12	2.5	0.5
Mean	•	1.3

Table 3

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(i) Complete **Table 3** by calculating the mean magnetic inclination for the Cotopaxi volcano. Show your working. [2]

(ii) Explain how the lavas erupted during the Cotopaxi eruption have preserved magnetic inclination data. [3]

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(iii) The formula below can be used to calculate the latitude of the Cotopaxi volcano.

$$\tan \lambda = \frac{\tan L}{2}$$

λ = latitude of Cotopaxi

L = mean magnetic inclination

Calculate the latitude of the Cotopaxi volcano. Show your working. [3]

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(c) **Table 4** shows the magnetic inclination data of lavas erupted in India over time and calculations required to determine standard deviation.

Sample number	Magnetic inclination (°)	$x - \overline{x}$	$(x - \overline{x})^2$
1	–20	–21.3	453.7
2	–30	–31.3	•
3	10	•	75.7
4	20	18.7	349.7
5	15	13.7	187.7
6	12	10.7	114.5
7	1.5	0.2	•
8	2	0.7	0.49
9	1	–0.3	0.09
10	–15	•	265.7
11	19	17.7	•
12	0.5	–0.8	0.64
	Mean inclination		$\sum(x - \overline{x})^2$
	1.3		**2741.26**

Positive magnetic inclination formed in the northern hemisphere, negative magnetic inclination formed in the southern hemisphere.

Table 4

(i) Complete **Table 4** by inserting the **five** missing values. [3]

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(ii) Using the formula, complete **Table 5** by calculating the standard deviation for the data in **Table 4**. Show your working. [2]

SD = standard deviation
n = sample size

$\sum (x - \overline{x})^2 = 2741.26$

$$SD = \sqrt{\frac{\sum (x - \overline{x})^2}{n}}$$

	Cotopaxi	India
Standard deviation	1.11	•

Table 5

(iii) The palaeomagnetic data sets in **Table 3** have similar means. Explain why the standard deviation of the palaeomagnetic data for India is so different to Cotopaxi. [3]

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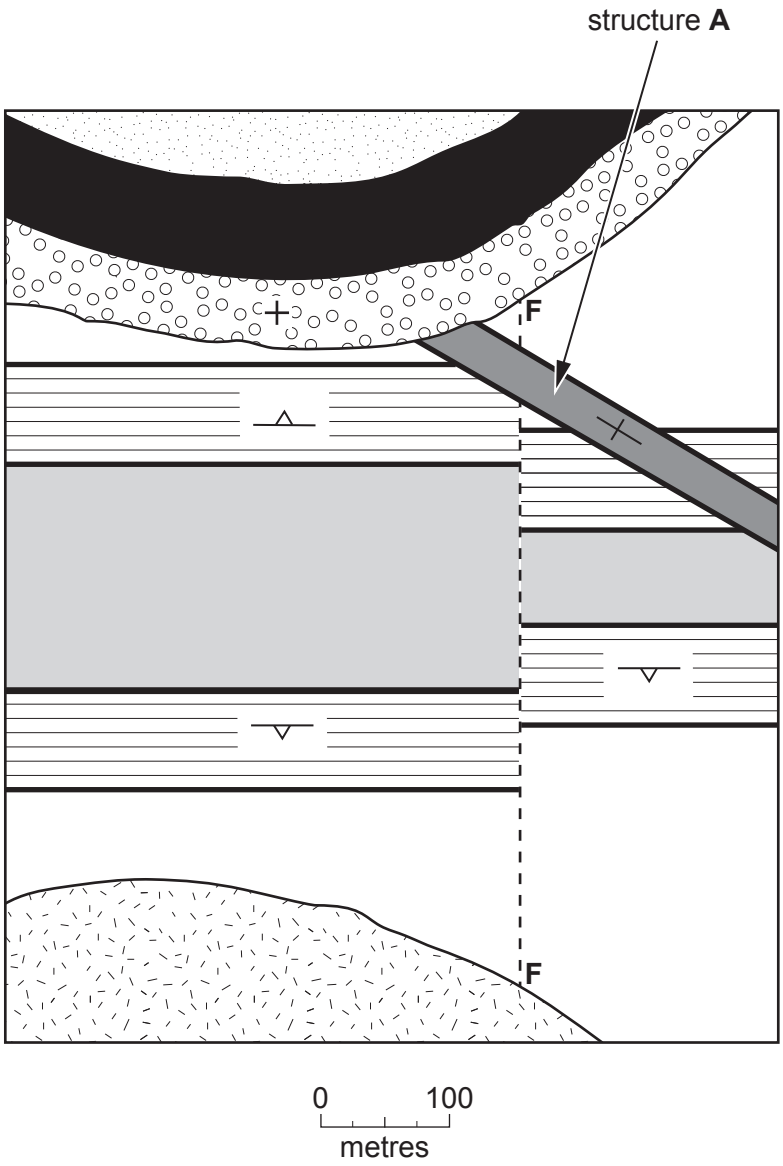
6. **Figure 6** is a geological map.



Key:

F Fault

Horizontal bed

Dip of bed

Vertical feature

Axial plane trace **(antiform)**

Axial plane trace **(synform)**

N

The rock units are not in order of age. Their ornament is not necessarily representative of rock type.

	Rock Unit A
	Rock Unit B (granite)
	Rock Unit C
	Rock Unit D
	Rock Unit E
	Rock Unit F
	Rock Unit G
	Rock Unit H (igneous)

Figure 6

Refer to **Figure 6**.

(a) Draw on **Figure 6** the axial plane trace of a fold using the correct symbol. [1]

(b) A student stated that structure **A** is a dyke. Give **two** reasons to support this statement. [2]

1. .....

2. .....

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(c) Fault **F** crops out in an area of varying topography. Using the evidence from **Figure 6**, tick (✓) **one** box which **best** identifies the type of fault shown by Fault **F**. Give reasons for your answer. [4]

Thrust	Normal	Strike-slip	Reverse	Dip-slip
☐	☐	☐	☐	☐

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(d) **Rock Unit H** is igneous. Explain **three** observations you might make in the field to determine whether it has formed a sill or a lava flow. [3]

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(e) None of the rocks in **Figure 6** are overturned. State the relative age of all rock units and structures shown in **Figure 6**. Explain the evidence for your conclusions. [6 QER]

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16

END OF PAPER

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

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Acknowledgements

Figure 2e – https://www.sandatlas.org/wp-content/uploads/1709-09.08.15_4-
https://www.geologysuperstore.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/c/h/
https://i.pinimg.com/originals/71/a6/19/71a61976c518a0779708434faeab8fd2.jpg

Figure 3c – https://geology.com/rocks/tuff.shtml