Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL – NEW

A480U20-1

S19-A480U20-1

THURSDAY, 6 JUNE 2019 – 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.	**15**	
2.	**14**	
3.	**15**	
4.	**16**	
5.	**14**	
6.	**16**	
Total	**90**	

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ADDITIONAL MATERIALS

In addition to this examination paper you will need
- a calculator;
- a protractor;
- a ruler.

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.
Write your answers in the spaces provided in this booklet.

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 in the spaces provided.*

1. **Figure 1a** shows a model of the relationship between the depth of weathered material and climatic (precipitation and temperature) zones.

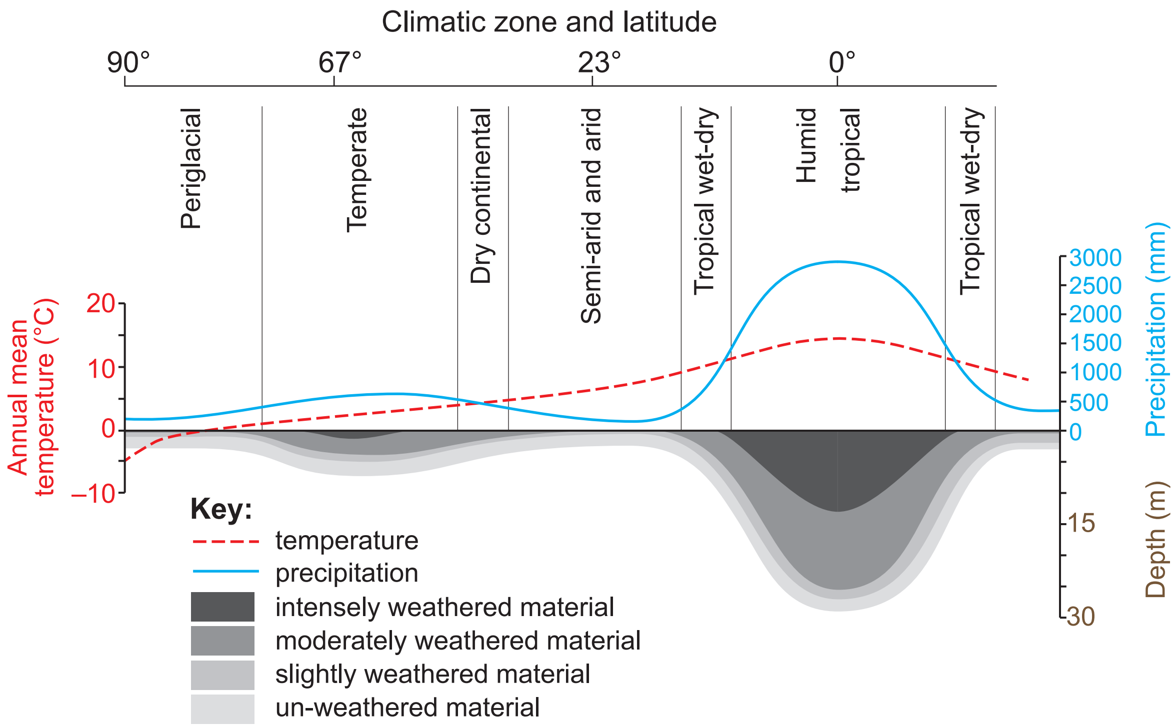

Figure 1a

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

(i) Describe the relationship between **precipitation** and the depth of weathering. [2]

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(ii) Explain why the effects of intense chemical weathering are deeper in humid tropical climates. [3]

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(iii) Name a climatic zone where freeze/thaw weathering is most likely to occur. Explain your answer. [3]

Climatic zone: ....

Explanation: ....

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Figure 1b shows the proportions of rock types in the continental crust by volume and surface area.

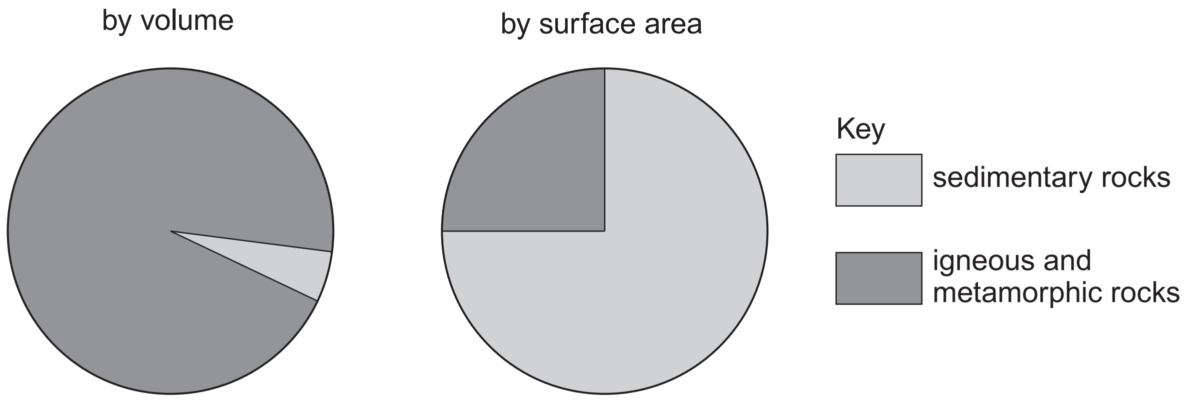

Figure 1b

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

(b) Explain why sedimentary rocks constitute 75% of the surface area of the continental crust but less than 10% of the volume of the continental crust. [3]

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(c) Most of the volume of the continental crust is formed of igneous rocks such as granite and andesite, and metamorphic rocks such as gneiss and schist. Estimates suggest that the continental sedimentary rocks are about 55% mudstone/shales, 20% sandstones and 25% carbonate rocks (e.g. limestone) and evaporite rocks (e.g. rock salt).

Using your knowledge, explain how this range of sedimentary rock types results from chemical weathering processes. [4]

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2. **Figure 2a** shows how the number of species on land and in the oceans has changed during the past 600 million years.

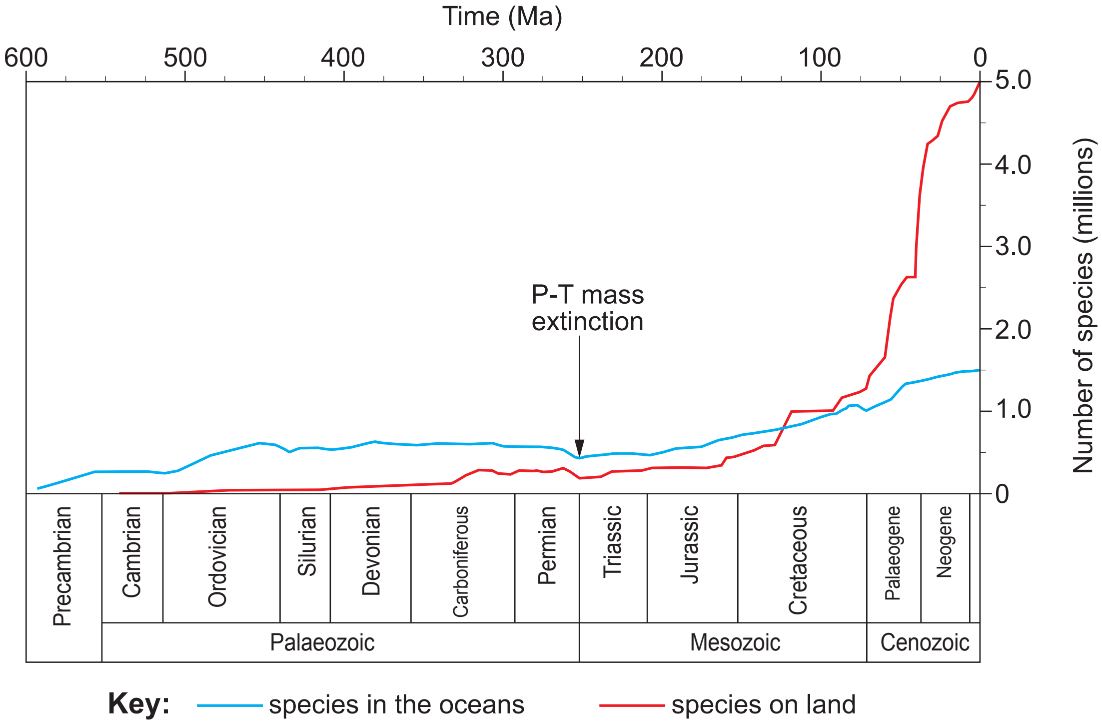

Figure 2a

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

(i) Complete **Table 1**. [2]

Geological period when the number of species on land first became greater than the number of species in the oceans	•
Total number of species present today on Earth	•

Table 1

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(ii) Describe the change in the number of species **in the oceans** during the past 600 million years. [3]

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(b) With reference to the P-T mass extinction event shown on **Figure 2a**, describe what is meant by the term 'mass extinction'. [3]

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Figure 2b is a graph showing the timing of major mass extinction events. **Figure 2c** shows the age and volume of large scale volcanicity (flood basalts) together with the type and age of lithospheric material through which these basalts were erupted.

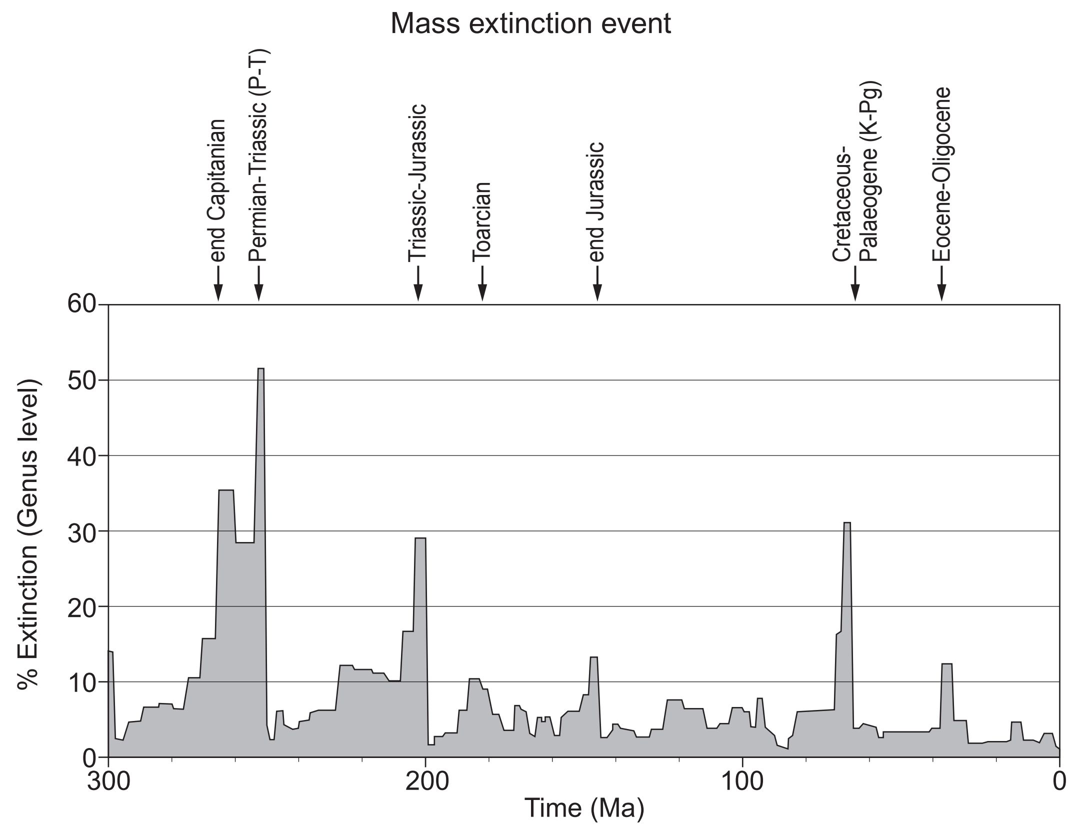

Figure 2b

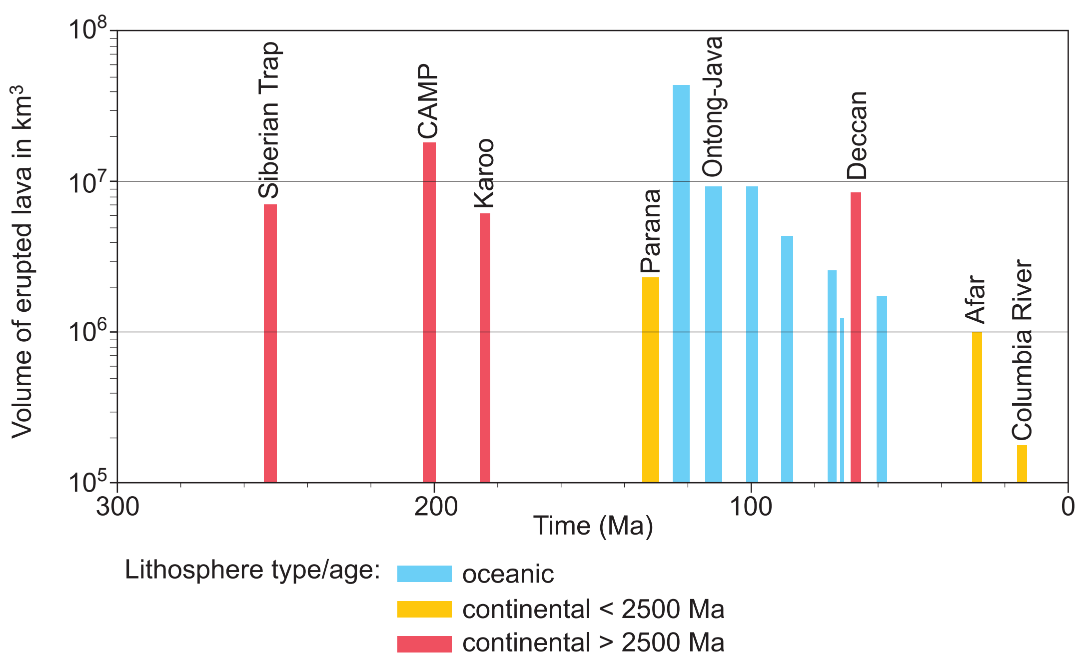

Figure 2c

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(c) Evaluate the relationship between mass extinction events and:

- timing of large scale volcanicity
- volume of erupted lava
- type of lithosphere (oceanic or continental) through which these lavas were erupted
- age of continental lithosphere through which these lavas were erupted. [6 QER]

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3. **Figure 3a** is a photomicrograph of the slate shown in **Figure 3b**. **Figure 3b** is a photograph of a vertical cliff section showing how a sequence of rocks, originally of constant thickness, has been deformed.

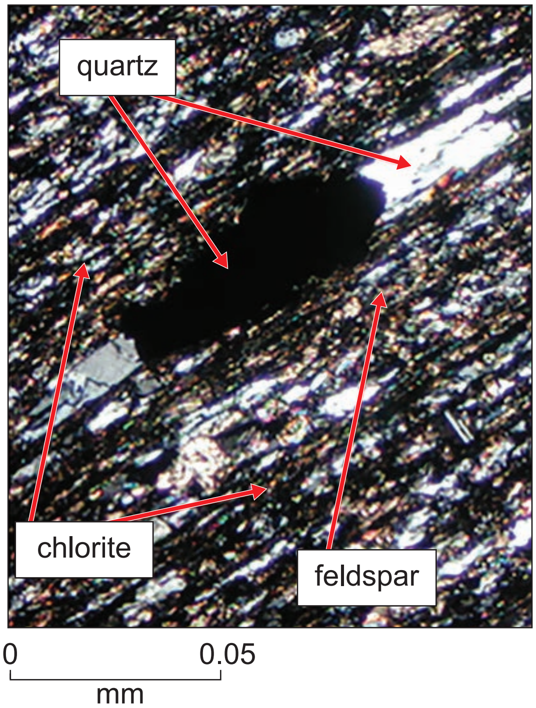

Figure 3a

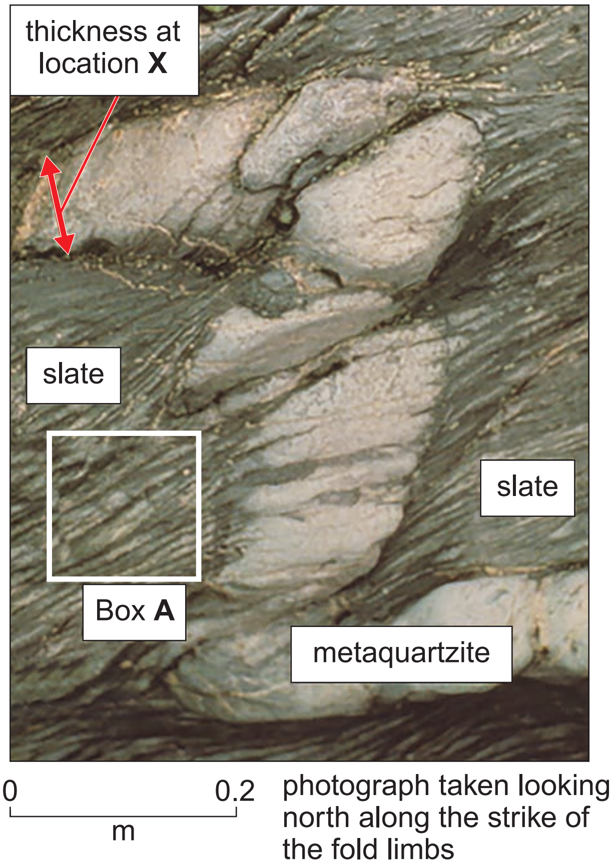

Figure 3b

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

State **three** pieces of evidence to support the identification of the rock in **Figure 3a** as slate. [3]

1. ....

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2. ....

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3. ....

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

(i) On **Figure 3b** draw an arrow labelled **BP (BP→)** to show the position of a bedding plane. [1]

(ii) Measure the dip angle and dip direction of the axial planar cleavage in the slate in Box **A**. Write your answers in **Table 2a**. [2]

dip angle of axial planar cleavage	•
dip direction of axial planar cleavage	•

Table 2a

(iii) Describe **two** differences in the axial planar cleavage in the slate compared to the metaquartzite. [2]

1 ....

....

2 ....

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(iv) Measure the thickness of the metaquartzite bed at:

- location **X**
- the antiformal fold hinge.

Write your answers in **Table 2b**. [2]

thickness of the metaquartzite bed at location **X**	• m
thickness of the metaquartzite bed at the antiformal fold hinge	• m

Table 2b

(v) Explain why the metaquartzite bed varies in thickness. [2]

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(c) A student described the antiformal fold in **Figure 3b** as *'an asymmetric, overturned, isoclinal fold'*. Evaluate this statement explaining the evidence for your conclusions. [3]

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4. **Figure 4a** shows photomicrographs of two sedimentary rocks, rock salt and sandstone. **Figure 4b** is a graph showing how the density of these two rocks and shale changes with depth.

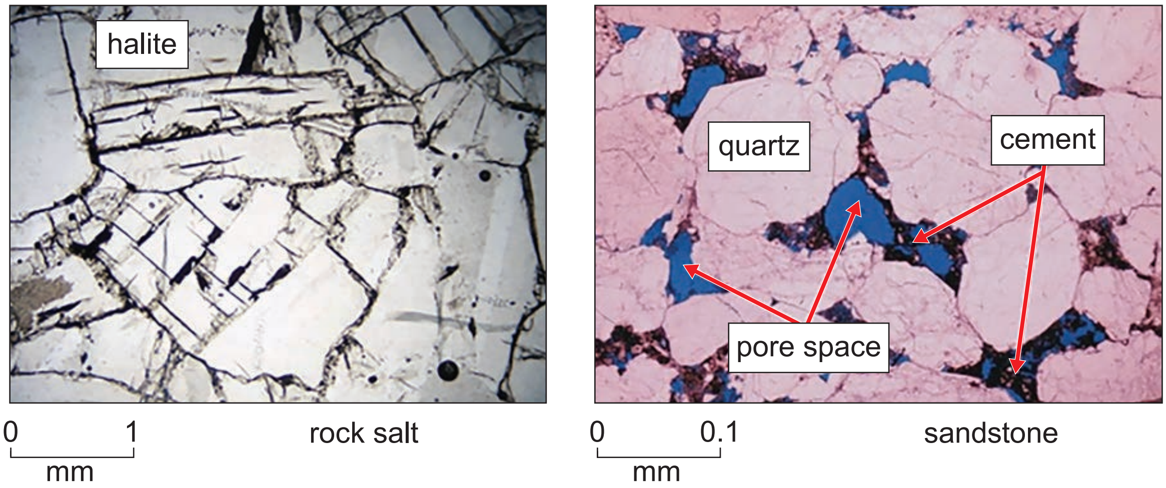

Figure 4a

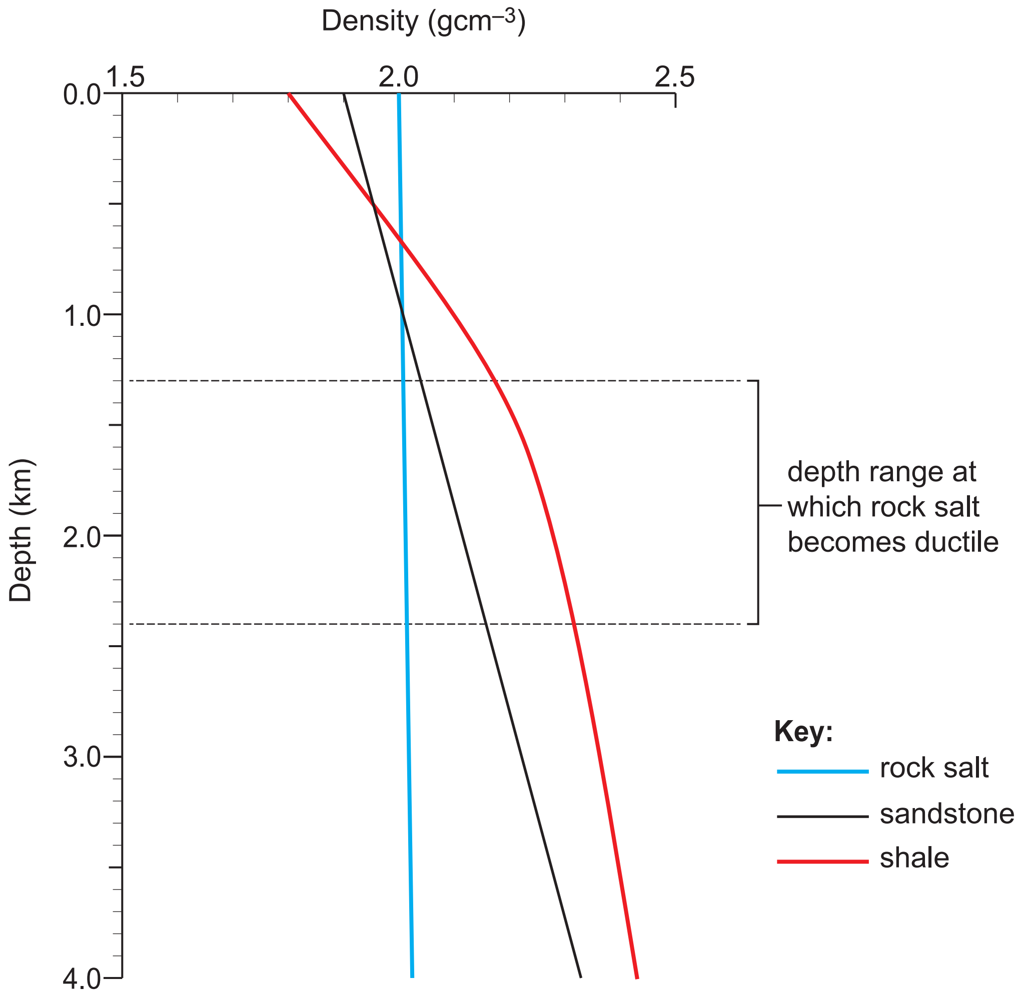

Figure 4b

Examiner only

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

State **three** differences in **texture** between rock salt and the sandstone in **Figure 4a**. [3]

1. ....

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2. ....

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3. ....

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

(i) Complete **Table 3** to give the depths at which rock salt becomes less dense than shale and sandstone. [2]

	depth (km)
depth at which rock salt becomes less dense than shale	•
depth at which rock salt becomes less dense than sandstone	•

Table 3

(ii) Calculate the rate of change in the density of sandstone for the top 4 km of the crust. Show your working and state the units. [3]

rate of change of sandstone density ....

(iii) Explain why rock salt shows no change in density with depth whereas the density of sandstone increases with depth. [3]

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(c) **Figure 4c** is a cross-section showing two stages in the formation of a salt dome.

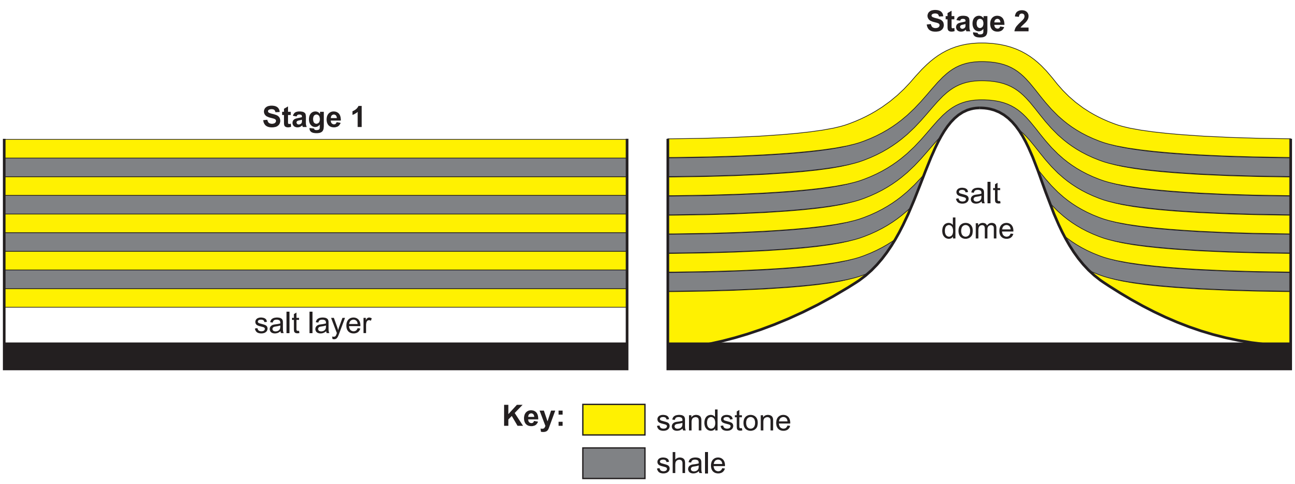

Figure 4c

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

(i) On the **Stage 2** cross-section in **Figure 4c** draw **two** horizontal lines to represent the position of the base of oil deposits associated with **two** different types of hydrocarbon trap. [2]

(ii) With reference to **Figure 4b** explain the formation of the salt dome shown in **Figure 4c**. [3]

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5. **Figure 5a** shows the paths of some P-waves and S-waves for an earthquake. **Figure 5b** shows a seismogram for the earthquake shown in **Figure 5a**.

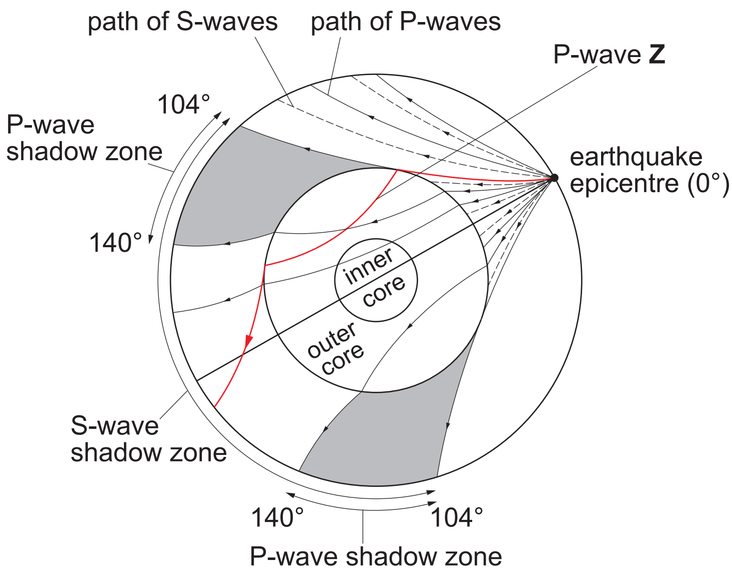

Figure 5a

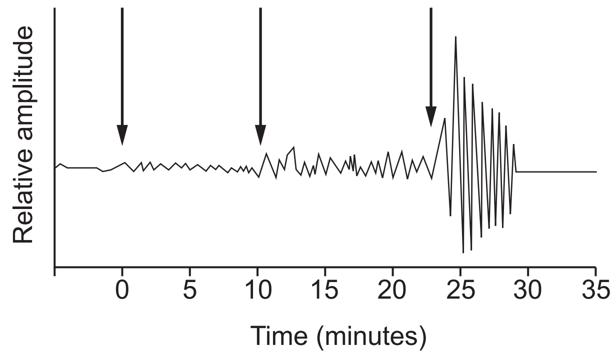

Figure 5b

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

(i) Label each of the arrows on **Figure 5b** to indicate the arrival of the following seismic waves:

Surface P S

Give reasons for your answer. [2]

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(ii) Indicate on **Figure 5a** with an arrow labelled **X (X→)** a likely location on the Earth's surface where a seismic station could have recorded the seismogram shown in **Figure 5b**. Give a reason for your answer. [2]

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

(i) Describe the path of P-wave **Z** as it passes through the Earth. [2]

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(ii) Explain why no direct P-waves are recorded in the P-wave shadow zone. [3]

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(iii) In 1936 Inge Lehmann explained the presence of some faint P-waves which had been detected in the P-wave shadow zone but were thought to have been anomalous. She concluded that these P-waves had been reflected at a boundary between the inner and outer core of the Earth.

Starting at the position of the earthquake epicentre on **Figure 5a** draw the path of a P-wave that illustrates her conclusion. [2]

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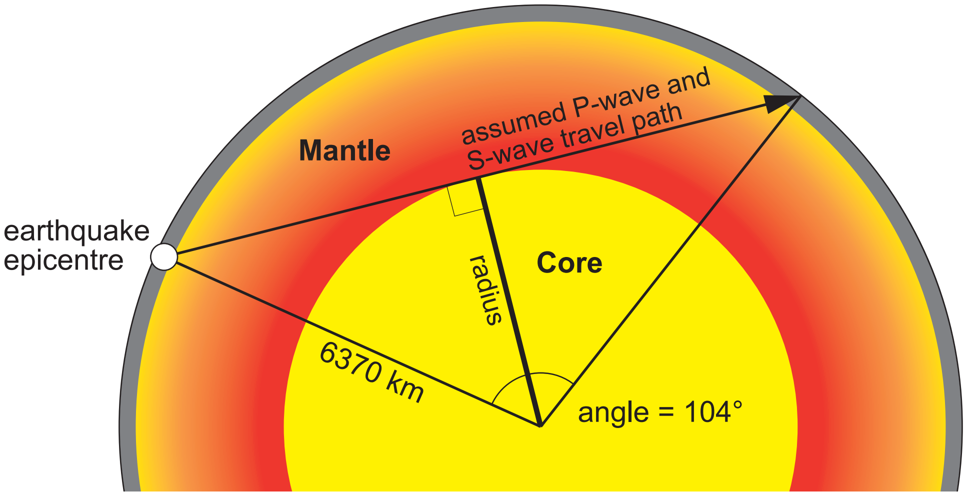
(c) It is possible to estimate the radius of the Earth's core by assuming that the travel path of the last P-waves and S-waves before the shadow zone starts at 104°, is a straight line. This is illustrated in **Figure 5c**.



not to scale

Figure 5c

With reference to **Figure 5c** only, use trigonometry to calculate the radius of the Earth's core. Show your working. [3]

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6. **Figure 6a** is a graph showing the silica content of lavas erupted at Hekla (Iceland) and the intervals between consecutive eruptions. **Figure 6b** shows data for some common silicate minerals from Bowen's reaction series and the associated lava types based on silica content.

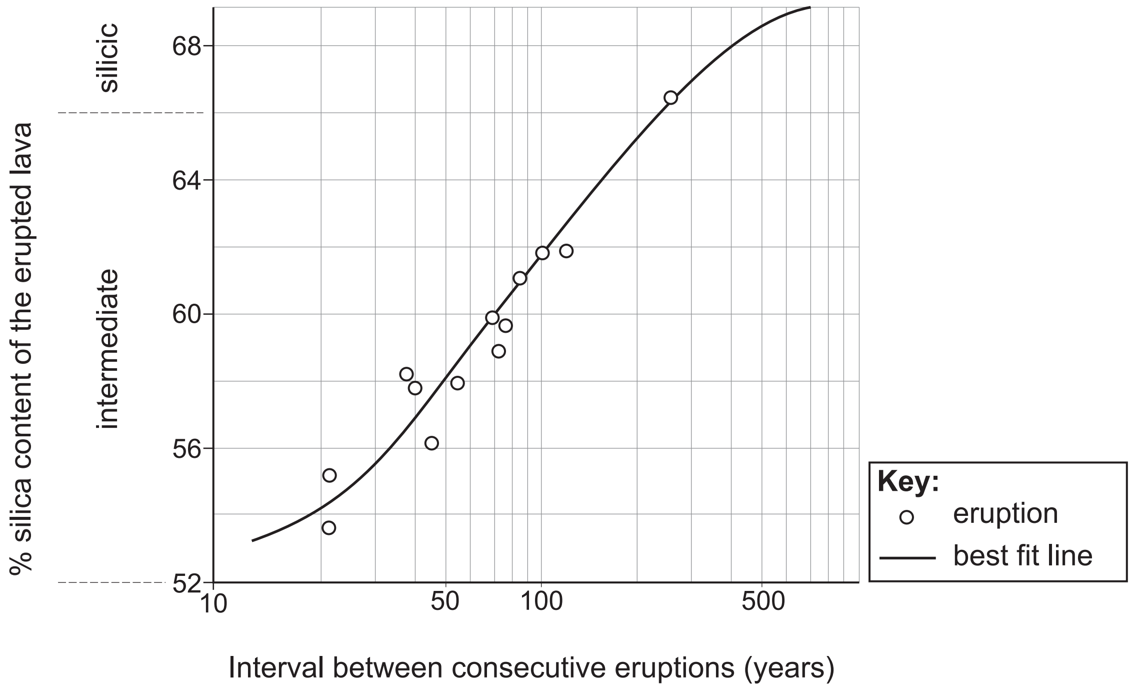

Figure 6a

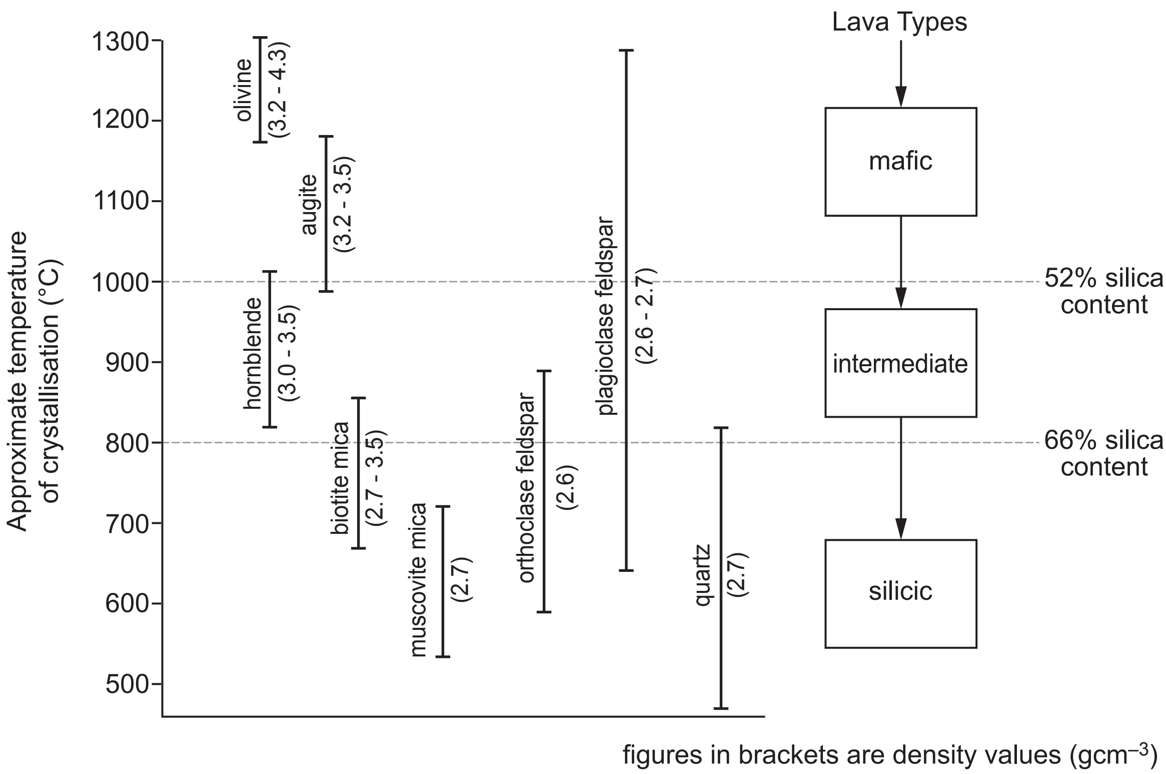

Figure 6b

Examiner only

(a) Refer to **Figure 6a**. Describe the relationship between the silica content of the erupted lava at Hekla and the interval between consecutive eruptions. [2]

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(b) Refer to **Figure 6a** and **Figure 6b**. The volcanism on Iceland is thought to result from the partial melting of mantle rocks by a mantle plume at an oceanic divergent plate boundary.

- Explain why the data on **Figure 6a** conflicts with this model.
- With reference to Bowen's reaction series describe and explain a process that might account for the compositions of the lavas erupted at Hekla. [6 QER]

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(c) The relationship between **eruption intervals** and **volume of erupted material** for the last ten eruptions of the Hekla volcano in Iceland has been investigated.

The null hypothesis (**H_o**) is that 'there is no significant relationship between the volume of erupted material and the interval between eruptions'.

Table 4 shows the start of a Spearman's rank correlation test for this data. Rank order is descending with the highest value ranked 1.

Year of eruption	Interval between consecutive eruptions (years)	Rank (r_1)	Volume of erupted material (km^3)	Rank (r_2)	Difference (d) (r_1-r_2)	d^2
2000	9	10	0.17	8	2	4
1991	10	9	0.15	9	0	0
1981	11	•	0.12	10	–2	4
1970	22	7	0.20	7	0	0
1948	103	1	0.80	4	–3	9
1845	77	3	0.63	5	–2	4
1768	75	4	1.30	1	3	9
1693	57	5	0.90	•	2.5	6.25
1636	39	•	0.50	6	0	0
1597	87	2	0.90	•	–0.5	0.25
						$\Sigma d^2 = 36.5$

Correlation coefficient formula: $r_s = 1 - \dfrac{6\Sigma d^2}{n^3 - n}$

where r_s is the correlation coefficient and n is the number of paired data.

Table 4

(i) Complete **Table 4** to show the missing values of rank r_1 and r_2. [2]

(ii) Using the formula, calculate the Spearman's rank correlation coefficient (r_s). Show your working. [2]

r_s = ...

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Figure 6c is a Spearman's rank correlation significance graph.

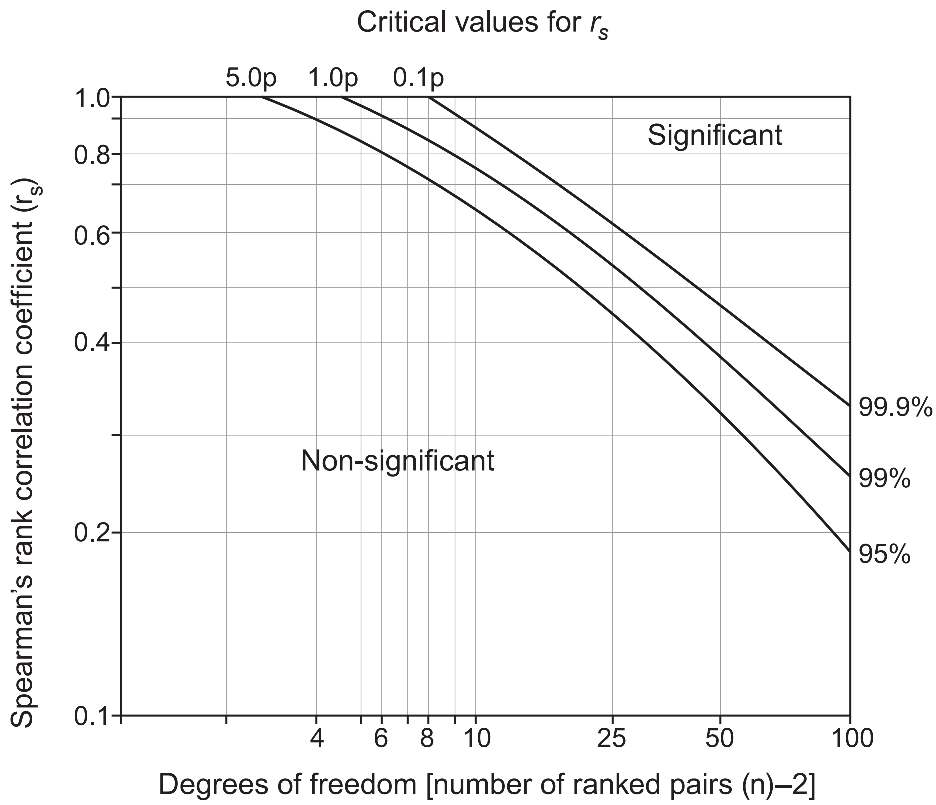

Figure 6c

(iii) Using **Figure 6c** comment on the statistical significance of the result calculated in *(c)*(ii). [2]

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(d) Provide a geological explanation for the relationship between the **volume of erupted material** and the **interval between eruptions** using **Table 4** and your answer to *(c)*(iii). [2]

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END OF PAPER

Acknowledgements

Figure 1a	https://userscontent2.emaze.com/images/5364384e-c878-48af-9ee1-8d4a465d2cb1/0ff46f13596e586d8014113f8c23a68e.png
Figure 1b	http://www.gly.uga.edu/railsback/1121RockProportions.jpeg
Figure 2a	Benton MJ (2016) Origins of Biodiversity. PLOS Biology 14(11): e2000724. https://doi.org/10.1371/journal.pbio.2000724
Figure 2b and Figure 2c	https://www.nature.com/articles/srep23168#f5
Figure 3a	http://slate.bcserver8.net/wp-content/uploads/2011/02/figure-4-5new1.jpg
Figure 4a	http://geohistory.valdosta.edu/basics/images_basics/rocks/basic_rocks/chem/rocksaltTS.gif And https://booksite.elsevier.com/9780444528186/htm/reschar_chapter_05/figure_5_1.htm
Figure 4b	Selley, R. C. 1985. Elements of petroleum Geology. Freeman
Figure 6b and Table 4,	Thorarinsson, S., and Sigvaldason, G.R., 1972, The Hekla eruption of 1970: Bull. Volcanol., v. 36, p. 269-288

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