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GCE A LEVEL

A480U20-1

TUESDAY, 13 JUNE 2023 – AFTERNOON

GEOLOGY – A LEVEL COMPONENT 2
GEOLOGICAL PRINCIPLES AND PROCESSES

1 hour 45 minutes plus your additional time allowance

Surname

First name(s)

Centre Number

Candidate Number

2

ADDITIONAL MATERIALS

In addition to this examination paper you will need:

- **Mineral Data Sheet**
- **a calculator**
- **a ruler.**

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces on the previous 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.

Answer ALL questions in the spaces provided.

1 FIGURE 1a opposite 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.

Refer to FIGURE 1a.

(a) State the name of the fossil groups represented by FOSSIL X and FOSSIL Y on FIGURE 1a. [2 marks]

FOSSIL X _____

FOSSIL Y _____

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

_____

_____

_____

_____

1 (b) (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 marks]

_____ %

1 (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 marks]

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

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

Model _____

1 (d) (ii) Describe the differences between the TWO evolutionary models shown on FIGURE 1b.

[4 marks]

15

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

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

2 (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.

TABLE 1

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

(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 marks]

Density = _____ g cm^{-3}

Percentage uncertainty = _____%

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

1 _____

_____

_____

_____

2 _____

_____

_____

_____

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

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

(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 mark]

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

(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 mark]

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

[2 marks]

17	

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

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

_____ **°C**

_____ **GPa**

3 (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 marks QER]

3 (c) FIGURE 3b opposite shows a photomicrograph of the metamorphic rock that formed under the conditions represented by PATHWAY 2 on FIGURE 3a.

(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 marks]

3 (c) (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 marks]

15

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

FIGURE 4b opposite the following page is a seismic tomography cross-section (X–Y) passing through the Yellowstone Hotspot.

(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 marks]

4 (b) Refer to FIGURE 4a opposite page 19 and FIGURE 4b opposite. 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 marks]

4 (c) FIGURE 4c opposite 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.

(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 marks]

4 (c) (ii) Refer to FIGURE 4c opposite page 21. Describe the differences in the way magma is believed to form beneath divergent plate boundaries and hot spots. [4 marks]

4 (c) (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 marks]

15

5 **FIGURE 5a opposite 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 opposite the following page is a partially completed bar chart showing some of the palaeolatitude data on FIGURE 5a.

FIGURE 5c opposite the following page is a photograph showing the texture of a Neoproterozoic deposit at the location shown on FIGURE 5a.

(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 marks]**

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

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

5 (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 marks QER]

13

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

(a) Refer to FIGURE 6a.

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

TABLE 2

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

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

Geothermal gradient = _____ °C m^{-1}

6 (a) (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 marks]**

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

(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 mark]**

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

6 (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 marks]

6 (c) (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 marks]

15	

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 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.**

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

FIGURE 1a

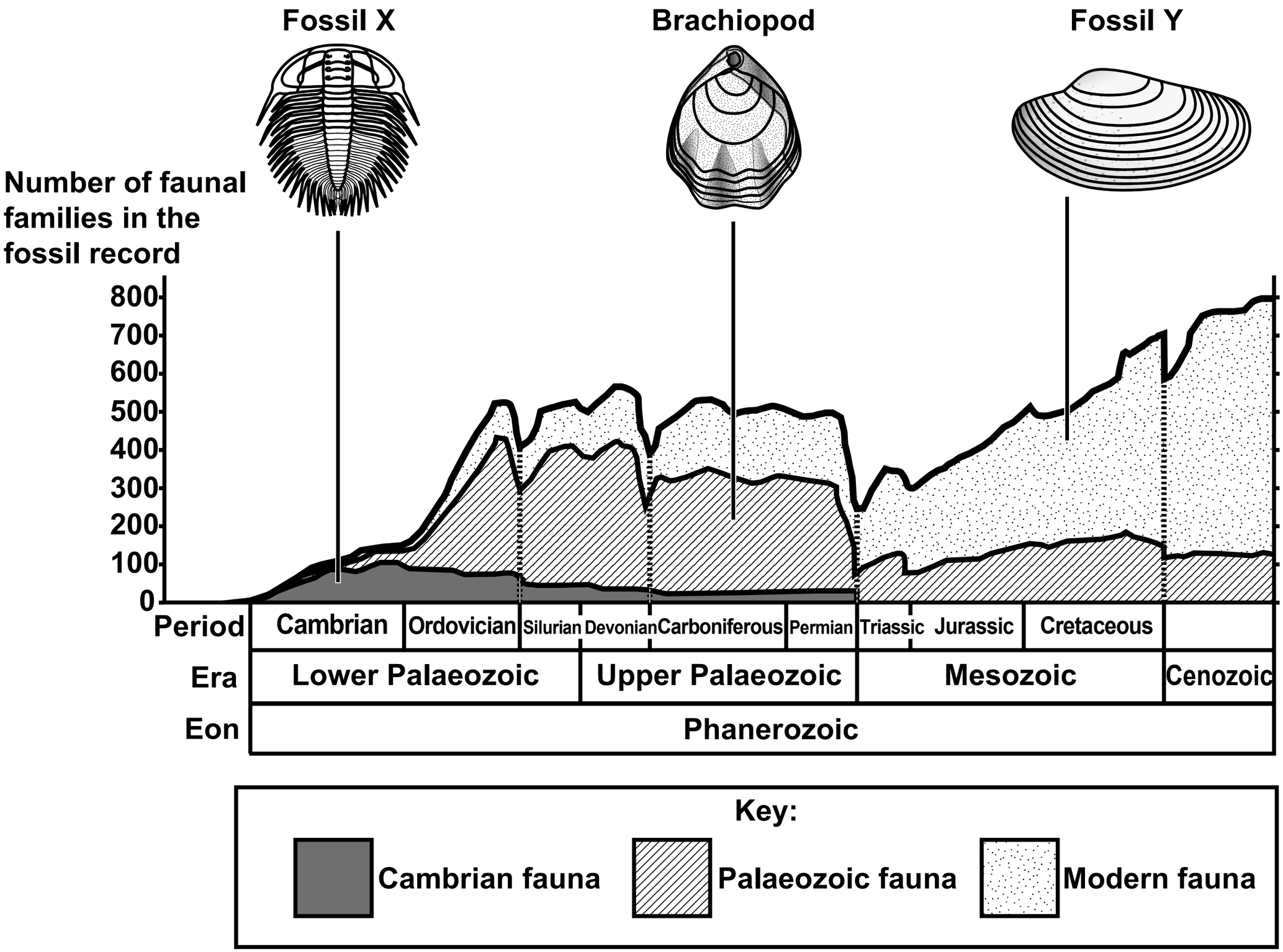

Fossil X
Brachiopod
Fossil Y
Number of faunal families in the fossil record
800
700
600
500
400
300
200
100
0
Period
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Era
Lower Palaeozoic
Upper Palaeozoic
Mesozoic
Cenozoic
Eon
Phanerozoic
Key:
Cambrian fauna
Palaeozoic fauna
Modern fauna

FIGURE 1b

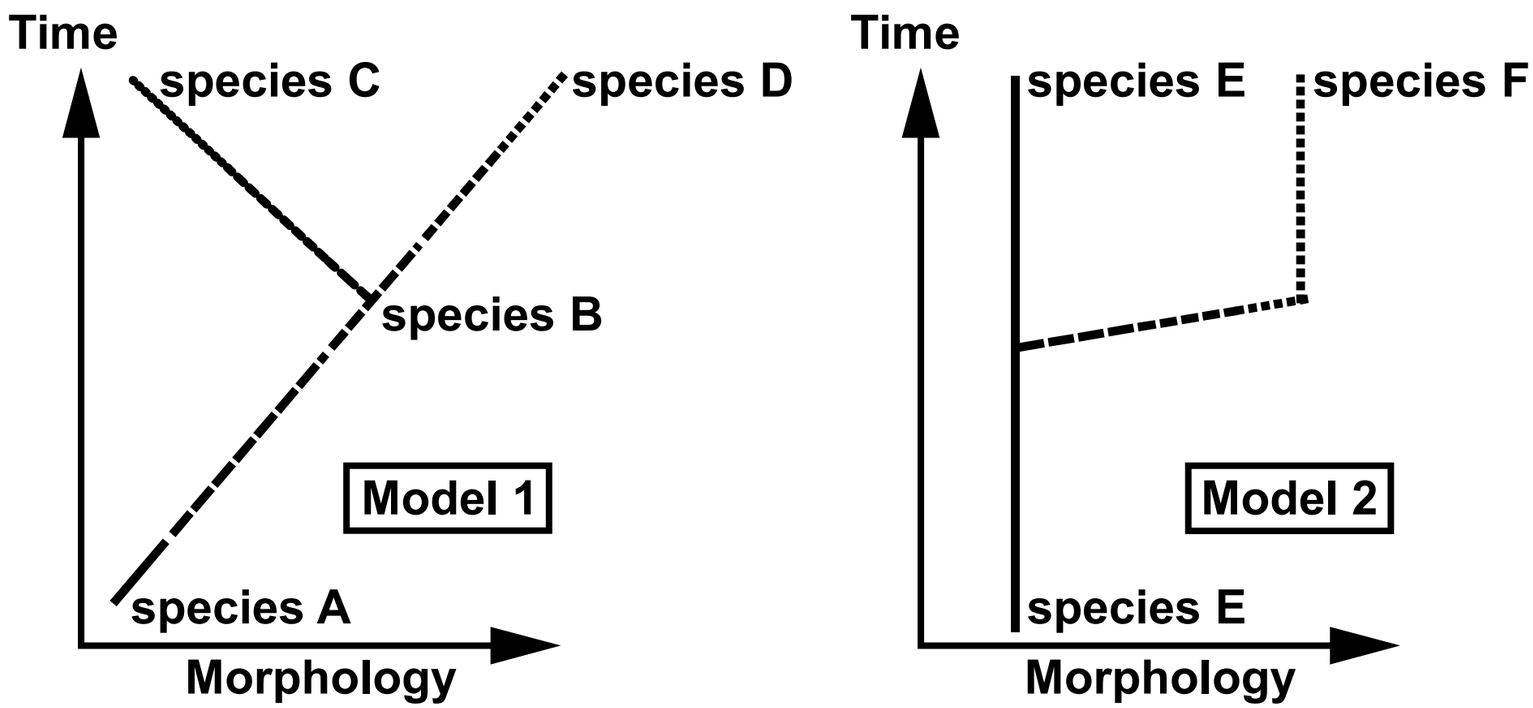

Time
species C
species D
species B
Model 1
species A
Morphology
Time
species E
species F
Model 2
species E
Morphology

FIGURE 2a

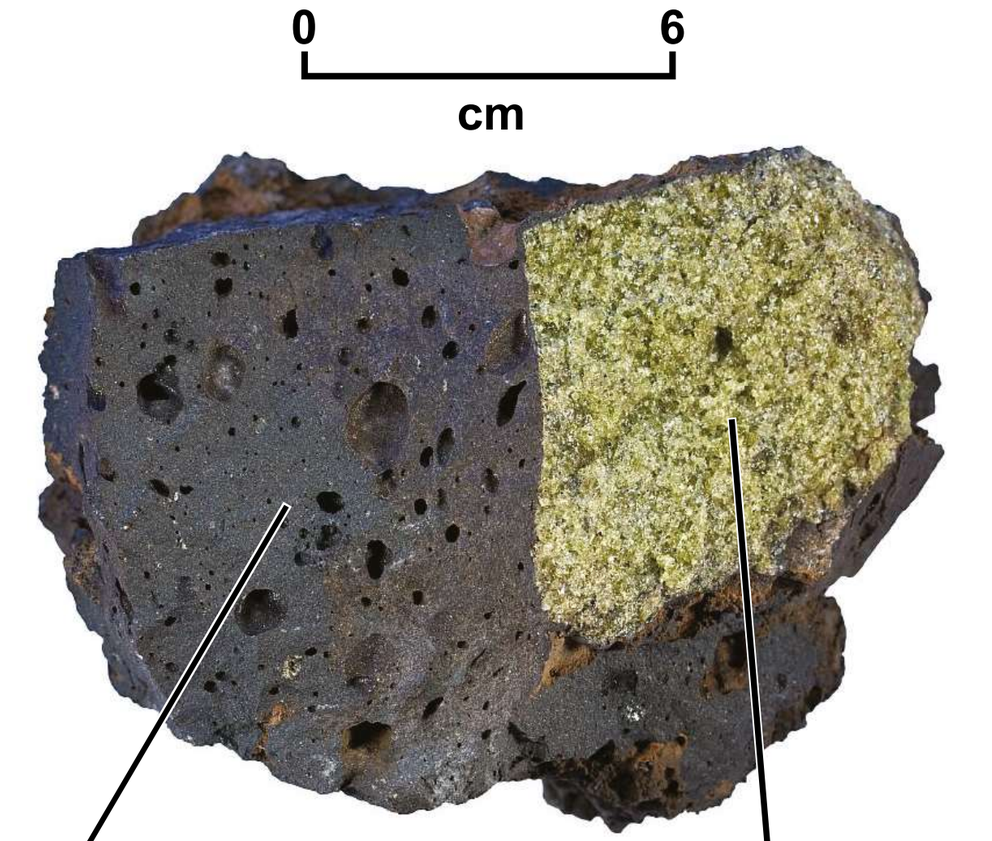


FIGURE 2b

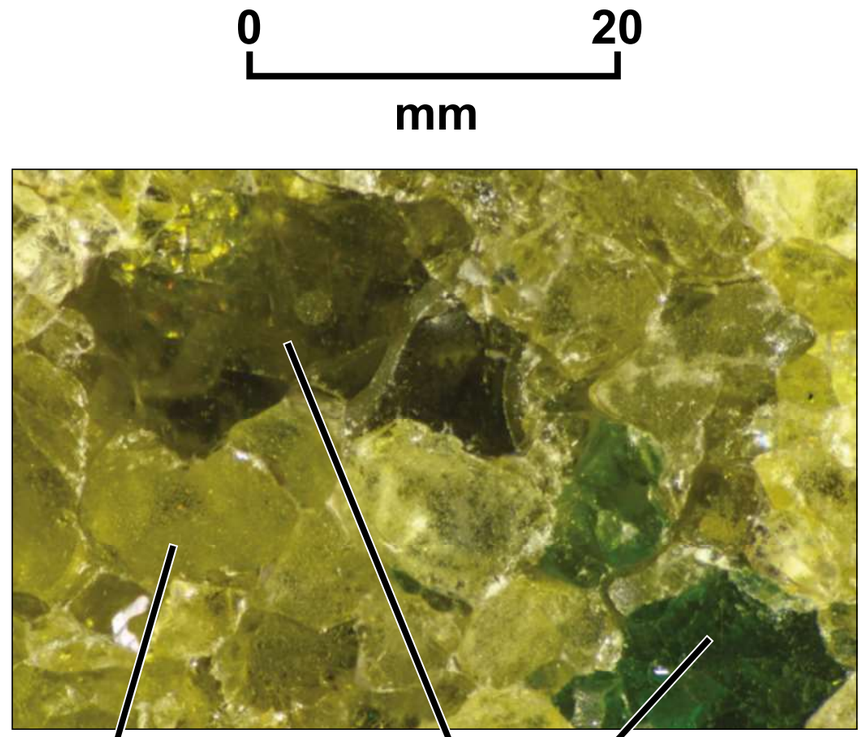


FIGURE 2c

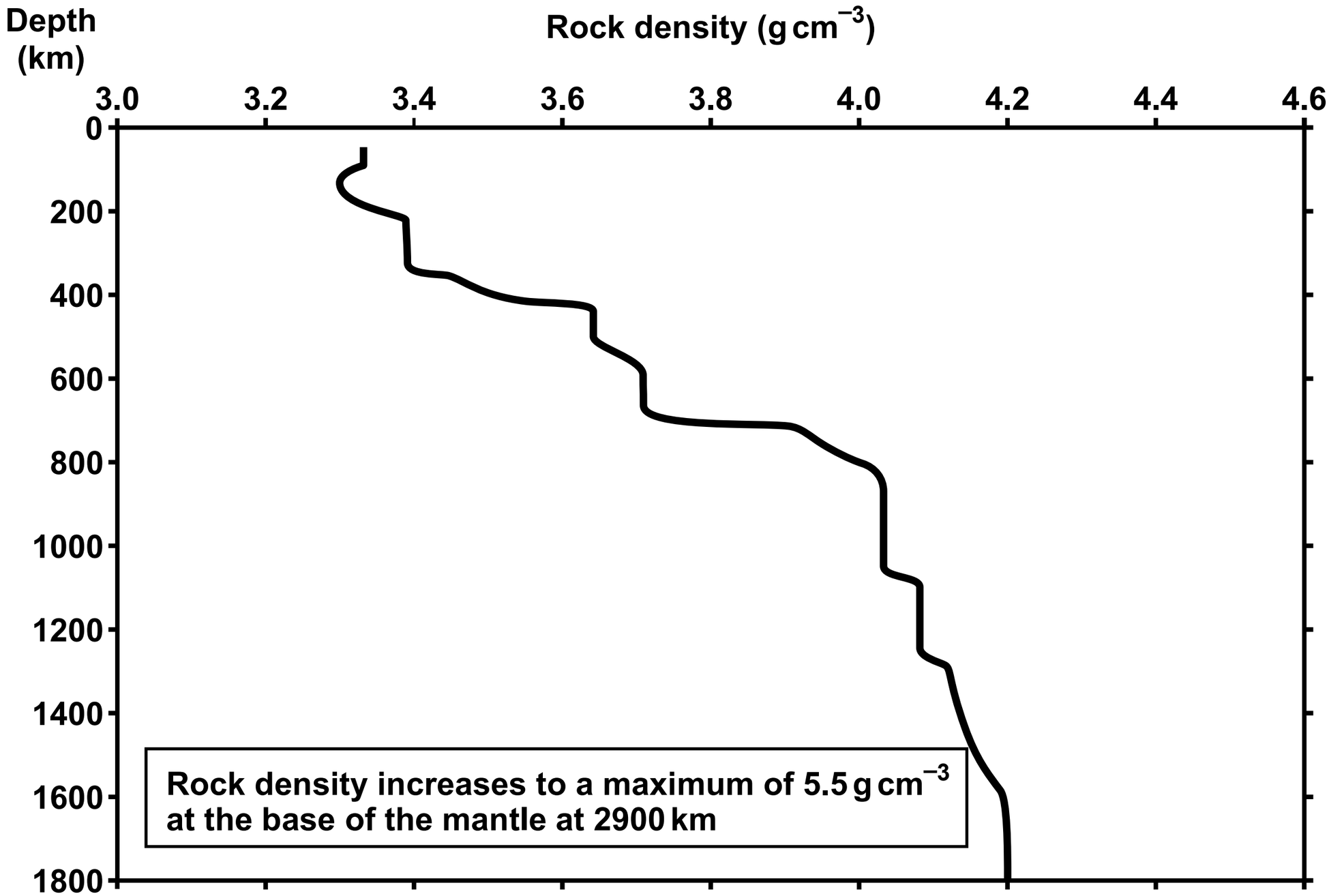
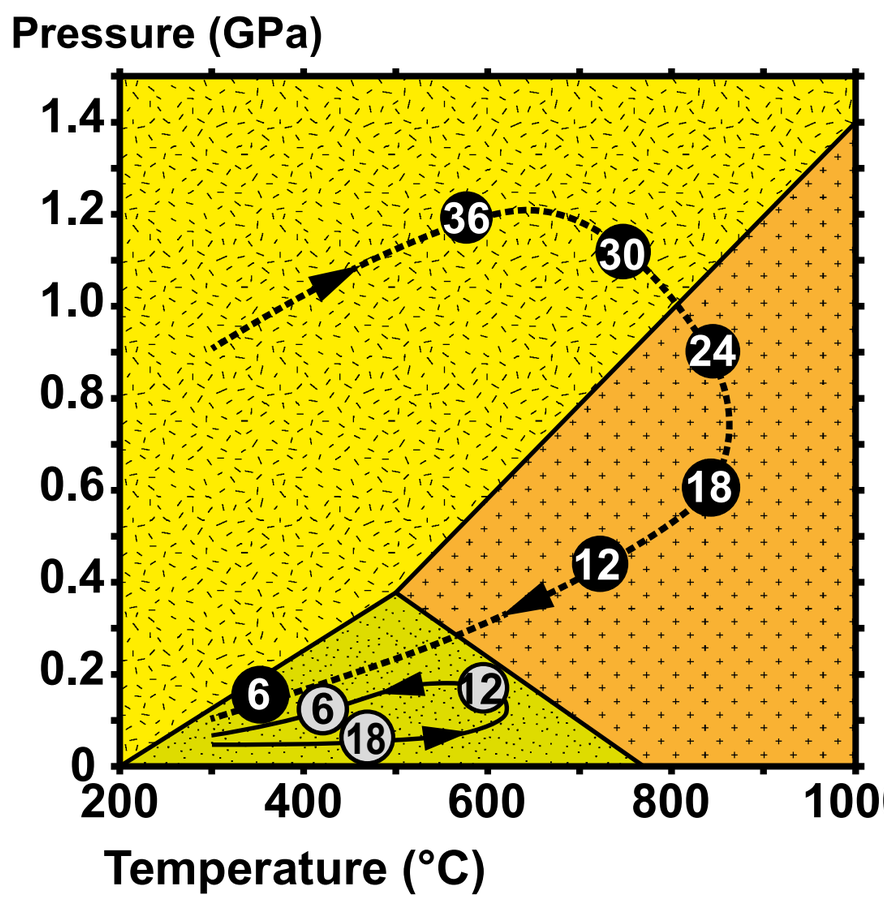

Depth
(km)
Rock density (g cm^{-3})
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
0
200
400
600
800
1000
1200
1400
1600
1800
Rock density increases to a maximum of 5.5 g cm^{-3}
at the base of the mantle at 2900 km

FIGURE 3a



Key:

- andalusite stability field
- kyanite stability field
- sillimanite stability field
- pathway 2
- 36 — date (in Ma) at which the metamorphic rock reached the pressure and temperature conditions indicated on pathway 2
- pathway 1
- 18 — date (in Ma) at which the metamorphic rock reached the pressure and temperature conditions indicated on pathway 1

FIGURE 3b

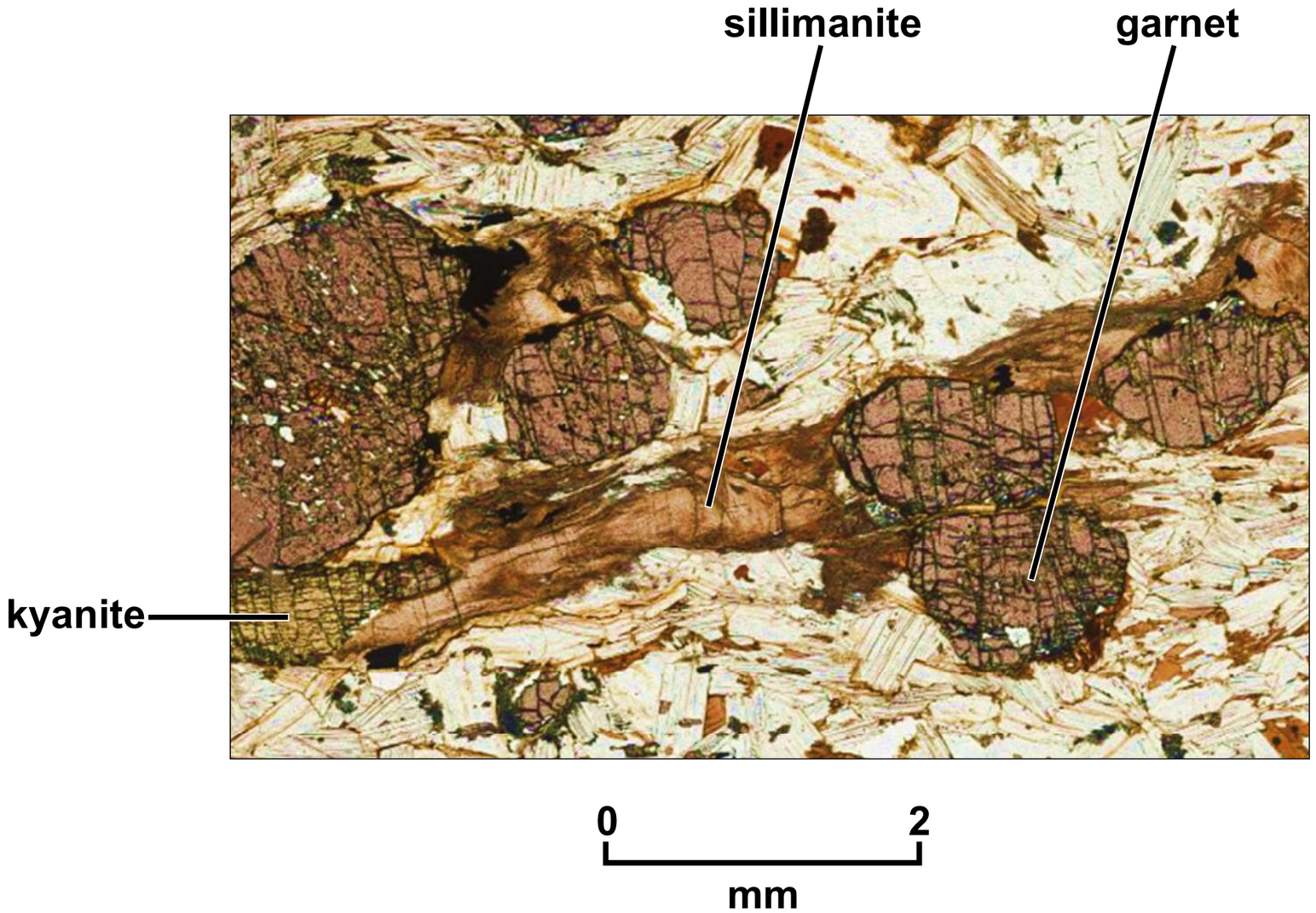
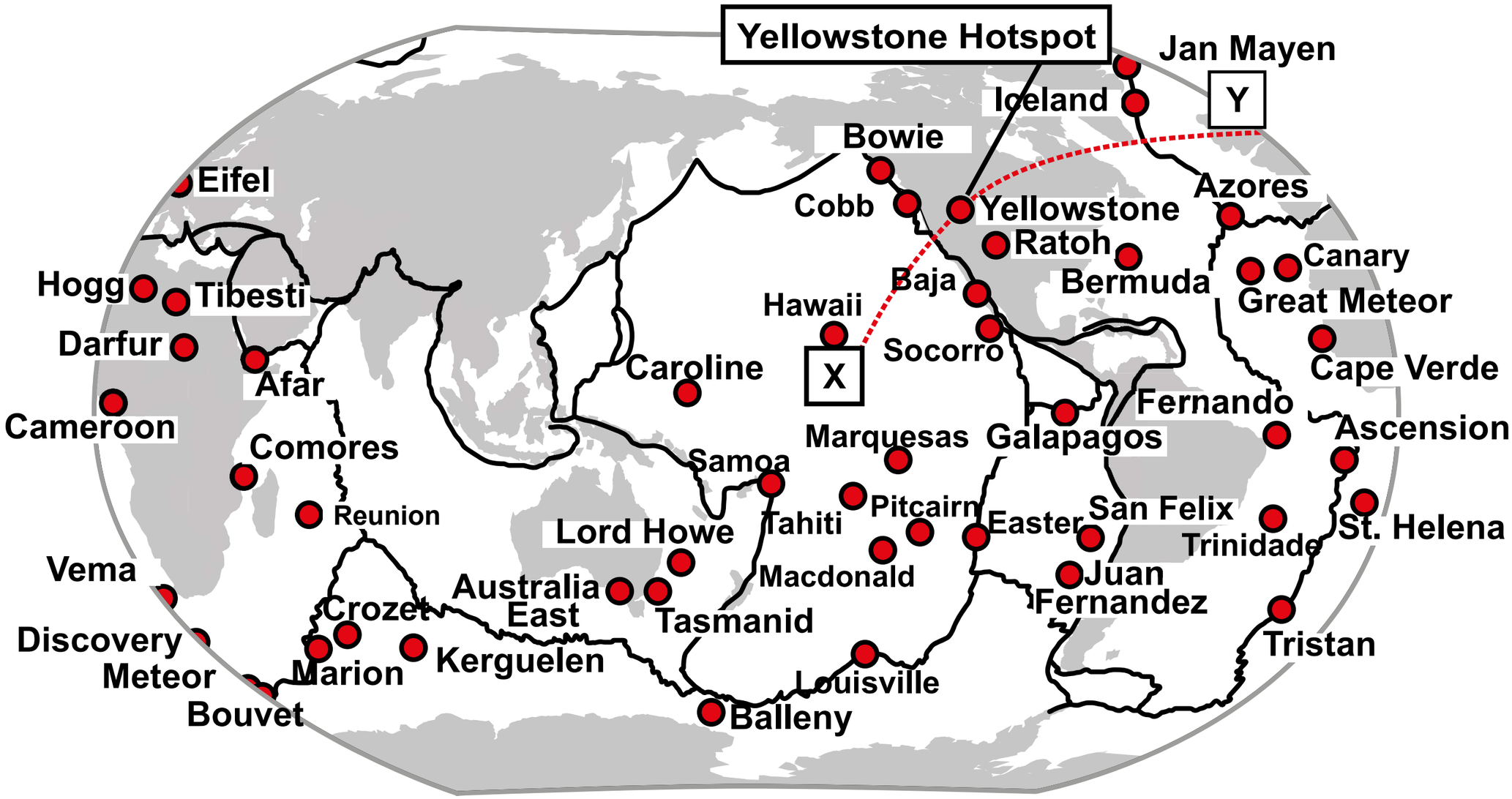


FIGURE 4a



Key:

position of hotspot

plate boundary

FIGURE 4b

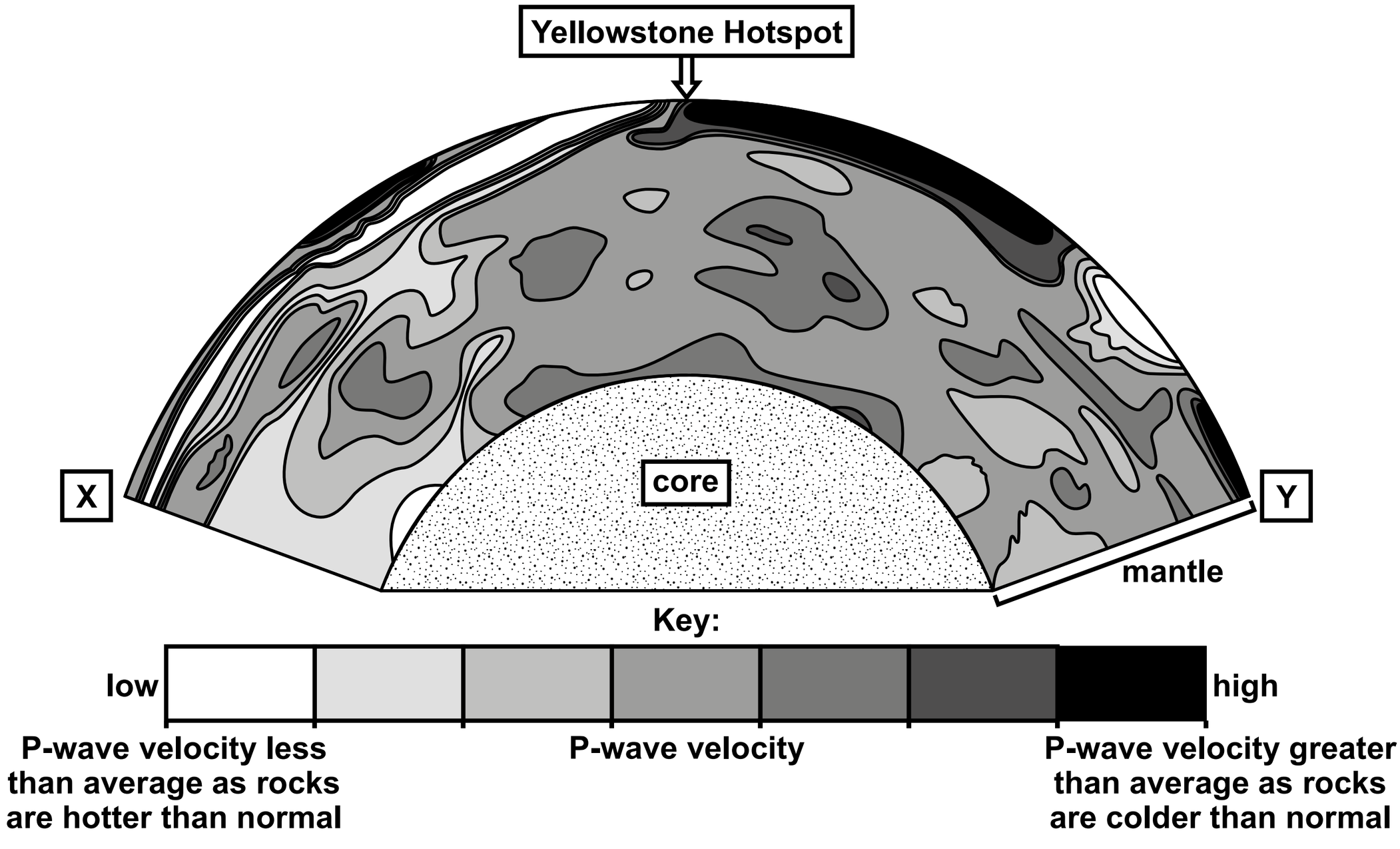

Yellowstone Hotspot
X
core
Y
mantle
Key:
low
high
P-wave velocity less than average as rocks are hotter than normal
P-wave velocity
P-wave velocity greater than average as rocks are colder than normal

FIGURE 4c

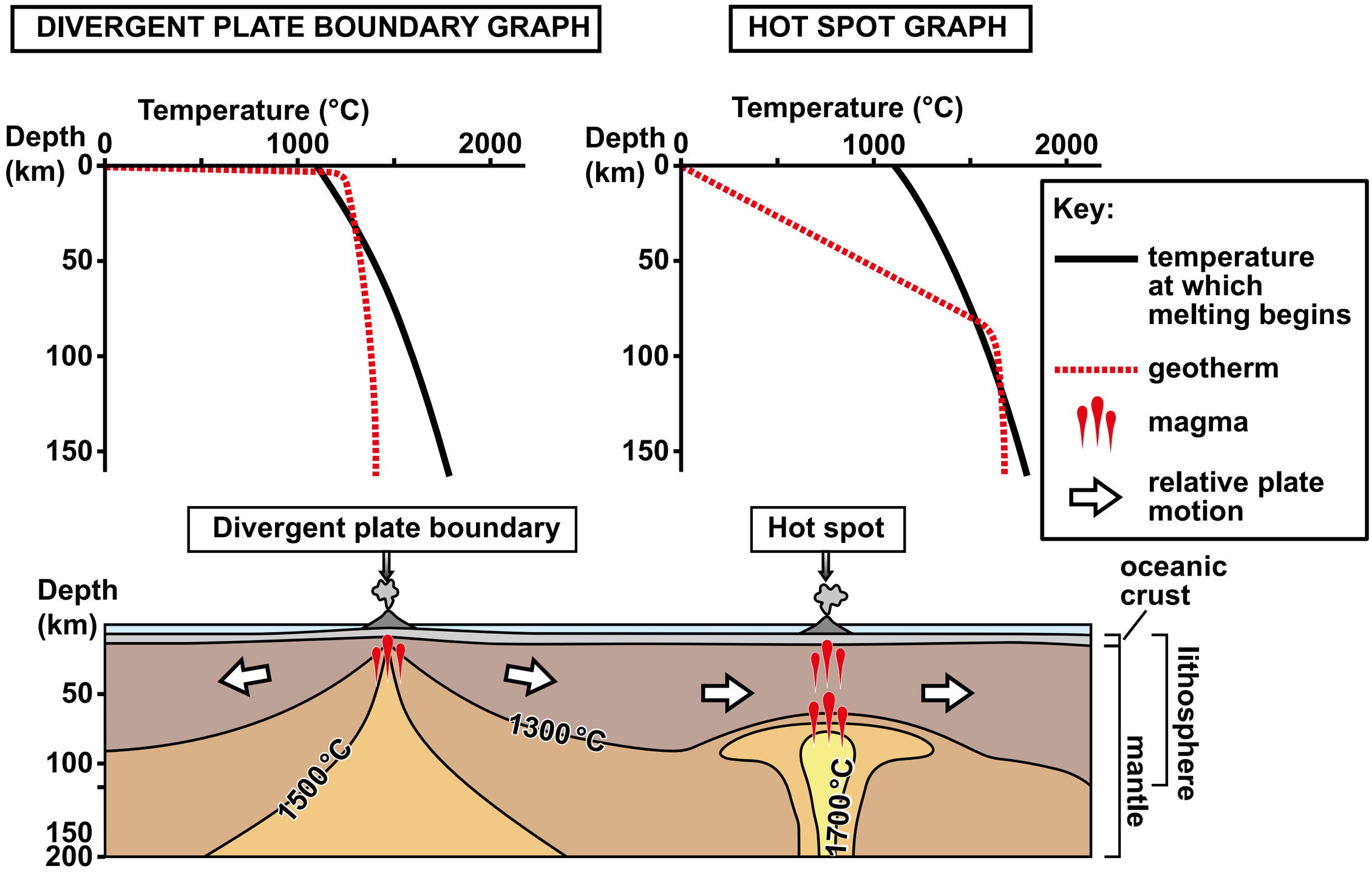
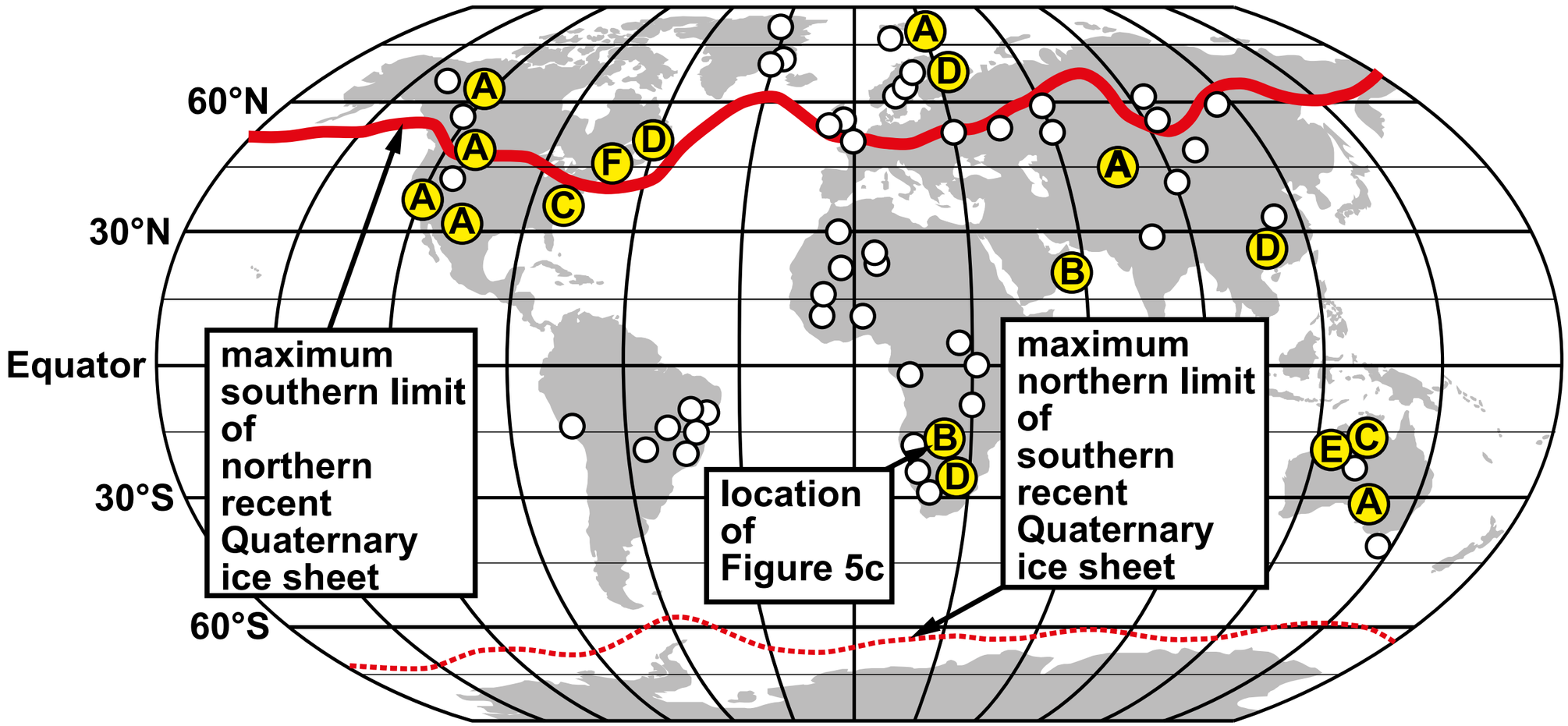

DIVERGENT PLATE BOUNDARY GRAPH
HOT SPOT GRAPH
Temperature (°C)
Depth (km)
0
1000
2000
50
100
150
Key:
temperature at which melting begins
geotherm
magma
relative plate motion
Divergent plate boundary
Hot spot
oceanic crust
lithosphere
mantle
1500 °C
1300 °C
1700 °C
200

FIGURE 5a



Key:
Latitude where the Neoproterozoic glacial deposits formed

A = 0–10° B = 10–20° C = 20–30° D = 30–40° E = 40–50° F = 50–60° ○ = no information on latitude

FIGURE 5b

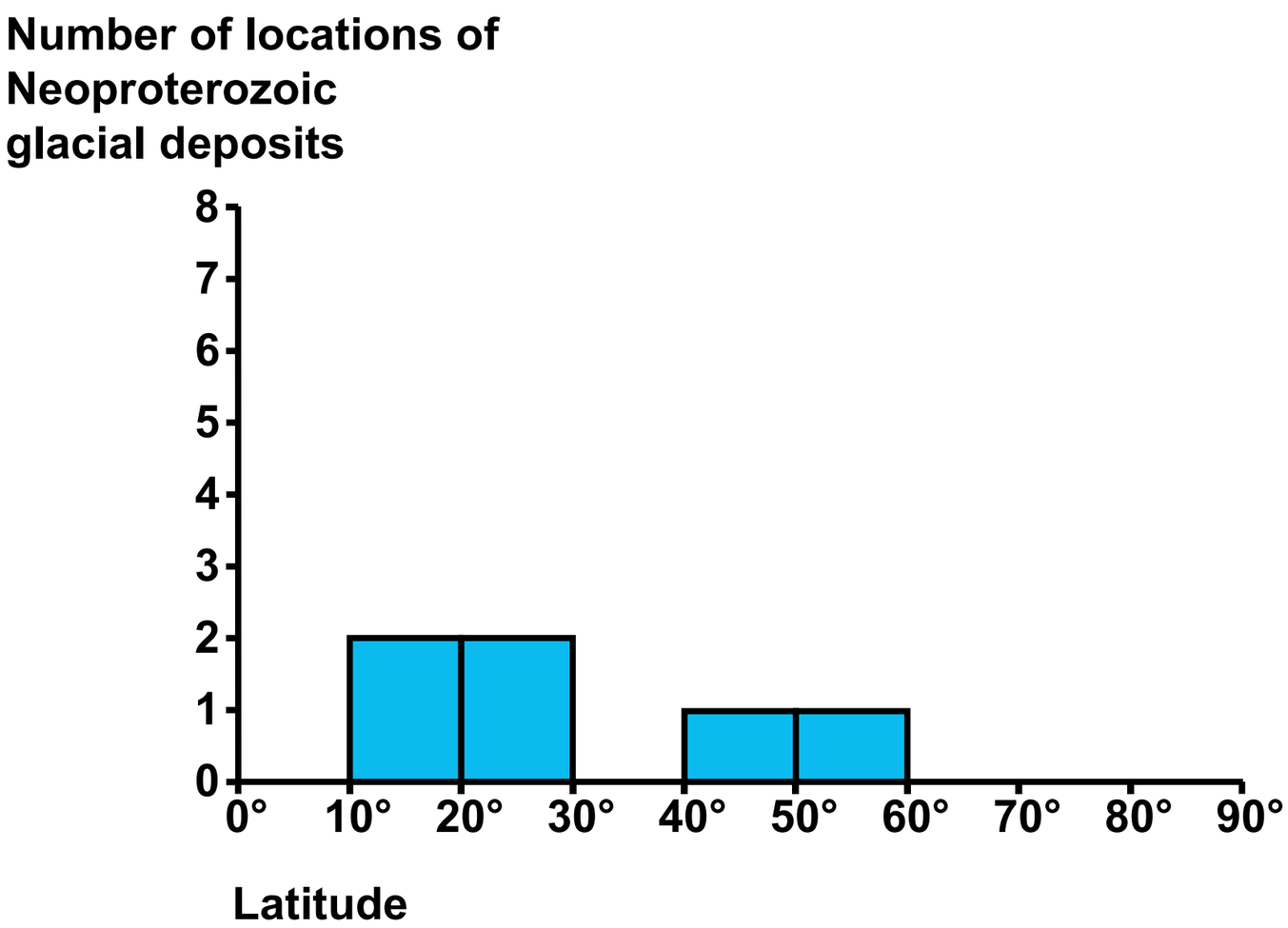


FIGURE 5c

FIGURE 6a

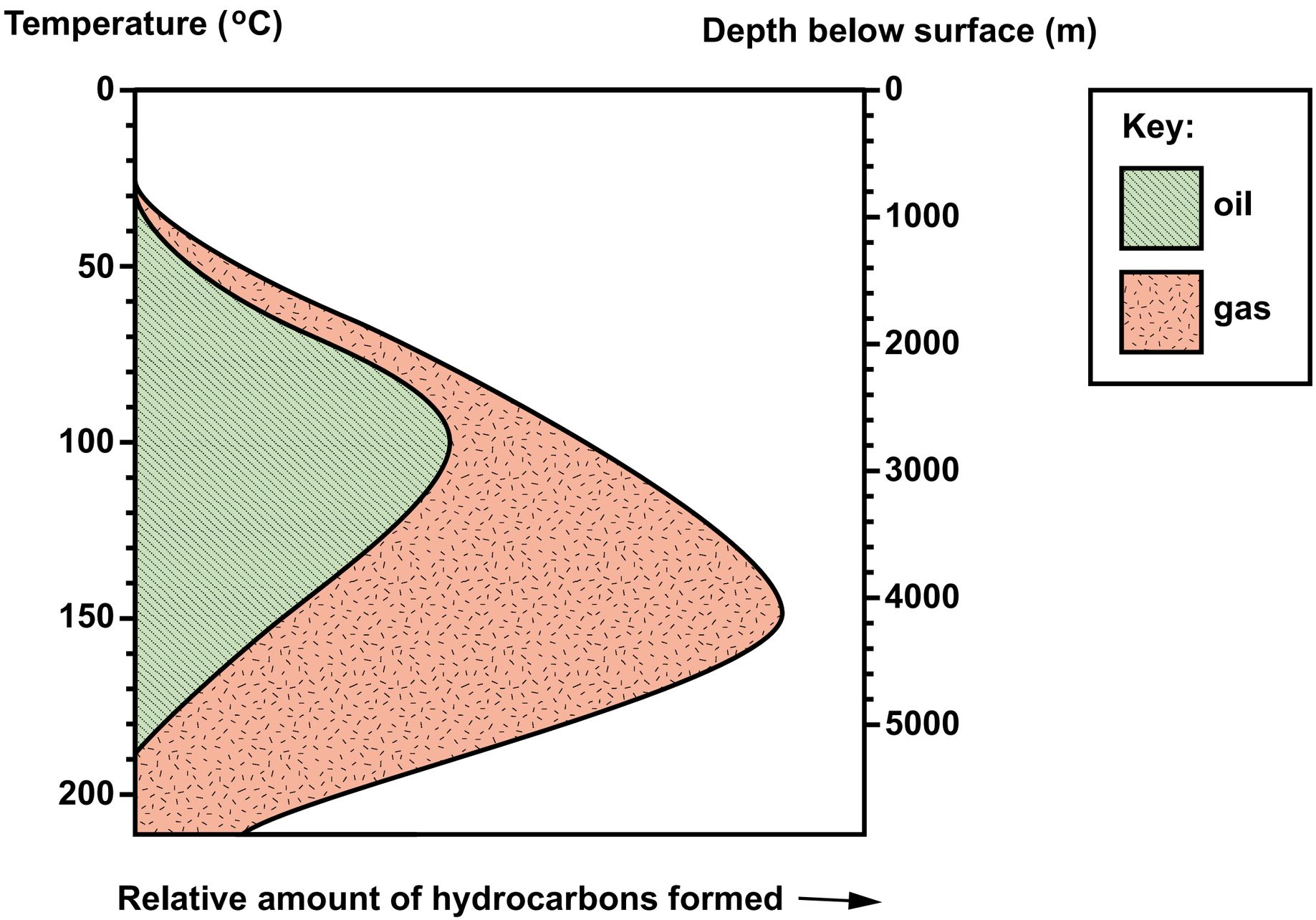

Temperature (°C)
Depth below surface (m)
0
50
100
150
200
0
1000
2000
3000
4000
5000
Key:
oil
gas
Relative amount of hydrocarbons formed

FIGURE 6b

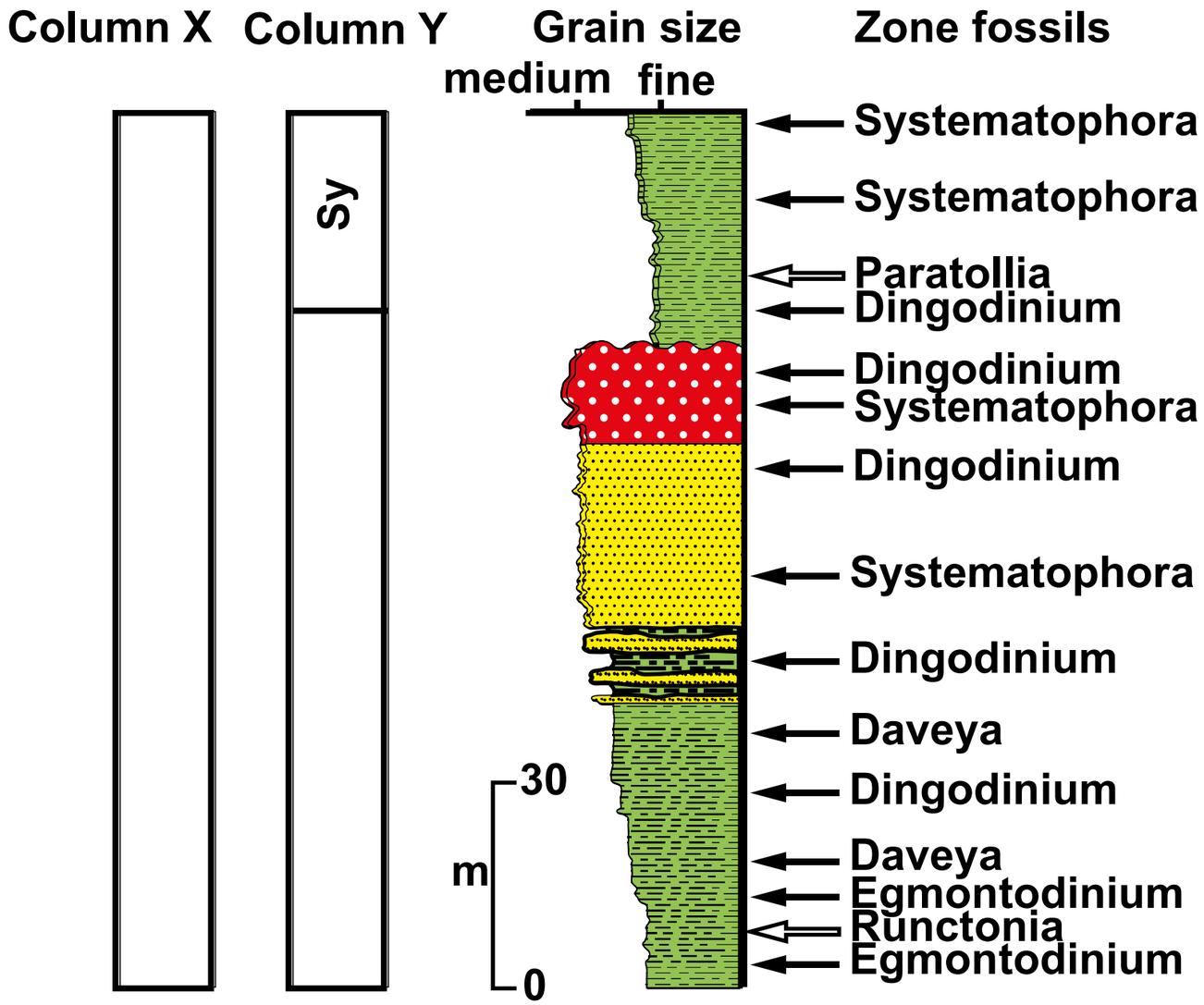


FIGURE 6c